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C. LAVETT SMITH, JAMES C. TYLER, WILLIAM P. DAVIS,
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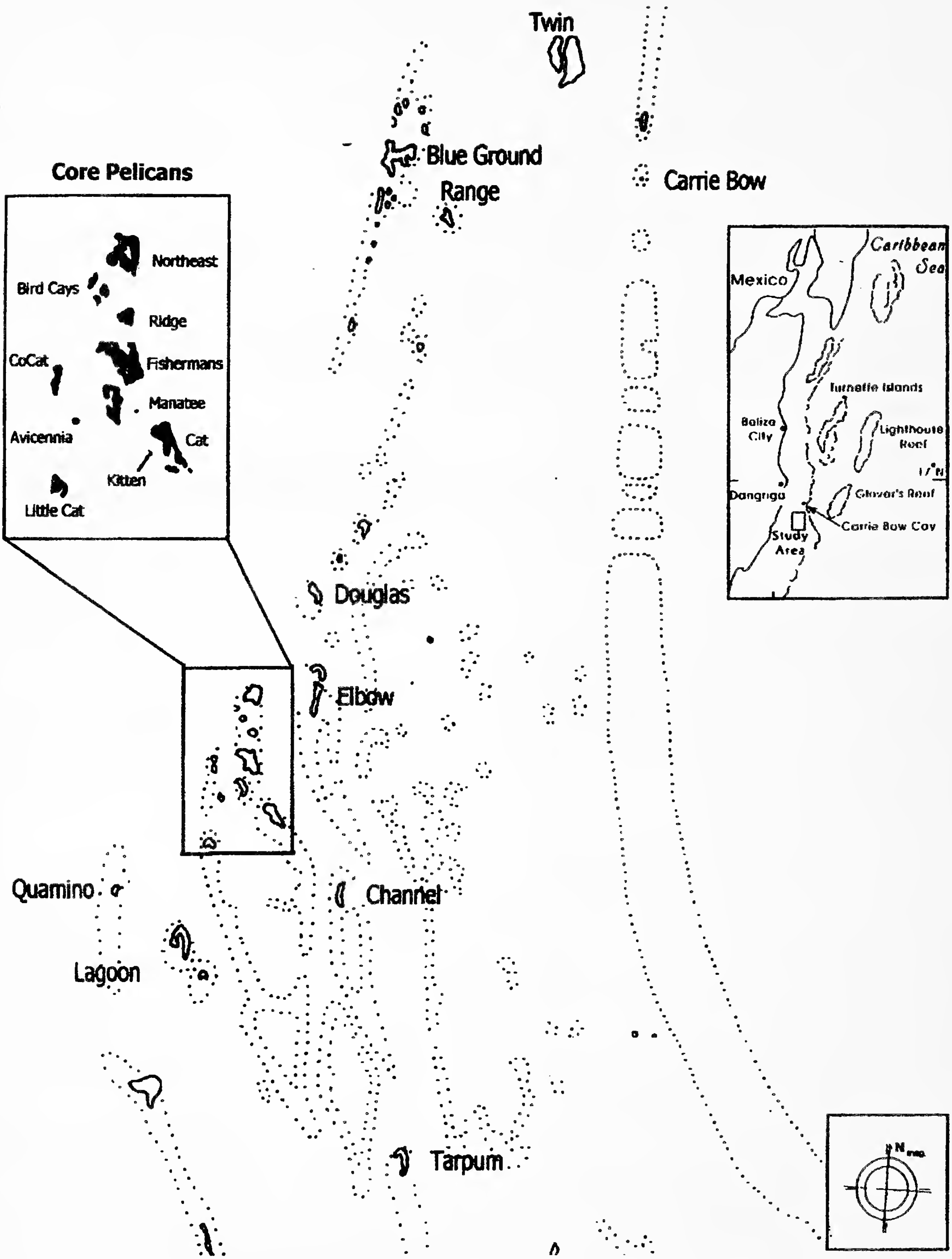

Figure 1. The Rhomboidal Cays and surrounding areas. The Core Pelican Cays are Northeast, Bird, Ridge, Co-Cat, Fisherman's, Avicennia, Manatee, Little Cat, Kitten, and Cat Cays. The Peripheral Rhomboidal Cays are Douglas, Elbow, Channel, Tarpum, Lagoon, and Quamino Cays.

FISHES OF THE PELICAN CAYS, BELIZE

BY

C. LAVETT SMITH,[1] JAMES C. TYLER,[2] WILLIAM P. DAVIS,[3]
ROBERT S. JONES,[4] DAVID G. SMITH,[5] CAROLE C. BALDWIN[5]

ABSTRACT

The Pelican Cays are a distinctive group of mangrove islands in the south central part of the Belize Barrier Reef Complex. As part of a coordinated investigation of biodiversity in the Pelican Cays, we sampled fishes using a combination of small rotenone stations and visual censuses. The Pelican Cays are part of a structurally defined larger group called the Rhomboidal Cays. We have records of 193 species of fishes from the Rhomboidal Cays, 168 from the Core Pelican Cays and 123 from the Peripheral Rhomboidal Cays. By contrast, 293 species are known from the Offshore Banks, 339 from the Barrier Reef, 106 from the Mid-Shelf area exclusive of the Peripheral Rhomboidal Cays, and 150 from the Coastal Marine region, a total of 497 from the entire region.

Twelve wide-ranging species recorded from the Pelican Cays have not been found in the other nearby areas. An undescribed species of wrasse, *Halichoeres* sp., is known only from the Rhomboidal Cays, and an undescribed serranid, *Hypoplectrus* sp., is abundant in the Pelican Cays, with a single record from Wee-Wee Cay. Other special features of the Pelican Cays are the conspicuous absence of some common species, such as the bluehead wrasse, *Thalassoma bifasciatum,* and differences in habitat of the blenny *Acanthemblemaria aspera*.

INTRODUCTION

This study is part of a series of investigations of the natural history of the Pelican Cays, Belize, coordinated by Ian G. Macintyre and Klaus Rützler of the Smithsonian Institution, and an outgrowth of the early interest in the Pelicans by Anthony (Tony) and Therese Rath, then of the Pelican Beach Hotel (now of Naturalight Productions) in Dangriga, Belize.

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The distinctive honeycomb pattern visible on maps of the Rhomboidal Cays is the result of underlying Pleistocene karst relief, which has been exaggerated by Holocene coral accumulations (Macintyre et al., 2000).

The mangrove islands of the Rhomboidal Cays differ from most of the other mangrove islands between the inshore coastline and the outer barrier reef in that the mangroves are anchored on top of a live and lush coral reef rather than to mud (Macintyre and Rützler, 2000). This is reflected in a great diversity of organisms in several groups, including algae, foraminifera, sponges, gnathostomulids, echinoderms, and ascidians, that have been studied by others.

The objectives of this study have been to determine if the Rhomboidal Cays support a correspondingly high diversity of fishes and if the fish fauna of the Pelican Cays (which form a compact group in the northern part of the Rhomboidal Cays) differs from that of the surrounding Mid-Shelf area.

METHODS

Sources

In addition to our own censuses and collections, this list is compiled from museum records of voucher specimens, especially from the National Museum of Natural History of the Smithsonian Institution, the Field Museum of Natural History, the Florida Museum of Natural History, and the American Museum of Natural History. Nearly all of the museum collections are the result of ichthyocide (rotenone) sampling.

Rotenone collections and systematic sight surveys were made in the Pelican Cays and nearby areas in October 1997, January-February 2000, and January-February 2001; a few specimens were collected by William P. Davis using microspears and traps. Some collected specimens of common and unmistakable species were identified but not retained. Other sight records were made during preliminary surveys by James C. and Diane M. Tyler and Arthur Sundberg in March 1994 and March 1995, and sporadic qualitative sight records were made by C. Lavett Smith at Carrie Bow Cay over a period of many years during the past decade.

Sampling effort for Belize fishes has been extremely variable. The offshore banks and the coastline marine environments of Belize have been thoroughly sampled by David W. Greenfield, Robert Karl Johnson and their co-workers from the Field Museum of Natural History. The immediate area of Carrie Bow Cay has been intensively sampled by investigators from the Smithsonian's National Museum of Natural History and by personnel from the Field Museum of Natural History. Sampling of the mid-shelf areas has been sporadic, and the only systematic collections and observations of fishes from the Pelican Cays are those we made in 1997, 2000, and 2001.

Sampling

Rotenone collections are the only effective way to collect small cryptic species but such collections are not effective for those species whose primary defense is flight.

As an example, a visual census at Glovers Reef by C. L. Smith and J. C. Tyler in November 1988 added 27 species to those known from there in spite of the very intensive rotenone sampling at Glovers by D.W. Greenfield, R.K. Johnson, et al. Visual censuses have the opposite drawback; small cryptic species cannot be observed and recorded effectively.

Our visual censuses were made by observers SCUBA diving along the edge of the slope beyond the reef crest. Our usual routine was to descend to approximately 50 feet and swim along the slope at that level, with one observer somewhat above the other. When the visibility was good we could see at least 20 feet above and below that level, i.e., from 30 to 70 feet. When half of our air supply was gone we would return to our starting point, this time centering our effort on the 30-foot contour. Species seen were recorded on plastic slates. This was a purely qualitative count; no effort was made to enumerate the individuals of each species.

Visual censuses have many sources of bias. Individual observers tend to concentrate on particular microhabitats. In our case, C.L. Smith tended to concentrate on benthic and partially cryptic species while R.S. Jones tended to specialize in species higher in the water column. Identification of some species is difficult or impossible in the field. For example, adult "dusky" damselfishes, *Stegastes adustus* and *S. diencaeus*, were especially troublesome. Ross Robertson of the Smithsonian Tropical Research Institute in Panama has since informed us of field characters to distinguish them of which we were unaware at the time of our observations. Small juveniles of these species, however, are very different from one another and easily distinguished in visual surveys. Other epecially troublesome species are noted in the annotated list of species below.

Our rotenone collections were made using small amounts (approximately 1 kilogram) of powdered rotenone premixed with sea water and kitchen detergent and deployed in selected areas of the various habitats so that sampling was thorough but the number of fishes affected was limited. For most stations, specimens were recovered by two SCUBA divers with some additional help from snorkelers. Specimens from these collections are deposited at the National Museum of Natural History, Smithsonian Institution (USNM).

Species lists were entered into tables in the Corel Paradox database management system for sorting and comparisons.

ANNOTATED LIST OF THE FISHES OF THE PELICAN CAYS AND RELATED AREAS

In this list we include the scientific name with author and date, the common name (a few of which are coined herein), and documentation of occurrences in the Barrier Reef Complex. With a few exceptions the scientific nomenclature follows the on-line version of the California Academy of Sciences Catalog of Fishes (www.calacademy.org/research/ichthyology), based on Eschmeyer (1998).

For our purposes, we recognize the following subdivisions:

Barrier Reef: The immediate vicinity of the outer edge of the barrier reef complex: Tobacco Cay, South Water Cay(e), Carrie Bow Cay(e) including Curlew Cay and Bank, and some of the more northern cays including Ambergris Cay and the Hol Chan reserve.

Mid-Shelf: Mid-Shelf Cays include Tobacco Range, Twin Cays, Cocoa Plum, Man of War, Ragged Cay, Blue Ground Range, Stewart Cay, Wee Wee Cay, Spruce Cay, Peter Douglas Cay (listed herein as Douglas Cay) and the Peripheral Rhomboidal Cays, the latter being the Elbow Cays, Channel Cay, Tarpum Cay, the Lagoon Cays, and Quamino Cay (Figure 1).

Pelican Cays: The Core Pelican Cays are defined as the northern group of cays in the Rhomboidal Cays area: Northeast Cay, Bird Cays, Ridge Cay, Fisherman's Cay, Co-Cat Cay, Manatee Cay, Avicennia Cay, Cat Cay, a small island close to Cat Cay we have designated as "Kitten Cay", and Little Cat Cay. Our original hypothesis was that the Core Pelicans supported a distinctive fish fauna.

Coastline Marine: Near-shore coastline marine collections, mostly from the Field Museum of Natural History, with some records from Amatique Bay provided by the American Museum of Natural History.

Offshore Banks: Glovers Reef, Lighthouse Reef, and Turneffe.

Voucher specimen data are given in the following format: museum catalog number followed in parentheses by location and, for our own collections, year of collection. Except for Pelican Cays, the word cay usually is omitted. Pelican Cays records are listed in the following order: catalog number with specific cay, and year of collection in parentheses. Catalog numbers are given for at least one lot from each museum although that institution may have additional specimens from the same area. Sight records are given as: observer (location, date). Literature citations are given in parentheses.

Locations of the major cays are shown on the Smithsonian Carrie Bow Research Areas map. Smaller cays connected to a larger cay by shallow water (< 1 m deep) are considered part of the larger cay and not listed separately. Some species are recorded from "shot holes" east of Twin Cays. These are circular sandy openings in the seagrass areas that have resulted from the use of explosives during seismic surveys conducted in the 1960s.

Acronyms:
AMNH — American Museum of Natural History
FMNH — Field Museum of Natural History
RD — Specimens collected by rotenone and discarded after identification.

SR — Sight record
J/S - R.S. Jones and C. L. Smith, recorded by both observers during the particular time period.
RSJ - Robert S. Jones
CLS - C. Lavett Smith
JCT - James C. Tyler
WPD - William P. Davis
DGS - David G. Smith
CB - Carole C. Baldwin
KC - Kathleen S. Cole
CT - Cheryl L. Thacker
ML - Michael A. Lang
MT - Milan K. Tyler
UF — University of Florida.
USNM — United States National Museum (collections now in the National Museum of Natural History, Smithsonian Institution)

Systematic List

Ginglymostomatidae
Ginglymostoma cirratum (Bonnaterre, 1878) — nurse shark
Barrier Reef: SR J/S (Carrie Bow, 2001).
Pelican Cays: SR CLS (Manatee, 1997); SR J/S (Manatee, 2000).

Rhincodon typus Smith, 1828 — whale shark
Barrier Reef: SR ML and KC (Carrie Bow).

Carcharhinidae
Carcharhinus perezii (Poey, 1876) — reef shark
Barrier Reef: AMNH 79908 (Carrie Bow).
Offshore Banks: AMNH 79919 (Glovers Reef).

Carcharhinus leucas (Müller and Henle, 1839) — bull shark
Barrier Reef: AMNH 79914 (Carrie Bow).

Carcharhinus limbatus (Müller and Henle, 1839) — blacktip shark
Barrier Reef: AMNH 79913 (Carrie Bow).

Negaprion brevirostris (Poey, 1868) — lemon shark
Mid-Shelf: SR WPD (Spruce, 2000).

Rhizoprionodon terraenovae (Richardson, 1836) — Atlantic sharpnose shark
Barrier Reef: FMNH 97448 (Carrie Bow); AMNH 79911 (Carrie Bow).

Sphyrnidae

Sphyrna lewini (Griffith and Smith, 1834) — scalloped hammerhead
Barrier Reef: FMNH 97449 (Carrie Bow).

Dasyatidae

Dasyatis americana Hildebrand and Schroeder, 1928 — southern stingray
Barrier Reef: SR J/S (Carrie Bow, 2001).
Mid-Shelf: SR J/S (Douglas, 2000).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Dasyatis guttata (Bloch and Schneider, 1801) — longnose stingray
Coastline Marine: AMNH 83640 (Bahia de Amatique).

Himantura schmardae (Werner, 1904) — Caribbean stingray
Barrier Reef: SR WPD (Carrie Bow, 1997).
There are few local records of this species and this observation needs confirmation.

Urolophidae

Urobatis jamaicensis (Cuvier, 1816) — yellow stingray
Barrier Reef: USNM 326659 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); SR J/S (patch reef south of Carrie Bow, 2000); SR J/S (Carrie Bow, 2001).
Mid-Shelf: SR J/S (Lagoon, 2000).
Pelican Cays: SR J/S (Little Cat, 2000); SR J/S (Cat, 2001).
Offshore Banks: FMNH 89488 (Glovers Reef).

Myliobatidae

Aetobatis narinari (Euphrasen, 1790) — spotted eagle ray
Pelican Cays: SR CT (Cat, 2000).

Albulidae

Albula nemoptera (Fowler, 1911) — shafted bonefish
Coastline Marine: AMNH 83644 (Bahia de Amatique).

Albula vulpes (Linnaeus, 1758) — bonefish
Barrier Reef: USNM 354548 (Carrie Bow); SR RSJ (Carrie Bow, 2000); AMNH 93356 (Carrie Bow).
Coastline Marine: FMNH 89486 (Belize City).

Megalopidae
Elops sp. — ladyfish
Barrier Reef: USNM 354549 (Carrie Bow).

Megalops atlanticus Valenciennes, 1847 — tarpon
Barrier Reef: SR CB and DGS (Carrie Bow).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Moringuidae
Moringua edwardsi (Jordan and Bollman, 1889) — spaghetti eel
Barrier Reef: USNM 267811 (Carrie Bow); FMNH 108317 (Carrie Bow); FMNH 108358 (Ambergris); FMNH 108314 (Sergeant's); AMNH 223153 (Carrie Bow).
Offshore Banks: FMNH 108315 (Glovers Reef); FMNH 108329 (Turneffe).

Ophichthidae
Ahlia egmontis (Jordan, 1884) — key worm eel
Barrier Reef: USNM 296366, FMNH 99221 (Carrie Bow); AMNH 224958 (Carrie Bow).
Mid-Shelf: USNM 360479 (Douglas, 2000); USNM 360598 (Spruce, 2000); FMNH 99197 (Blue Ground Range).
Pelican Cays: USNM 360512 (Co-Cat, 2000); USNM 346212 (Cat, 1997); USNM 360565 (Cat, 2000); USNM 365195 (Cat, 2001).
Offshore Banks: FMNH 108340 (Glovers Reef); FMNH 99239 (Turneffe).

Aprognathodon platyventris (Böhlke, 1967) — stripe eel
Barrier Reef: USNM 316040 (Carrie Bow).
Offshore Banks: FMNH 99188 (Glovers Reef).

Ichthyapus ophioneus (Evermann and Marsh, 1900) — surf eel
Barrier Reef: USNM 235090 (Carrie Bow).

Myrichthys breviceps (Richardson, 1848) — sharptail eel (*M. acuminatus* is a synonym.)
Barrier Reef: USNM 235091 (Carrie Bow); FMNH 99223 (Carrie Bow).
Offshore Banks: FMNH 108316 (Glovers Reef).

Myrichthys ocellatus (Lesueur, 1825) — goldspotted eel
Barrier Reef: FMNH 99224 (Carrie Bow).
Mid-Shelf: RD (Spruce, 2000).
Offshore Banks: FMNH 99159 (Glovers Reef).

Myrophis anterodorsalis McCosker, Böhlke and Böhlke, 1989 — longfin worm eel
Pelican Cays: USNM 346447 (Manatee, 1997).

Myrophis platyrhynchus Breder, 1927 — broadnose worm eel
Barrier Reef: USNM 353136 (Carrie Bow).
Mid-Shelf: USNM 360599 (Spruce, 2000).
Pelican Cays: USNM 346448 (Manatee, 1997).

Myrophis punctatus Lütken, 1852 — speckled worm eel
Barrier Reef: USNM 235085 (Carrie Bow).
Mid-Shelf: FMNH 99210 (Cayo Negro).
Pelican Cays: USNM 346449 (Manatee, 1997); USNM 364854 (Fisherman's, 2001); USNM 365196 (Cat, 2001).
Coastline Marine: FMNH 83119 (Belize City); FMNH 99262 (Gales Point).

Muraenidae
Echidna catenata (Bloch, 1795) — chain moray
Barrier Reef: FMNH 99113 (South Water); FMNH 99060 (Ambergris); AMNH 87168 (Ambergris).
Offshore Banks: FMNH 108314 (Glovers Reef).

Enchelycore carychroa Böhlke and Böhlke, 1976 — chestnut moray
Barrier Reef: USNM 267813 (Carrie Bow); FMNH 98961 (Carrie Bow); FMNH 108250 (Ambergris).
Offshore Banks: FMNH 98900 (Glovers Reef) FMNH 99005 (Turneffe).

Enchelycore nigricans (Bonnaterre, 1788) — viper moray
Barrier Reef: USNM 349056 (Carrie Bow); FMNH 99111 (Carrie Bow); FMNH 99058 (Ambergris); FMNH 99004 (Sergeant's).
Offshore Banks: FMNH 108309 (Glovers Reef); FMNH 98924 (Lighthouse).

Gymnothorax funebris Ranzani, 1840 — green moray
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001); FMNH 99068 (Ambergris).
Mid-Shelf: USNM 346446, USNM 360576 (Douglas, 2000); USNM 360600 (Spruce, 2000); FMNH 98994 (Spanish).
Pelican Cays: USNM 346446 (Manatee, 1997).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Gymnothorax miliaris (Kaup, 1856) — goldentail moray
Barrier Reef: USNM 278176 (Carrie Bow); FMNH 98970 (Carrie Bow); FMNH 108356 (Ambergris).
Offshore Banks: FMNH 98904 (Glovers Reef); FMNH 99078 (Turneffe).

Gymnothorax moringa (Cuvier, 1829) — spotted moray
Barrier Reef: USNM 285820 (Carrie Bow); FMNH 99117 (South Water); USNM 365197 (3.1 mi. south of Carrie Bow, 2001); AMNH 224950 (Carrie Bow).
Mid-Shelf: FMNH 99110 (Twin).
Pelican Cays: SR J/S (Avicennia, 2001).
Coastline Marine: FMNH 98917 (Belize City); FMNH 99011 (Punta Gorda).
Offshore Banks: FMNH 98988, 101106 (Glovers Reef).

Gymnothorax vicinus (Castelnau, 1855) — purplemouth moray
Barrier Reef: USNM 327553 (Carrie Bow); FMNH 99106 (Carrie Bow); FMNH 108357 (Ambergris); AMNH 223154 (Carrie Bow).
Coastline Marine: FMNH 101103 (Punta Gorda).
Offshore Banks: FMNH 108360 (Glovers Reef).

Uropterygius macularius (Lesueur, 1825) — marbled moray
Barrier Reef: USNM 278165 (Carrie Bow); FMNH 108359 (Ambergris).
Offshore Banks: FMNH 108321 (Glovers Reef); FMNH 99078 (Turneffe).

Congridae
Conger triporiceps Kanazawa, 1958 — manytooth conger
Barrier Reef: FMNH 99185 (Carrie Bow).

Heteroconger longissimus Günther, 1870 — garden eel (formerly *H. halis* and *H. discus*)
Barrier Reef: USNM 316037 (Carrie Bow); SR CLS (Carrie Bow, 2000).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Chlopsidae
Kaupichthys hyoproroides (Strömann, 1896) — reef eel
Barrier Reef: USNM 267815 (Carrie Bow); AMNH 225082 (Carrie Bow).
Offshore Banks: FMNH 98803 (Glovers Reef).

Kaupichthys nuchalis Böhlke, 1967 — collared eel
Barrier Reef: USNM 267817 (Carrie Bow).

Engraulidae
Anchoa cayorum (Fowler, 1906) — key anchovy
Coastline Marine: FMNH 99467 (Belize City).

Anchoa cubana (Poey, 1868) — Cuban anchovy
Coastline Marine: FMNH 99468 (Belize City).

Anchoa hepsetus (Linnaeus, 1758) — striped anchovy
Coastline Marine: FMNH 99470 (Belize City).

Anchoa lamprotaenia Hildebrand, 1943 — bigeye anchovy
Mid-Shelf: AMNH 58677 (Twin).
Coastline Marine: FMNH 99450 (Belize City).

Anchovia clupeoides (Swainson, 1839) — zabaleta anchovy
Coastline Marine: FMNH 80409 (Belize City).

Cetengraulis edentulus (Cuvier, 1829) — Atlantic anchoveta
Coastline Marine: FMNH 10750 (Belize City).

Clupeidae
Harengula clupeola (Cuvier, 1829) — false pilchard
Pelican Cays: USNM 347657 (Manatee, 1997); USNM 360510 (Co-Cat, 2000); USNM 348657 (Manatee, 1997).
Offshore Banks: FMNH 89490 (Glovers Reef).

Harengula humeralis (Cuvier, 1829) — redear sardine
Barrier Reef: AMNH 224988 (Carrie Bow).
Pelican Cays: USNM 347367 (Manatee, 1997); USNM 360509 (Co-Cat, 2000); SR J/S (Manatee, 2000).

Harengula jaguana Poey, 1865 — scaled herring
Coastline Marine: FMNH 96001 (Belize City); AMNH 83638 (Bahia de Amatique).

Jenkinsia lamprotaenia (Gosse, 1851) — dwarf herring
Barrier Reef: USNM 349064 (Carrie Bow); SR J/S (Carrie Bow, 2000); AMNH 224999 (Carrie Bow).
Pelican Cays: USNM 347311 (Cat 1997). Probably this species: SR J/S (Cat, 2000); SR J/S (Manatee, 2000).

Jenkinsia stolifera (Jordan and Gilbert, 1884) — shortband herring
Barrier Reef: USNM 353552 (Carrie Bow).
Pelican Cays: USNM 346450 (Manatee, 1997).

Opisthonema oglinum (Lesueur, 1818) — Atlantic thread herring
Coastline Marine: FMNH 77807 (Belize City).

Characidae
Astyanax aeneus (Günther, 1860) — central tetra
Coastline Marine: FMNH 103761, (Belize City).

Ariidae
Ariopsis assimilis (Günther, 1864) — Mayan catfish
Coastline Marine: FMNH 95979 (Belize City); FMNH 77788 (mouth of Stann Creek, Dangriga).

Bagre marinus (Mitchill, 1815) — gafftopsail catfish
Coastline Marine: FMNH 103769 (Belize City).

Synodontidae
Saurida suspicio Breder, 1927 — suspicious lizardfish
Barrier Reef: USNM 353556 (Carrie Bow).

Synodus foetens (Linnaeus, 1766) — inshore lizardfish
Coastline Marine: AMNH 83647 (Bahia de Amatique).

Synodus intermedius (Spix and Agassiz, 1829) — sand diver
Barrier Reef: USNM 327555 (Carrie Bow); SR J/S (Carrie Bow, 2001).
Mid-Shelf: SR J/S (Tarpum, 2001); SR J/S (Channel, 2001).
Pelicans: SR RSJ (Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001).

Synodus saurus (Linnaeus, 1758) — bluestriped lizardfish
Barrier Reef: USNM 276220 (Carrie Bow).
Mid-Shelf: SR RSJ (Lagoon, 2000).
Pelican Cays: USNM 347395 (Cat, 1997).
Offshore Banks: FMNH 104634 (Glovers Reef).

Synodus synodus (Linnaeus, 1758) — red lizardfish
Barrier Reef: USNM 276206 (Carrie Bow); AMNH 225071 (Carrie Bow).
Offshore Banks: FMNH 77864 (Glovers Reef).

Synodus sp.
Mid-Shelf: USNM 360490 (SE Lagoon, 2000).

Ophidiidae
Lepophidium brevibarbe (Cuvier, 1829) — blackedge cusk-eel
Coastline Marine: AMNH 83468 (Bahia de Amatique).

Parophidion schmidti (Woods and Kanazawa, 1951) — dusky cusk-eel
Barrier Reef: USNM 351301 (Carrie Bow).
Offshore Banks: FMNH 104690 (Glovers Reef).

Carapidae

Carapus bermudensis (Jones, 1874) — pearlfish
Barrier Reef: AMNH 98280 (Carrie Bow).
Tenuis larvae were taken in set plankton nets at Carrie Bow Cay but we found no adults in more than 50 holothurians examined.

Bythitidae

Calamopteryx goslinei Böhlke and Cohen, 1966 — longarm brotula
Barrier Reef: USNM 3210772 (Carrie Bow).
Offshore Banks: FMNH 71086 (Glovers Reef); FMNH 77583 (Lighthouse).

Grammonus claudei (Torre y Huerta, 1930) — reef-cave brotula
Offshore Banks: FMNH 89499 (Glovers Reef).

Ogilbia sp.
Barrier Reef: FMNH 89680 (Carrie Bow); FMNH 77538 (Gallows Point Reef).
Mid-Shelf: USNM 360536 (Douglas, 2000); USNM 360537 (SE Lagoon, 2000).
Pelican Cays: USNM 360535 (Cat, 2000).
Coastline Marine: FMNH 89652 (Tarpon).
Offshore Banks: FMNH 71099 (Glovers Reef); FMNH 94879 (Turneffe).

Petrotyx sanguineus (Meek and Hildebrand, 1928) — redfin brotula
Barrier Reef: USNM 276205 (Carrie Bow); FMNH 89667 (Carrie Bow); AMNH 224991 (Carrie Bow).
Offshore Banks: FMNH 71081 (Glovers Reef).

Batrachoididae

Batrachoides gilberti Meek and Hildebrand, 1928 — Central American toadfish
Coastline Marine: FMNH 71317 (Belize City); FMNH 86555 (Gales Point).

Opsanus beta (Goode and Bean, 1880) — gulf toadfish
Barrier Reef: USNM 321075 (Carrie Bow).

Opsanus dichrostomus Collette, 2001 — bicolor toadfish
Coastline Marine: USNM 361063 (Belize City).

Porichthys pauciradiatus Caldwell and Caldwell, 1963 — lowcount toadfish
Pelican Cays: USNM 360497 (Cat, 2000); USNM 365038 (Cat, 2001).

Sanopus astrifer (Robins and Starck, 1965) — whitespotted toadfish
Offshore Banks: FMNH 71318 (Glovers Reef).

Sanopus barbatus (Meek and Hildebrand, 1928) — bearded toadfish
Mid-Shelf: USNM 360639 (SE Lagoon, 2000).
Coastline Marine: FMNH 105004 (Punta Gorda).

Sanopus greenfieldorum Collette, 1983 — whitelined toadfish
Barrier Reef: USNM 213555 (Carrie Bow); FMNH 94575 (Carrie Bow); AMNH 215988 (Carrie Bow).

Triathalassothia gloverensis (Greenfield and Greenfield, 1973) — reef toadfish
Barrier Reef: USNM 261602 (Carrie Bow); FMNH 104581 (Carrie Bow); FMNH 104593 (Goff's); FMNH 104590 (Ambergris).
Mid-Shelf: FMNH 104589 (Blue Ground Range).
Pelican Cays?: USNM 346478 (? catalog entry reads: N of East Cut in the Rhomboidal Cays; probably not Pelican Cays, 1997).
Offshore Banks: FMNH 91035 (Glovers Reef); FMNH 104594 (Turneffe).

Antennariidae
Antennarius multiocellatus (Valenciennes, 1837) — longlure frogfish
Barrier Reef: USNM 353632 (Carrie Bow).
Offshore Banks: FMNH 91755 (Glovers Reef).

Antennarius ocellatus (Bloch and Schneider, 1801) — ocellated frogfish
Offshore Banks: FMNH 86561 (Glovers Reef) (recorded as *Antennarius triocellatus,* which is not listed by Pietsch and Grobecker, 1987).

Antennarius pauciradiatus Schultz, 1957— dwarf frogfish
Barrier Reef: USNM 276195 (Carrie Bow).
Offshore Banks: FMNH 91757 (Glovers Reef).

Antennarius striatus (Shaw in Shaw and Nodder, 1794) — striated frogfish
Offshore Banks: FMNH 91775 (Glovers Reef).

Ogcocephalidae
Ogcocephalus declivirostris Bradbury, 1980 — slopesnout batfish
Coastline Marine: AMNH 83650 (Bahia de Amatique).

Ogcocephalus nasutus (Valenciennes, 1829) — shortnose batfish
Offshore Banks: FMNH 91246 (Glovers Reef).

Mugilidae

Mugil curema Valenciennes, 1836 — white mullet
Coastline Marine: FMNH 103743 (Belize City); FMNH 103742 (Dangriga); FMNH 77693, FMNH 77693 (South Lagoon).

Mugil trichodon Poey, 1875 — fantail mullet
Coastline Marine: FMNH 100640 (Belize City).

Mugil liza Valenciennes, 1836 — liza (formerly *Mugil brasiliensis*)
Coastline Marine: FMNH 103745, 96083 (Belize City).

Atherinidae

Atherinomorus stipes (Müller and Troschel, 1848) — hardhead silverside
Barrier Reef: USNM 276217 (Carrie Bow); USNM 364862 (3.1 mi. south of Carrie Bow, 2001); FMNH 108689 (South Water); AMNH 224956 (Carrie Bow).
Mid-Shelf: USNM 365177 (Quamino, 2001).
Pelican Cays: USNM 346455 (Manatee, 1997); USNM 360513 (Co-Cat, 2000); USNM 364861 (Cat, 2001).
Coastline Marine: FMNH 96107 (Belize City).
Offshore Banks: FMNH 39637 (Glovers Reef); FMNH 39610 (Turneffe).

Hypoatherina harringtonensis (Goode, 1877) — reef silverside
Barrier Reef: USNM 349221 (Carrie Bow); SR J/S (Carrie Bow, 2001); USNM 364864 (3.1 mi. south of Carrie Bow, 2001); AMNH 224953 (Carrie Bow).
Mid-Shelf: USNM 360638 (Douglas, 2000); USNM 365178 (Quamino, 2001); USNM 364863 (North Elbow).
Offshore Banks: FMNH 39612 (Turneffe); SR CLS and JCT (Glovers Reef, 1988).

Belonidae

Ablennes hians (Valenciennes, 1846) — flat needlefish
Barrier Reef: USNM 323235 (Carrie Bow); SR RSJ (Carrie Bow, 2001).

Platybelone argalus argalus (Lesueur, 1821) — keeltail needlefish
Barrier Reef: USNM 349226 (Carrie Bow).

Strongylura marina (Walbaum, 1792) — Atlantic needlefish
Coastline Marine: FMNH 97250 (Pelican Beach, Dangriga); FMNH 35414 (Belize City).

Strongylura notata notata (Poey, 1860) — redfin needlefish
Barrier Reef: USNM 327560 (Carrie Bow); FMNH 97502 (Carrie Bow); SR J/S (Carrie Bow, 2001).
Mid-Shelf: USNM 365194 (Quamino, 2001).
Pelican Cays: USNM 360514 (Co-Cat, 2000); SR RSJ (Manatee, 2000).
Coastline Marine: FMNH 77800 (Belize City); FMNH 97508 (Punta Gorda).
Offshore Banks: FMNH 97515, 77527 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Strongylura timucu (Walbaum, 1792) — timucu
Barrier Reef: FMNH 97525 (Carrie Bow); FMNH 97528 (Ambergris).
Mid-Shelf: FMNH 97536 (Twin).
Pelican Cays: USNM 360515 (Co-Cat, 2000).
Coastline Marine: FMNH 97522, (Belize City); FMNH 97535 (Punta Gorda); FMNH 7722 (mouth of Stann Creek, Dangriga); FMNH 97531 (Middle Snake).
Offshore Banks: FMNH 97523 (Glovers Reef); FMNH 97533 (Turneffe).

Tylosurus crocodilus crocodilus (Péron and Lesueur, 1821) — houndfish
Barrier Reef: USNM 344629 (Carrie Bow); SR J/S (Carrie Bow, 2001); FMNH 97548 (Ambergris).
Pelican Cays: SR CLS (Cat, 1997).
Offshore Banks: FMNH 97550 (Glovers Reef).

Hemiramphidae
Hemiramphus brasiliensis (Linnaeus, 1758) — ballyhoo
Barrier Reef: USNM 343865 (Carrie Bow); SR RSJ (Carrie Bow, 2000, 2001).

Hyporhamphus roberti hildebrandi Jordan and Evermann, 1929 — Central American halfbeak
Coastline Marine: FMNH 97483 (Belize City).

Hyporhamphus unifasciatus (Ranzini, 1841) — silverstripe halfbeak
Pelican Cays: USNM 360516 (Co-Cat, 2000).
Coastline Marine: FMNH 97537 (Belize City).
Offshore Banks: FMNH 39618 (Turneffe).

Aplocheilidae
Rivulus marmoratus Poey, 1880 — mangrove rivulus
Barrier Reef: FMNH 104450 (St. George's).
Mid-Shelf: Trapped by WPD (Twin, 2000, 2001).

Poeciliidae

Belonesox belizanus Knerr, 1860 — pike killifish
Mid-Shelf: AMNH 225066 (Twin).
Coastline Marine: FMNH 103754 (Belize City); FMNH 89277 (South Lagoon).

Gambusia nicaraguensis Günther, 1866 — Nicaraguan mosquitofish
Coastline Marine: FMNH 87626 (Belize City); FMNH 87625 (Placentia).

Gambusia punctata Poey, 1854 — spotted mosquitofish
Mid-Shelf: USNM 360477 (SE Lagoon, 2000).

Gambusia yucatana (Regan, 1914) — Southern Yucatan mosquitofish (*Gambusia puncticulata yucatana* of Greenfield, Greenfield, and Wildrick, 1982, *Gambusia yucatana australis* Greenfield, 1985).
Barrier Reef: FMNH 104466 (St. George's); FMNH 93919 (Ambergris).
Mid-Shelf: (Heath, Turner, and Davis, 1993) (Twin).
Coastline Marine: FMNH 95086 (Belize City); FMNH 87664 (South Lagoon); FMNH 93916 (East Snake).

Poecilia orri Fowler, 1943 — mangrove molly
Barrier Reef: FMNH 104511 (St. George's); FMNH 104512 (Ambergris).
Mid-Shelf: USNM 360478 (SE Lagoon, Feb 2000).
Coastline Marine: FMNH 105413 (Belize City); FMNH 103750 (Pelican Beach, Dangriga).

Cyprinodontidae

Cyprinodon artifrons Hubbs, 1936 — Yucatan pupfish
Barrier Reef: (Greenfield and Thomerson, 1997) (Cay Caulker).
Mid-Shelf : (Heath, Turner, and Davis, 1993) (Twin); AMNH 222861 (Twin).

Floridichthys polyommus Hubbs, 1936 — ocellated killifish
Barrier Reef: (Greenfield and Thomerson, 1997) (Ambergris).
Mid-Shelf: (Heath, Turner, and Davis, 1993) (Twin); AMNH 225060 (Twin).
Coastline Marine: (Greenwood and Thomerson, 1997) (Southern Lagoon).

Jordanella pulchra (Hubbs, 1936) — orange flagfish
Mid-Shelf: (Heath, Turner, and Davis, 1993) (Twin); AMNH 225064 (Twin).

Holocentridae

Holocentrus adscensionis (Osbeck, 1765) — squirrelfish
Barrier Reef: SR J/S (Carrie Bow, 2000); SR J/S (Carrie Bow, 2001).

Mid-Shelf: SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001); SR J/S (Quamino, 2001); SR J/S (Elbow, 2001); RD (Elbow, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Little Cat, 2000); SR J/S (Co-Cat, 2001); SR J/S (Avicennia, 2001).
Offshore Banks: FMNH 89481 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Holocentrus rufus (Walbaum, 1792) — longspine squirrelfish
Barrier Reef: USNM 267790 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 77835 (Gallows Point); FMNH 108292 (Ambergris); AMNH 224972 (Carrie Bow).
Mid-Shelf: SR J/S (Lagoon, 2000); SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Manatee); SR J/S (Little Cat, 2000); SR J/S (Cat, 2001); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39795 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Myripristis jacobus Cuvier, 1829 — blackbar soldierfish
Barrier Reef: USNM 327563 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Offshore Banks: FMNH 89472 (Glovers Reef).

Neoniphon marianus (Cuvier, 1829) — longjaw squirrelfish
Barrier Reef: USNM 267791 (Carrie Bow); SR RSJ (Carrie Bow, 2000, 2001); FMNH 108297 (Ambergris); FMNH 108290 (English).
Offshore Banks: FMNH 77832 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Plectrypops retrospinis (Guichenot, 1853) — cardinal soldierfish
Barrier Reef: USNM 277810 (Carrie Bow); FMNH 89693 (Carrie Bow); FMNH 108297 (Ambergris).
Offshore Banks: FMNH 77740 (Glovers Reef); FMNH 77827 (Lighthouse).

Sargocentron coruscum (Poey, 1860) — reef squirrelfish
Barrier Reef: USNM 31646 (Carrie Bow); FMNH 108289 (Ambergris).
Mid-Shelf: USNM 360637 (Douglas, 2000).
Offshore Banks: FMNH 89477 (Glovers Reef).

Sargocentron vexillarium (Poey, 1860) — dusky squirrelfish
Barrier Reef: USNM 276222 (Carrie Bow); FMNH 89672; SR J/S (Carrie Bow, 2001); FMNH 10823 (Ambergris); FMNH 89682 (Gallows Point).
Pelican Cays: USNM 347325 (Cat, 1997); USNM 360568 (Cat, 2000).

Offshore Banks: FMNH 89671 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Syngnathidae

Acentronura dendritica (Barbour, 1905) — pipehorse
Barrier Reef: USNM 353960 (Carrie Bow).

Bryx dunckeri (Metzelaar, 1919) — pugnose pipefish
Mid-Shelf: USNM 365354 (North Elbow, 2001); USNM 365352 (Channel, 2001).
Pelican Cays: USNM 365353 (Cat, 2001).
Offshore Banks: FMNH 83891 (Glovers Reef).

Bryx randalli (Herald, 1965) — ocellated pipefish
Mid-Shelf: USNM 360491 (Douglas, 2000); USNM 360644 (SE Lagoon, 2000); USNM 365351 (North Elbow, 2001).
Pelican Cays: USNM 347308 (Cat, 1997); USNM 360584 (Cat, 2000).
Offshore Banks: FMNH 93579 (Glovers Reef).

Cosmocampus albirostris (Kaup, 1856) — whitenose pipefish
Barrier Reef: USNM 353146 (Carrie Bow).
Offshore Banks: FMNH 84588 (Glovers Reef).

Cosmocampus brachycephalus (Poey, 1868) — crested pipefish
Mid-Shelf: USNM 360601 (Spruce); USNM 365348 (sand spit between Spruce and Wee Wee, 2001); USNM 365349 (Channel, 2001); FMNH 83879 (Robinson).
Pelican Cays: USNM 360517 (Co-Cat, 2000); USNM 365350 (Cat, 2001).
Coastline Marine: FMNH 83843 (Placentia); FMNH 83885 (Punta Gorda).
Offshore Banks: FMNH 83890 (Glovers Reef).

Cosmocampus elucens (Poey, 1868) — shortfin pipefish
Pelican Cays: USNM 346452 (Manatee, 1997); USNM 365347 (Fisherman's, 2001).
Offshore Banks: FMNH 83848 (Glovers Reef).

Hippocampus erectus Perry, 1810 — lined seahorse
Coastline Marine: AMNH 83645 (Bahia de Amatique).

Hippocampus reidi Ginsburg, 1933 — longsnout seahorse
Pelican Cays: USNM 365198 (North Elbow, 2001).

Halicampus crinitis (Jenyns, 1842) — banded pipefish
Barrier Reef: USNM 276073 (Carrie Bow).
Offshore Banks: FMNH 83880 (Glovers Reef).

Anarchopterus tectus (Dawson, 1978) — insular pipefish
Barrier Reef: FMNH 83862 (Carrie Bow) (cataloged as *Micrognathus tectus*).

Penetopteryx nanus (Rosén, 1911) — worm pipefish
Barrier Reef: USNM 346207 (Carrie Bow).

Syngnathus caribbaeus Dawson, 1979 — Caribean pipefish
Coastline Marine: FMNH 93580 (Placentia).

Syngnathus floridae (Jordan and Gilbert, 1882) — dusky pipefish
Barrier Reef: FMNH 83845 (Gallows Point).
Pelican Cays: USNM 360518 (Co-Cat, 2000).
Offshore Banks: FMNH 83846 (Glovers Reef).

Syngnathus scovellii (Evermann and Kendall, 1896) — Gulf pipefish (*S. rousseau* is probably a synonym.)
Coastline Marine: FMNH 83844 (Belize City).

Aulostomidae
Aulostomus maculatus Valenciennes, 1837 — trumpetfish
Barrier Reef: USNM 267794 (Carrie Bow); SR RSJ (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Channel, 2001).
Pelican Cays: SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 77570 (Glovers Reef).

Synbranchidae
Ophisternon aenigmaticum Rosen and Greenwood, 1976 — swamp eel
Mid-Shelf: USNM 329295 (Twin).
Coastline Marine: FMNH 103756 (Belize City).

Dactylopteridae
Dactylopterus volitans (Linnaeus,1758) — flying gurnard
Barrier Reef: AMNH 225007 (Carrie Bow).

Scorpaenidae
Scorpaena albifimbria Evermann and Marsh, 1900 — coral scorpionfish
Barrier Reef: USNM 276145 (Carrie Bow); FMNH 105023 (Carrie Bow); FMNH 105036 (Ambergris); FMNH 77754 (Gallows Point).
Offshore Banks: FMNH 77858 (Glovers Reef); FMNH 105048 (Turneffe).

Scorpaena bergii Evermann and Marsh, 1900 — goosehead scorpionfish
Barrier Reef: USNM 353631, FMNH 105436 (Carrie Bow).
Offshore Banks: FMNH 105033 (Glovers Reef).

Scorpaena brasiliensis Cuvier, 1829 — barbfish
Barrier Reef: FMNH 105267 (South Water).
Offshore Banks: FMNH 105437 (Glovers Reef).
Coastline Marine: AMNH 83643 (Bahia de Amatique).

Scorpaena dispar Longley and Hildebrand, 1940 — hunchback scorpionfish
Offshore Banks: FMNH 105034 (Glovers Reef).

Scorpaena grandicornis Cuvier, 1829 — plumed scorpionfish
Pelican Cays: USNM 346466 (Manatee, 1997).
Offshore Banks: FMNH 86509 (Glovers Reef).

Scorpaena inermis Cuvier, 1829 — mushroom scorpionfish
Mid-Shelf: USNM 360606 (Spruce, 2000).
Offshore Banks: FMNH 105016, 86506 (Glovers Reef).

Scorpaena plumieri Bloch, 1789 — spotted scorpionfish
Barrier Reef: USNM 276203, FMNH 105457 (Carrie Bow); SR J/S (Carrie Bow, 2001); FMNH 86511 (Gallows Point); FMNH 105038 (Ambergris); FMNH 105449 (Sergeant's).
Mid-Shelf: SR RSJ (Spruce, 2000); FMNH 105448 (Spanish).
Coastline Marine: FMNH 105450 (Punta Gorda); FMNH 105456 (Tarpon, north of Frenchman's).
Offshore Banks: FMNH 86510 (Glovers Reef); FMNH 105041 (Turneffe); FMNH 105008 (Lighthouse).

Scorpaenodes caribbaeus Meek and Hildebrand, 1928 — reef scorpionfish
Barrier Reef: USNM 276188, FMNH 105484 (Carrie Bow); FMNH 105465 (Sergeant's); FMNH 105035 (Ambergris).
Offshore Banks: FMNH 105040 (Glovers Reef); FMNH 105474 (Turneffe).

Scorpaenodes tredecimspinosus (Metzelaar, 1919) — deepreef scorpionfish
Barrier Reef: USNM 267808, FMNH 105056 (Carrie Bow); FMNH 105039 (Ambergris).
Offshore Banks: FMNH 105012 (Glovers Reef); FMNH 105042 (Turneffe).

Triglidae

Bellator militaris (Goode and Bean, 1896) — horned searobin
Coastline Marine: AMNH 83641 (Bahia de Amatique).

Centropomidae

Centropomus ensiferus Poey, 1860 — swordspine snook
Coastline Marine: FMNH 77805 (Belize City); FMNH 104082 (Dangriga).

Centropomus parallelus Poey, 1860 — fat snook
Coastline Marine: FMNH 104651 (Belize City).

Centropomus pectinatus Poey, 1860 — tarpon snook
Coastline Marine: FMNH 77804 (Belize City); FMNH 104652 (South Lagoon).

Centropomus poeyi Chávez, 1961 — Mexican snook
Coastline Marine: FMNH 80423 (Belize City).

Centropomus undecimalis (Bloch, 1792) — common snook
Coastline Marine: FMNH 103872 (Belize City).

Serranidae

Cephalopholis cruentata (Lacepède, 1802) — graysby
Barrier Reef: USNM 274908, FMNH 95833 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 95847 (English); FMNH 95866 (Ambergris).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Elbow, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 95837, 95840 (Glovers Reef); FMNH 95878 (Turneffe); FMNH 95928 (Lighthouse).

Cephalopholis fulva (Linnaeus, 1758) — coney
Barrier Reef: USNM 349057 (Carrie Bow); SR CLS (Carrie Bow, 2001); FMNH 95919 (Ambergris); FMNH 95935 (Hol Chan); AMNH 83085 (Ambergris).
Offshore Banks: FMNH 95944 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Diplectrum bivittatum (Valenciennes, 1828) — dwarf sandperch
Barrier Reef: USNM 354569 (Carrie Bow).

Epinephelus adscensionis (Osbeck, 1765) — rock hind
Barrier Reef: SR RSJ (Carrie Bow, 2000).

Epinephelus guttatus (Linnaeus, 17858) — red hind
Barrier Reef: USNM 276225 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Offshore Banks: FMNH 95803 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Epinephelus itajara (Lichtenstein, 1822) — jewfish
Pelican Cays: SR CLS (Cat, 1997).
Coastline Marine: FMNH 103771 (Belize City).

Epinephelus morio (Valenciennes, 1828) — red grouper
Pelican Cays: SR J/S (Avicennia, 2001); SR J/S (Co-Cat, 2001).

Epinephelus striatus (Bloch, 1792) — Nassau grouper
Barrier Reef: AMNH 93324 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Tarpum, 2001); SR J/S (Elbow, 2001).
Pelican Cays: SR JCT et al. (Cat, 1995); SR J/S (Cat, 2000); SR CLS (Cat, 1997).
Offshore Banks: FMNH 39719 (Glovers Reef.); SR CLS and JCT (Glovers Reef, 1988).

Hypoplectrus aberrans Poey , 1868 — yellowbellied hamlet
Barrier Reef: USNM 327573 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR CLS (Lagoon, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347373 (Manatee, 1997); SR J/S (Little Cat, 2000); SR J/S (Cat, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001).

Hypoplectrus chlorurus (Cuvier, 1828) — yellowtail hamlet
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Quamino, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR CLS (Cat, 1997).

Hypoplectrus indigo (Poey, 1851) — indigo hamlet
Barrier Reef: USNM 349063 (Carrie Bow); SR J/S (Carrie Bow, 2001).
Offshore Banks: SR CL and JCT (Glovers Reef, 1988).

Hypoplectrus sp. nov. — Mayan hamlet. (Figure 2) (This species is being described by P. Lobell.)
Mid-Shelf: Record from P. Lobell (pers. comm.) (Wee Wee).

Pelican Cays: USNM 360467 (Manatee, 2000); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR CLS (Cat, 1997).

Hypoplectrus nigricans (Poey, 1852) — black hamlet
Barrier Reef: USNM 327572 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 95953 (English).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Quamino, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347371 (Manatee, 1997); USNM 347414 (Cat, 1997); SR J/S (Cat, 2000, 2001); SR CLS (Cat, 1997); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 95954 (Turneffe); SR CLS and JCT (Glovers Reef, 1988).

Hypoplectrus puella (Cuvier, 1828) — barred hamlet
Barrier Reef: USNM 327575 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: USNM 360630 (Douglas, 2000); SR J/S (Douglas, 2000); USNM 360640 (SE Lagoon, 2000); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347327 (Cat, 1997); USNM 347413 (Cat, 1997); USNM 347464 (Manatee, 1997); SR J/S (Manatee, 2000, 2001); USNM 360586 (Cat, 2000); SR J/S (Cat, 2000, 2001); USNM 347372 (Manatee, 1997); USNM 347364 (Manatee, 1997); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 95947 (Glovers Reef).

Hypoplectrus unicolor (Walbaum, 1792) — butter hamlet
Barrier Reef: USNM 327574 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Mid-Shelf: USNM 360641 (SE Lagoon, 2000); SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001); SR J/S (Elbow, 2001).
Pelican Cays: USNM 360646 (Little Cat, 2000); SR J/S (Cat 2000); SR J/S (Little Cat, 2000); SR CLS (Cat, 1997); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 95775 (Placentia).
Offshore Banks: FMNH 95770 (Glovers Reef); FMNH 95771 (Turneffe); SR CLS and JCT (Glovers Reef, 1988).

Hypoplectrus "blueback hybrid?"
Mid-Shelf: SR J/S (Elbow, 2001).

Liopropoma carmabi (Randall, 1963) — candy basslet
Offshore Banks: FMNH 70945 (Glovers Reef).

Liopropoma mowbrayi Woods and Kanazawa, 1951 — cave bass
Barrier Reef: USNM 267786 (Carrie Bow).
Offshore Banks: FMNH 95669 (Glovers Reef); FMNH 95673 (Lighthouse).

Liopropoma rubre Poey, 1861 — peppermint bass
Barrier Reef: USNM 267787, FMNH 95600 (Carrie Bow); FMNH 95618 (Ambergris); AMNH 225020 (Carrie Bow).
Offshore Banks: FMNH 95602, 77757 (Glovers Reef); FMNH 95606 (Turneffe); FMNH 95597 (Lighthouse).

Mycteroperca bonaci (Poey, 1860) — black grouper
Pelican Cays: SR J/S (Kitten, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Mycteroperca phenax Jordan and Swain, 1884 — scamp (formerly cataloged as *M. falcata*)
Offshore Banks: FMNH 39714 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Mycteroperca tigris (Valenciennes, 1833) — tiger grouper
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Mycteroperca venenosa (Linnaeus, 1758) — yellowfin grouper
Barrier Reef: SR J/S (Carrie Bow, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Pseudogramma gregoryi (Breder, 1927) — reef bass
Barrier Reef: USNM 274897, FMNH 95398 (Carrie Bow); FMNH 95354 (Gallows Point); FMNH 95492 (Goff's); FMNH 95383 (Ambergris); FMNH 95370 (Sergeant's).
Offshore Banks: FMNH 95643 (Glovers Reef); FMNH 95371 (Turneffe); FMNH 90196 (Lighthouse) .

Rypticus bistrispinus (Mitchill, 1818) — freckled soapfish
Mid-Shelf: AMNH 223158 (Twin Cays shot hole).
Coastline Marine: FMNH 95451 (Belize City, Salt Creek approach channel).

Rypticus bornoi Beebe and TeeVan, 1928 — largespotted soapfish
Barrier Reef: USNM 321040 (Carrie Bow).
Pelican Cays: USNM 347375 (Manatee, 1997).

Rypticus randalli Courtenay, 1967 — Randall's soapfish
Coastline Marine: FMNH 95439 (Placentia); FMNH 95455 (Punta Gorda).

Rypticus saponaceus (Schneider, 1801) — greater soapfish
Offshore Banks: FMNH 95450 (Glovers Reef).

Rypticus subbifrenatus (Gill, 1861) — spotted soapfish
Barrier Reef: USNM 276231, FMNH 90188 (Carrie Bow); FMNH 95470 (Ambergris); FMNH 90174 (Gallows Point Reef); FMNH 95452 (Goff's); AMMNH 224971 (Carrie Bow).
Coastline Marine: FMNH 95454 (Punta Gorda).
Offshore Banks: FMNH 95445 (Glovers Reef); FMNH 95665 (Turneffe).

Serranus baldwini (Evermann and Marsh, 1899) — lantern bass
Barrier Reef: USNM 354564, FMNH 87967 (Carrie Bow); FMNH 95472 (Ambergris); AMNH 224994 (Carrie Bow).
Offshore Banks: FMNH 87962 (Glovers Reef); FMNH 95745 (Turneffe); SR CLS and JCT (Glovers Reef, 1988).

Serranus flaviventris (Cuvier, 1829) — two-spot bass (Figure 3)
Mid-Shelf: USNM 360485 (SE Lagoon, 2000); USNM 364874 (Quamino, 2001); SR J/S (Quamino, 2001); SR J/S (Elbow, 2001); FMNH 95726 (Blue Ground Range) .
Pelican Cays: USNM 347302 (Cat, 1997); USNM 360587 (Cat, 2000); USNM 360486 (Little Cat, 2000); USNM 364873 (Cat, 2001); SR J/S (Avicennia, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 95723 (Belize City); FMNH 95724 (Punta Gorda); FMNH 95722 (Frenchman's).

Serranus tabacarius (Cuvier, 1829) — tobacco fish
Barrier Reef: USNM 349079 (Carrie Bow); SR CLS (Carrie Bow, 2000); FMNH 95728 (English); FMNH 95730 (Ambergris).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001); SR J/S (Channel, 2001); SR J/S (Elbow, 2001).
Pelican Cays: USNM 347302 (Cat, 1997); USNM 360595 (Cat, 2000); SR J/S (Cat, 2000,2001); SR J/S (Manatee, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Co-Cat, 2001); SR J/S (Ridge, 2001); SR CLS (Cat, 1997).
Offshore Banks: FMNH 87986 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Serranus tigrinus (Bloch, 1790) — harlequin bass
Barrier Reef: USNM 276229, FMNH 87980 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 95704 (Ambergris); FMNH 95704 (Hol Chan).
Mid-Shelf: SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 87968 (Glovers Reef); FMNH 87985 (Turneffe); FMNH 87974 (Lighthouse); SR CLS and JCT (Glovers Reef, 1988).

Serranus tortugarum Longley, 1935 — chalk bass (Figure 4)
Barrier Reef: USNM 349231 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR J/S (Quamino, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347388 (Cat, 1997); USNM 360588 (Cat, 2000); SR JCT et al. (Cat 1995); USNM 360596 (Cat, 2000); USNM 347374 (Manatee, 1997); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Grammatidae

Gramma loreto Poey, 1868 — royal gramma
Barrier Reef: USNM 267803, FMNH 89438 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 95234 (English); FMNH 95254 (Hol Chan); FMNH 95255 (Ambergris); AMNH 225026 (Carrie Bow).
Offshore Banks: FMNH 95225 (Glovers Reef); FMNH 95235 (Turneffe); FMNH 89447 (Lighthouse); SR CLS and JCT (Glovers Reef, 1988).

Gramma melacara Böhlke and Randall, 1963 — blackcap basslet
Barrier Reef: USNM 317454 (Carrie Bow).
Offshore Banks: FMNH 95292 (Glovers Reef); FMNH 95299 (Turneffe); FMNH 89460 (Lighthouse); SR CLS and JCT (Glovers Reef, 1988).

Lipogramma anabantoides Böhlke, 1960 — dusky basslet
Barrier Reef: USNM 267783 (Carrie Bow); FMNH 95411 (English).
Offshore Banks: FMNH 95399 (Glovers Reef); FMNH 95418 (Turneffe).

Lipogramma trilineatum Randall, 1963 — threeline basslet
Barrier Reef: USNM 317479, FMNH 95406 (Carrie Bow).
Offshore Banks: FMNH 95409 (Glovers Reef).

Lobotidae

Lobotes surinamensis (Bloch, 1790) — tripletail (Figure 5).
Barrier Reef: Juvenile caught by C. Daniel Miller on 6 February 2001 (Carrie Bow).

Opistognathidae

Lonchopisthus micrognathus (Poey, 1860) — swordtail jawfish
Pelican Cays: USNM 347305 (Cat, 1997).

Opistognathus aurifrons (Jordan and Thompson, 1905) — yellowhead jawfish
Barrier Reef: USNM 327597 (Carrie Bow); SR CLS (Carrie Bow, 2000).
Offshore Banks: FMNH 82577 (Glovers Reef).

Opistognathus gilberti Böhlke, 1967 — yellow jawfish
Barrier Reef: USNM 287969 (Carrie Bow).

Opistognathus maxillosus Poey, 1860 — mottled jawfish
Barrier Reef: USNM 321014 (Carrie Bow).
Offshore Banks: FMNH 82581 (Glovers Reef).

Opistognathus whitehurstii (Longley, 1927) — dusky jawfish
Mid-Shelf: USNM 360605 (Spruce, 2000); USNM 365167 (Channel, 2001).
Pelican Cays: USNM 360498 (Cat, 2000); USNM 365168 (Cat, 2001).
Coastline Marine: FMNH 82580 (Frenchman's).

Priacanthidae

Heteropriacanthus cruentatus (Lacepède, 1801) — glasseye snapper
Barrier Reef: USNM 276154 (Carrie Bow); SR J/S (Carrie Bow, 2000); FMNH 89637 (Gallows Point).
Offshore Banks: FMNH 89491 (Glovers Reef).

Apogonidae

Apogon aurolineatus (Mowbray, 1927) — bridle cardinalfish
Barrier Reef: FMNH 86068 (Gallows Point).
Pelican Cays: USNM 347392 (Cat, 1997); USNM 360494 (Cat, 2000); USNM 364857 (Manatee, 2001).
Offshore Banks: FMNH 98091 (Glovers Reef); FMNH 98147 (Lighthouse).

Apogon binotatus (Poey, 1867) — barred cardinalfish
Barrier Reef: FMNH 98459 (Carrie Bow).
Mid-Shelf: USNM 360628 (Douglas, 2000); USNM 364858 (North Elbow, 2001).
Pelican Cays: USNM 347319 (Cat, 1997); USNM 360533 (Cat, 2000); USNM 360534 (Little Cat, 2000).
Coastline Marine: FMNH 98406 (Punta Gorda).
Offshore Banks: FMNH 98227 (Glovers Reef).

Apogon lachneri Böhlke, 1959 — whitestar cardinalfish
Barrier Reef: USNM 267803, FMNH 98260 (Carrie Bow); FMNH 97255 (Ambergris); FMNH 97207 (English); AMNH 22019 (Carrie Bow).
Offshore Banks: FMNH 97167 (Glovers Reef); FMNH 98385 (Turneffe); FMNH 98145 (Lighthouse).

Apogon leptocaulus Gilbert, 1972 — slendertail cardinalfish
Offshore Banks: FMNH 98356 (Glovers Reef).

Apogon maculatus (Poey, 1860) — flamefish
Barrier Reef: USNM 276174, FMNH 98831 (Carrie Bow); FMNH 98504 (Ambergris); SR J/S (Carrie Bow, 2001); FMNH 97237 (Sergeant's); FMNH 98055 (Gallows Point); FMNH 98392 (Goff's); FMNH 98504 (Ambergris); FMNH 98531 (Hol Chan).
Mid-Shelf: FMNH 98470 (Twin); USNM 365175 (Tarpum, 2001).
Coastline Marine: FMNH 97185 (Punta Gorda).
Offshore Banks: FMNH 98568 (Glovers Reef); FMNH 98388 (Turneffe).

Apogon mosavi Dale, 1977 — dwarf cardinalfish
Mid-Shelf: UF 10388 (Twin Cays shot hole).

Apogon phenax Böhlke and Randall, 1968 — mimic cardinalfish
Barrier Reef: FMNH 98829 (Carrie Bow); FMNH 98393 (English); FMNH 98535 (Ambergris).
Pelican Cays: USNM 347391 (Cat, 1997); USNM 360609 (Little Cat, 2000); USNM 365176 (Avicennia, 2001).
Offshore Banks: FMNH 98345, 98349 (Glovers Reef); FMNH 98580 (Turneffe); FMNH 98154 (Lighthouse).

Apogon pillionatus Böhlke and Randall, 1968 — broadsaddle cardinalfish
Offshore Banks: FMNH 97220 (Glovers Reef).

Apogon planifrons Longley and Hildebrand, 1940 — pale cardinalfish
Barrier Reef: FMNH 98465 (Carrie Bow); FMNH 98562 (Ambergris); AMNH 225075 (Carrie Bow).
Mid-Shelf: USNM 364859 (North Elbow, 2001).
Offshore Banks: FMNH 98570 (Glovers Reef); FMNH 98590 (Turneffe); FMNH 98149 (Lighthouse).

Apogon pseudomaculatus Longley, 1932 — twospot cardinalfish
Barrier Reef: USNM 349045 (Carrie Bow); FMNH 98395 (English).
Offshore Banks: FMNH 97180 (Glovers Reef).

Apogon quadrisquamatus Longley, 1934 — sawcheek cardinalfish
Barrier Reef: FMNH 98466 (Carrie Bow); FMNH 98546 (Ambergris).
Pelican Cays: USNM 347393 (Cat, 1997); USNM 360594 (Cat, 2000); USNM 364860 (Manatee, 2001).
Offshore Banks: FMNH 98241 (Glovers Reef).

Apogon robbyi Gilbert and Tyler, 1997 — lined cardinalfish
Barrier Reef: SR JCT (Carrie Bow).
Mid-Shelf: USNM 338013 (Twin Cays shot hole).

Apogon townsendi (Breder, 1927) — belted cardinalfish
Barrier Reef: USNM 349046, FMNH 97275 (Carrie Bow); FMNH 98505 (Ambergris); FMNH 98532 (Hol Chan); FMNH 98396 (English); AMNH 225023 (Carrie Bow).
Mid-Shelf: USNM 360629 (Douglas, 2000).
Offshore Banks: FMNH 97249, 98161 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 98389 (Turneffe); FMNH 97200 (Lighthouse).

Astrapogon alutus (Jordan and Gilbert, 1882) — bronze cardinalfish
Pelican Cays: USNM 347362 (Manatee, 1997).
Offshore Banks: FMNH 98574 (Turneffe).

Astrapogon puncticulatus (Poey, 1867) — blackfin cardinalfish
Barrier Reef: USNM 327993 (Carrie Bow); FMNH 98506 (Ambergris).
Mid-Shelf: FMNH 98379 (Robinson Point Cay).
Coastline Marine: FMNH 98400 (Punta Gorda).
Offshore Banks: FMNH 98347 (Glovers Reef); FMNH 98615 (Turneffe).

Astrapogon stellatus (Cope, 1867) — conchfish
Barrier Reef: FMNH 98317 (Carrie Bow); FMNH 98383 (Sergeant's); FMNH 98312 (Cay Caulker).
Pelican Cays: USNM 360569 (Cat, 2000).
Coastline Marine: FMNH 98402 (Punta Gorda).
Offshore Banks: FMNH 98230 (Glovers Reef); FMNH 98591 (Turneffe).

Phaeoptyx conklini (Silvester, 1915) — freckled cardinalfish
Barrier Reef: USNM 276141 (Carrie Bow); FMNH 98468 (Carrie Bow); FMNH 98507 (Ambergris); FMNH 98534 (Hol Chan); FMNH 98391 (Goff's); FMNH 98384 (Sergeant's); FMNH 98054 (Gallows Point Reef); AMNH 225076 (Carrie Bow).
Mid-Shelf: USNM 360626 (Douglas, 2000); USNM 365171 (North Elbow, 2001).

Coastline Marine: FMNH 97265 (Belize City); FMNH 98404 (Punta Gorda).
Offshore Banks: FMNH 98346 (Glovers Reef); FMNH 98583 (Turneffe); FMNH 98146 (Lighthouse).

Phaeoptyx pigmentaria (Poey, 1860) — dusky cardinalfish
Barrier Reef: USNM 267807, FMNH 98830, 98239 (Carrie Bow); AMNH 225085 (Carrie Bow).
Mid-Shelf: USNM 360627 (Douglas, 2000); USNM 365172 (North Elbow, 2001).
Pelican Cays: USNM 347318 (Cat, 1997); USNM 347465 (Cat, 1997).
Offshore Banks: FMNH 98572 (Glovers Reef); FMNH 98387 (Turneffe); FMNH 98155 (Lighthouse).

Phaeoptyx xenus (Böhlke and Randall, 1968) — sponge cardinalfish
Barrier Reef: FMNH 329553 (Carrie Bow); FMNH 98398 (English); FMNH 98559 (Ambergris); FMNH 98056 (Gallows Point Reef).
Mid-Shelf: USNM 360642 (SE Lagoon, 2000); USNM 365174 (Channel, 2001).
Pelican Cays: USNM 347394 (Cat, 1997); USNM 360484 (Cat, 2000); USNM 365169 (Cat, 2001); USNM 360508 (Little Cat, 2000); USNM 365170 (Ridge, 2001); USNM 365173 (Manatee, 2001).
Coastline Marine: FMNH 98399 (Punta Gorda); FMNH 98162 (Frenchman's).
Offshore Banks: FMNH 98828 (Glovers Reef); FMNH 98612 (Turneffe); FMNH 98152 (Lighthouse).

Malacanthidae
Malacanthus plumieri (Bloch, 1786) — sand tilefish
Barrier Reef: USNM 349069 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 225686 (Carrie Bow).
Offshore Banks: FMNH 89485 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Echeneidae
Echeneis naucrates Linnaeus, 1758 — sharksucker
Barrier Reef: SR J/S (Carrie Bow 2000).
Coastline Marine: AMNH 83639 (Bahia de Amatique).

Carangidae
Carangoides bartholomaei Cuvier, 1833 — yellow jack
Mid-Shelf: SR RSJ (Lagoon, 2000); SR J/S (Quamino, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 89506 (Belize City).

Carangoides ruber (Bloch, 1793) — bar jack
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Channel, 2001); SR J/S (Elbow, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2000); SR CLS (Cat, 1997); SR J/S (Kitten, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39813 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Caranx crysos (Mitchill, 1815) — blue runner
Pelican Cays: SR RSJ (Cat, 2000).

Caranx hippos (Linnaeus, 1766) — crevalle jack
Mid-Shelf: SR J/S (Quamino, 2001).
Coastline Marine: FMNH 89507 (Belize City).

Caranx latus Agassiz, 1831 — horse-eye jack
Pelican Cays: SR CLS (Cat, 1997).
Coastline Marine: FMNH 89504 (Belize City); FMNH 77697 (South Lagoon).
Offshore Banks: FMNH 39717 (Glovers Reef.); SR CLS and JCT (Glovers Reef, 1988).

Chloroscombrus chrysurus (Linnaeus, 1766) — Atlantic bumper
Coastline Marine: AMNH 83654 (Bahia de Amatique).

Decapterus macarellus (Cuvier, 1833) — mackerel scad
Barrier Reef: USNM 327581 (Carrie Bow).
Mid-Shelf: SR RSJ (Quamino, 2001).
Pelican Cays: SR RSJ (Manatee, 2001).

Oligoplites saurus (Bloch and Schneider, 1801) — leatherjack
Coastline Marine: FMNH 89505 (Belize City); FMNH 77540 (South Lagoon).

Selar crumenophthalmus (Block, 1793) — bigeye scad
Offshore Banks: FMNH 89502 (Glovers Reef).

Selene vomer (Linnaeus, 1758) — lookdown
Coastline Marine: FMNH 89508 (Belize City).

Trachinotus falcatus (Linnaeus, 1758) — permit
Mid-Shelf: SR RSJ (Quamino, 2001).
Pelican Cays: USNM 360524 (Co-Cat, 2000).

Coastline Marine: FMNH 89503 (Belize City).

Lutjanidae

Lutjanus analis (Cuvier, 1828) — mutton snapper
Barrier Reef: SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Channel, 2001); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 77720 (Belize City).
Offshore Banks: FMNH 39721 (Glovers Reef).

Lutjanus apodus (Walbaum, 1792) — schoolmaster
Barrier Reef: USNM 356238 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 84542 (Ambergris).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Elbow, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 346463 (Manatee, 1997); USNM 360521 (Co-Cat, 2000); SR J/S (Manatee, 2000); SR J/S (Cat, 2000); SR J/S (Little Cat, 2000); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001); SR J/S (Avicennia, 2001).
Coastline Marine: UF 206781 (Belize City); FMNH 103789 (Southern Lagoon).
Offshore Banks: FMNH 39820 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Lutjanus buccanella (Cuvier, 1828) — blackfin snapper
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Lutjanus cyanopterus (Cuvier, 1828) — cubera snapper
Pelican Cays: SR CLS (Cat, 1997).

Lutjanus griseus (Linnaeus, 1758) — gray snapper
Barrier Reef: USNM 327582 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR J/S (Elbow, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); USNM 347351 (Manatee, 1997); SR J/S (Avicennia, 2001).
Coastline Marine: FMNH 89644 (Belize City); FMNH 77845 (Southern Lagoon).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Lutjanus jocu (Bloch and Schneider, 1801) — dog snapper
Barrier Reef: SR CLS (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: SR CLS (Cat, 1997); SR J/S (Cat, 2000); SR J/S (Little Cat, 2000); SR J/S (Avivennia, 2001).
Coastline Marine: FMNH 103788 (Belize City).
Offshore Banks: FMNH 104657 (Glovers Reef).

Lutjanus mahogoni (Cuvier, 1828) — mahogany snapper
Barrier Reef: USNM 349068 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 224984 (Carrie Bow).
Mid-Shelf: SR J/S (Quamino, 2001).

Lutjanus synagris (Linnaeus, 1758) — lane snapper
Barrier Reef: USNM 356240 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Channel, 2001); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001).
Pelican Cays: USNM 347303 (Cat, 1997); SR J/S (Cat, 2000); USNM 360522 (Co-Cat, 2000); USNM 347352 (Manatee, 1997); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 77748 (Belize City); AMNH 83642 (Bahia de Amatique).
Offshore Banks: FMNH 89639 (Glovers Reef).

Ocyurus chrysurus (Bloch, 1791) — yellowtail snapper
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); USNM 347354 (Manatee, 1997); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 89650 (Belize City).
Offshore Banks: FMNH 39736 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Haemulidae
Anisotremus virginicus (Linnaeus, 1758) — porkfish
Barrier Reef: USNM 343869 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).

Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Elbow, 2001); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001); SR J/S (Channel, 2001).
Pelican Cays: USNM 360496 (Little Cat, 2000); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Kitten, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 104661 (Punta Gorda).

Haemulon aurolineatum Cuvier, 1830 — tomtate
Barrier Reef: USNM 349060 (Carrie Bow, 2001); AMNH 224986 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001);
Pelican Cays: USNM 347390 (Cat, 1997); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Kitten, 2001); SR J/S (Acicennia, 2001).
Offshore Banks: FMNH 104660 (Glovers Reef).

Haemulon carbonarium Poey, 1860 — caesar grunt
Barrier Reef: SR J/S (Carrie Bow, 2000).
Pelican Cays: SR J/S (Cat, 2000).

Haemulon chrysargyreum Günther, 1859 — smallmouth grunt
Barrier Reef: USNM 349061 (Carrie Bow); SR J/S (Carrie Bow, 2000).

Haemulon flavolineatum (Desmarest, 1823) — French grunt (Figure 6)
Barrier Reef: USNM 327584 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); ANMH 224992.
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347356 (Manatee, 1997); SR J/S (Manatee, 2000, 2001); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39815 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Haemulon macrostomum Günther, 1859 — Spanish grunt
Barrier Reef: SR J/S (Carrie Bow, 2000).
Mid-Shelf: RD (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Manatee, 2000).

Haemulon parra (Desmarest, 1823) — sailors choice
Barrier Reef: SR RSJ (Carrie Bow, 2001).

Haemulon plumieri (Lacepède, 1801) — white grunt
Barrier Reef: USNM 327585 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001).
Pelican Cays: USNM 347355 (Manatee, 1997); USNM 360495 (Cat, 2000); USNM 365186 (Fisherman's, 2001); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39764 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Haemulon sciurus (Shaw, 1803) — bluestriped grunt
Barrier Reef: USNM 327583 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 83090 (Ambergris); AMNH 224998 (Carrie Bow) .
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 346464, 348658 (Manatee, 1997); SR J/S (Cat, 2000); SR J/S (Manatee, 2000, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39809 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Gerreidae

Diapterus rhombeus (Cuvier, 1830) — silver mojarra
Coastline Marine: FMNH 71370 (Belize City); FMNH 77645 (Southern Lagoon); AMNH 83632 (Bahia de Amatique).

Eucinostomus argenteus Baird and Girard, 1855 — spotfin mojarra
Barrier Reef: FMNH 104685 (South Water); FMNH 104683 (Cay Caulker); AMNH 224969 (Carrie Bow).
Mid-Shelf: USNM 360602 (Spruce, 2000); USNM 365188 (unnamed sand spit between Spruce and Wee Wee, 2001).
Pelican Cays: USNM 346458 (Manatee, 1997); USNM 360519 (Co-Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 77654 (Belize City); FMNH 104621 (Placentia); FMNH 103784 (Pelican Beach, Dangriga); FMNH 77648 (Southern Lagoon).
Offshore Banks: FMNH 77650 (Glovers Reef).

Eucinostomus lefroyi (Goode, 1874) — mottled mojarra
Barrier Reef: AMNH 224970 (Carrie Bow).

Eucinostomus gula (Quoy and Gaimard, 1824) — silver jenny
Barrier Reef: FMNH 104687 (Cay Caulker).
Pelican Cays: USNM 347366 (Manatee, 1997).
Coastline Marine: FMNH 77704 (Belize City); FMNH 77646 (Southern Lagoon).

Eucinostomus melanopterus (Bleeker, 1863) — flagfin mojarra
Coastline Marine: FMNH 104623 (Belize City); FMNH 104688 (Pelican Beach, Dangriga); FMNH 77661 (Southern Lagoon).

Eugerres plumieri (Cuvier, 1830) — striped mojarra
Coastline Marine: FMNH 71369 (Belize City).

Gerres cinereus (Walbaum, 1792) — yellowfin mojarra
Barrier Reef: USNM 343870 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 104630 (St.Georges).
Mid-Shelf: AMNH 225062 (Twin).
Coastline Marine: FMNH 104629 (Belize City); FMNH 104631 (Placentia).
Offshore Banks: FMNH 104628 (Glovers Reef).

Inermiidae
Inermia vittata Poey, 1860 — boga
Barrier Reef: USNM 319705 (Carrie Bow).

Sparidae
Archosargus probatocephalus (Walbaum, 1792) — sheepshead
Pelican Cays: SR CLS (Cat, 2000).
Coastline Marine: FMNH 77758 (Belize City); FMNH 103768 (Southern Lagoon).

Archosargus rhomboidalis (Linnaeus, 1758) — sea bream
Coastline Marine: FMNH 77761 (Belize City).

Calamus bajonado (Bloch and Schneider, 1801) — jolthead porgy
Offshore Banks: FMNH 39715 (Glovers Reef).

Calamus calamus (Valenciennes, 1830) — saucereye porgy
Barrier Reef: USNM 343864 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR RSJ (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Elbow, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR RSJ (Cat, 2000); SR RSJ (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001).

Calamus penna (Valenciennes, 1830) — sheepshead porgy
Coastline Marine: FMNH 89648 (Belize City).

Calamus pennatula Guichenot, 1868 — pluma porgy
Barrier Reef: SR RSJ (Carrie Bow, 2000).

Calamus proridens Jordan and Gilbert, 1844 — littlehead porgy
Offshore Banks: FMNH 39734 (Glovers Reef).

Sciaenidae

Bairdiella ronchus (Cuvier, 1830) — ground croaker
Coastline Marine: FMNH 77867 (Belize City); FMNH 103764 (Dangriga); FMNH 89664 (Southern Lagoon).

Cynoscion leiarchus (Cuvier, 1830) — smooth weakfish
Coastline Marine: FMNH 104666 (Belize City).

Equetus lanceolatus (Linnaeus, 1758) — jackknife-fish
Pelican Cays: USNM 365187 (Fisherman's, 2001); SR CLS (Little Cat, 2000).

Equetus punctatus (Bloch and Schneider, 1801) — spotted drum
Barrier Reef: USNM 349058 (Carrie Bow).
Mid-Shelf: SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001); SR J/S (Elbow, 2001).

Larimus breviceps Cuvier, 1830 — shorthead drum
Coastline Marine: AMNH 83652 (Bahia de Amatique).

Odontoscion dentex (Cuvier, 1830) — reef croaker
Barrier Reef: FMNH 77869 (Gallows Point Reef).
Mid-Shelf: USNM 360624 (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 104665 (Belize City).

Ophioscion punctatissimus Meek and Hildebrand, 1925 — dotted croaker
Coastline Marine: AMNH 83649 (Bahia de Amatique).

Stellifer colonensis Meek and Hildebrand, 1925— stardrum
Coastline Marine: FMNH 83839 (Belize City); FMNH 83840 (Dangriga).

Mullidae

Mulloidichthys martinicus (Cuvier, 1829) — yellow goatfish
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001).
Offshore Banks: FMNH 39724 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Pseudupeneus maculatus (Bloch, 1793) — spotted goatfish
Barrier Reef: USNM 327587 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: USNM 360603 (Spruce, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 104664 (Belize City).
Offshore Banks: FMNH 77848 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Pempheridae

Pempheris schomburgkii Müller and Troschel, 1848 — glassy sweeper
Barrier Reef: USNM 276232 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 93773 (Sergeant's).
Coastline Marine: FMNH 93774 (Punta Gorda).
Offshore Banks: FMNH 93772 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Kyphosidae

Kyphosus sectator (Linnaeus, 1758) — Bermuda chub
This species is difficult to distinguish from *Kyphosus incisor*, the yellow chub, and sight records may be unreliable.
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001).
Pelican Cays: SR J/S (Kitten, 2001).
Offshore Banks: FMNH 39862 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Polynemidae

Polydactylus virginicus (Linnaeus, 1758) — barbu
Barrier Reef: USNM 349277 (Carrie Bow, 2000).
Coastline Marine: FMNH 77750 (Belize City); FMNH 94868 (Pelican Beach, Dangriga).

Cirrhitidae

Amblycirrhitus pinos (Mowbray, 1927) — redspotted hawkfish
Barrier Reef: USNM 274917, FMNH 89679 (Carrie Bow).

Offshore Banks: FMNH 89662 (Glovers Reef).

Chaetodontidae

Prognathodes aculeatus (Poey, 1860) — longsnout butterflyfish
Offshore Banks: FMNH 104667 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Chaetodon capistratus Linnaeus, 1758 — foureye butterflyfish
Barrier Reef: USNM 327588 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 83086 (Ambergris).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347361 (Manatee, 1997); USNM 360571 (Cat, 2000, 2001); SR J/S (Cat, 2000); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 70949 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Chaetodon ocellatus Bloch, 1787 — spotfin butterflyfish
Barrier Reef: USNM 349051 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Little Cat, 2000); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Chaetodon striatus Linnaeus 1758 — banded butterflyfish
Barrier Reef: USNM 327589 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Pelican Cays: SR JCT et al. (Cat, 1995).
Offshore Banks: FMNH 39810 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Pomacanthidae

Centropyge argi Woods and Kanazawa, 1951 — cherubfish
Barrier Reef : SR CLS (seen at Carrie Bow in rubble nest of *Malacanthus*).

Holacanthus ciliaris (Linnaeus, 1758) — queen angelfish
Barrier Reef: USNM 327591 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: UF 27751 (Blue Ground Range); SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Tarpum, 2001); SR J/S (Quamino, 2001).

Pelican Cays: SR J/S (Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Holacanthus tricolor (Bloch, 1795) — rock beauty
Barrier Reef: USNM 343868 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Pomacanthus arcuatus (Linnaeus, 1758) — gray angelfish
Barrier Reef: USNM 327590 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); UF 27757 (Blue Ground Range); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR JCT et al. (Cat, 1995); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Pomacanthus paru (Bloch, 1787) — French angelfish
Barrier Reef: SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR J/S (Douglas, 2000).
Pelican Cays: SR J/S (Kitten, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Cichlidae

Cichlasoma urophthalmum (Günther, 1862) — Mayan cichlid
Barrier Reef: FMNH 104565 (Ambergris); FMNH 97681 (St. George's).
Mid-Shelf: SR WPD (Twin, 2001).
Coastline Marine: FMNH 83142 (Belize City); FMNH 83151 (Southern Lagoon).

Pomacentridae

Abudefduf saxatilis (Linnaeus, 1758) — sergeant major
Barrier Reef: USNM 349037 (Carrie Bow); FMNH 84932 (South Water); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 86562 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Abudefduf taurus (Müller and Troschel, 1848) — night sergeant
Barrier Reef: SR J/S (Carrie Bow, 2000).

Chromis cyanea (Poey, 1860) — blue chromis
Barrier Reef: USNM 267799 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 225078 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000).
Pelican Cays: SR JCT et al. (Cat, 1995).
Offshore Banks: FMNH 70954 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Chromis insolata (Cuvier, 1830) — sunshinefish
Barrier Reef: USNM 267797 (Carrie Bow); SR J/S (Carrie Bow, 2001); AMNH 225022 (Carrie Bow).
Offshore Banks: FMNH 89492 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Chromis multilineata (Guichenot, 1853) — brown chromis
Barrier Reef: USNM 327592 (Carrie Bow); SR RSJ (Carrie Bow, 2000).

Microspathodon chrysurus (Cuvier, 1830) — yellowtail damselfish
Barrier Reef: USNM 276059 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Offshore Banks: FMNH 89641 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Stegastes adustus (Troschel, 1865) — dusky damselfish
Barrier Reef: USNM 276062 (Carrie Bow); FMNH 86589 (Gallows Point Reef); USNM 365037 (3.1 mi. south of Carrie Bow, 2001); SR RSJ (Carrie Bow, 2000); SR J/S (Carrie Bow, 2001).
Mid-Shelf: USNM 360631 (Douglas, 2000); USNM 365180 (North Elbow, 2001).
Offshore Banks: FMNH 86590 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Stegastes diencaeus (Jordan and Rutter, 1897) — longfin damselfish
Barrier Reef: USNM 276038 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: USNM 365181 (North Elbow, 2001).
Pelican Cays: USNM 360570 (Cat, 2000); SR J/S (Little Cat, 2000).
Offshore Banks: FMNH 86580 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Stegastes leucostictus (Müller and Troschel, 1848) — beaugregory
Barrier Reef: USNM 306516, FMNH 86598 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 86132 (Gallows Point Reef); AMNH 224961 (Carrie Bow).
Mid-Shelf: USNM 360634 (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).

Pelican Cays: USNM 360589 (Cat, 2000); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39589 (Glovers Reef).

Stegastes partitus (Poey, 1868) — bicolor damselfish
Barrier Reef: USNM 267796 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 86632 (Gallows Point Reef); AMNH 224983 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Quamino, 2001).
Pelican Cays: USNM 347320 (Cat, 1997); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 86639 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Stegastes planifrons (Cuvier, 1830) — threespot damselfish
Barrier Reef: USNM 276034 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 86650 (Buttonwood); AMNH 84543 (Ambergris).
Mid-Shelf: USNM 360632 (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 86647 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Stegastes variabilis (Castelnau, 1855) — cocoa damselfish
Barrier Reef: USNM 327596 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 84326 (Carrie Bow).
Mid-Shelf: USNM 360578 (Douglas, 2000); SR J/S (Channel, 2001); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347321 (Cat, 1997); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 71314 (Glovers Reef).

Labridae

Bodianus rufus (Linnaeus, 1758) — Spanish hogfish
Barrier Reef: USNM 276204 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Clepticus parrae (Bloch and Schneider, 1801) — creole wrasse
Barrier Reef: USNM 327600 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Doratonotus megalepis Günther, 1862 — dwarf wrasse
Barrier Reef: USNM 353543 (Carrie Bow); USNM 364872 (3.1 mi. south of Carrie Bow, 2001).
Offshore Banks: FMNH 89684 (Glovers Reef).

Halichoeres bivittatus (Bloch, 1791) — slippery dick
Barrier Reef: USNM 327599 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347322 (Cat, 1997); USNM 360492 (Cat, 2000); USNM 360520 (Co-Cat, 2000); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 70925 (Glovers Reef); FMNH 39765 (Lighthouse); SR CLS and JCT (Glovers Reef, 1988).

Halichoeres cyanocephalus (Bloch, 1791) — yellowcheek wrasse (Figure 7)
Barrier Reef: SR with photograph by CLS (Carrie Bow, 1988).

Halichoeres garnoti (Valenciennes, 1839) — yellowhead wrasse
Barrier Reef: USNM 274926 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 225084 (Carrie Bow).
Mid-Shelf: SR J/S (Channel, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Little Cat, 2000); SR J/S (Kitten, 2001).
Offshore Banks: FMNH 70998 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Halichoeres maculipinna (Müller and Troschel, 1848) — clown wrasse
Barrier Reef: USNM 329838 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 224975 (Carrie Bow).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Halichoeres pictus (Poey, 1860) — rainbow wrasse
Barrier Reef: USNM 306536 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Halichoeres poeyi (Steindachner, 1867) — blackear wrasse
Barrier Reef: SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Kitten, 2001).

Halichoeres radiatus (Linnaeus, 1758) — puddingwife
Barrier Reef: USNM 327598 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Offshore Banks: FMNH 39733 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Halichoeres sp. nov — schooling wrasse (Figure 8)
This species is being described by J. Randall and P. Lobel. It resembles the non-supermale form of *H. pictus* and was so recorded in our notes for 2000.
Mid-Shelf: SR J/S (Lagoon, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347385 (Manatee 1997); USNM 347274 (Cat, 1997); USNM 360487 (Cat, 2000); USNM 360488 (Cat, 2000); USNM 360489 (Little Cat, 2000); USNM 365182 (Avicennia, 2001); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Lachnolaimus maximus (Walbaum, 1792) — hogfish
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001); AMNH 93323 (Carrie Bow).
Mid-Shelf: SR J/S (Tarpum, 2001).
Pelican Cays: SR JCT et al. (Cat, 1995); SR J/S (Cat, 2000); SR J/S (Kitten, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Thalassoma bifasciatum (Bloch, 1791) — bluehead
Barrier Reef: USNM 276237 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 89683 (Gallows Point Reef); AMNH 83087 (Ambergris); AMNH 225077 (Carrie Bow).
Offshore Banks: FMNH 71001 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Xyrichtys novacula (Linnaeus, 1758) — pearly razorfish
Barrier Reef: USNM 349220 (Carrie Bow).
Mid-Shelf: SR RSJ (Twin Cays shot hole, 2000).

Scaridae

Cryptotomus roseus Cope, 1871 — bluelip parrotfish
Barrier Reef: USNM 353878 (Carrie Bow).

Scarus coelestinus Valenciennes, 1840 — midnight parrotfish
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Scarus coeruleus (Bloch, 1786) — blue parrotfish
Offshore banks: SR CLS and JCT (Glovers Reef, 1988).

Scarus guacamaia Cuvier, 1829 — rainbow parrotfish
Offshore Banks: FMNH 39755 (Glovers Reef).

Scarus iserti (Bloch, 1789) — striped parrotfish (formerly *S. croicensis*) (Figures 9, 10, 11)
Barrier Reef: USNM 349137 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: USNM 360597 (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347323 (Cat, 1997); USNM 347384 (Manatee, 1997); USNM 347350 (Manatee, 1997); USNM 360572 (Cat, 2000); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 89642 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Scarus taeniopterus Desmarest, 1831 — princess parrotfish
Barrier Reef: SR J/S (Carrie Bow, 2000).
Pelican Cays: USNM 347411 (Cat, 1997).

Scarus vetula Bloch and Schneider, 1801 — queen parrotfish
Barrier Reef: USNM 306488 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 93322 (Carrie Bow).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Sparisoma aurofrenatum (Valenciennes, 1840) — redband parrotfish
Barrier Reef: USNM 306544 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 224997 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Manatee, 2000, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Sparisoma chrysopterum (Bloch and Schneider, 1801) — redtail parrotfish
Barrier Reef: USNM 274910 (Carrie Bow); USNM 365377 (3.1 mi. south of Carrie Bow, 2001); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 360573 (Cat, 2000); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39727 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Sparisoma radians (Valenciennes, 1840) — bucktooth parrotfish
Barrier Reef: FMNH 89636 (Gallows Point Reef).
Mid-Shelf: SR J/S (Elbow, 2001).
Pelican Cays: USNM 365376 (Fisherman's, 2001); SR J/S (Ridge, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Sparisoma rubripinne (Valenciennes in Cuvier and Valenciennes, 1840) — redfin parrotfish
Barrier Reef: SR J/S (Carrie Bow, 2000, 2001); AMNH 224995 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000).
Pelican Cays: SR J/S (Cat, 2000); SR CLS (Manatee, 2000); SR J/S (Co-Cat, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Sparisoma viride (Bonnaterre, 1788) — stoplight parrotfish
Barrier Reef: USNM 306491 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 224962 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000); SR J/S (Little Cat, 2000); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39730 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Tripterygiidae

Enneanectes altivelis Rosenblatt, 1960 — lofty triplefin

Barrier Reef: USNM 274894, FMNH 89349 (Carrie Bow); FMNH 89403 (Gallows Point); FMNH 94317 (Sergeant's); FMNH 94038 (Hol Chan); FMNH 94034 (Ambergris); AMNH 225074 (Carrie Bow).

Mid-Shelf: USNM 360302 (SE Lagoon, 2000); USNM 365158 (Quamino, 2001).

Offshore Banks: FMNH 86149, 90432 (Glovers Reef); FMNH 94327 (Turneffe).

Enneanectes atrorus Rosenblatt, 1960 — blackedge triplefin

Barrier Reef: USNM 274898 (Carrie Bow).

Mid-Shelf: USNM 360305 (SE Lagoon, 2000); USNM 364837 (North Elbow, 2001); USNM 364838 (Tarpum, 2001).

Offshore Banks: FMNH 86128, 90441 (Glovers Reef); FMNH 94381 (Turneffe); FMNH 86127 (Lighthouse).

Enneanectes boehlkei Rosenblatt, 1960 — roughhead triplefin

Barrier Reef: USNM 274930, FMNH 89288 (Carrie Bow); FMNH 86114 (Gallows Point); FMNH 90454 (Sergeant's); FMNH 90458 (Goff's); FMNH 94049 (Ambergris); AMNH 224996 (Carrie Bow).

Coastline Marine: FMNH 87894 (Punta Gorda).

Offshore Banks: FMNH 82590 (Glovers Reef); FMNH 90457 (Turneffe); FMNH 86112 (Lighthouse).

Enneanectes jordani (Evermann and Marsh, 1899) — mimic triplefin

Barrier Reef: FMNH 89363 (Carrie Bow); FMNH 86130 (Buttonwood).

Offshore Banks: FMNH 86129 (Glovers Reef).

Enneanectes pectoralis (Fowler, 1941) — redeye triplefin

Barrier Reef: USNM 276050, FMNH 89289 (Carrie Bow); FMNH 94052 (Ambergris); FMNH 90462 (Goff's); FMNH 86152 (Gallows Point).

Coastline Marine: FMNH 86155 (Placentia); FMNH 87901 (Punta Gorda); FMNH 86155 (Bugle); FMNH 86156 (Tarpon).

Offshore Banks: FMNH 86154 (Glovers Reef); FMNH 90461 (Turneffe); FMNH 86153 (Lighthouse).

Dactyloscopidae

Dactyloscopus tridigitatus Gill, 1859 — sand stargazer

Barrier Reef: FMNH 83919 (Carrie Bow).

Gillelus uranidea Böhlke, 1968 — warteye stargazer

Barrier Reef: USNM 274931, FMNH 83928 (Carrie Bow).

Mid-Shelf: USNM 360636 (Douglas, 2000); USNM 365164 (Quamino, 2001).
Offshore Banks: FMNH 83926 (Glovers Reef).

Platygillelus rubrocinctus (Longley, 1934) — saddle stargazer
Barrier Reef: USNM 276230, FMNH 93891 (Carrie Bow).
Offshore Banks: FMNH 93888 (Glovers Reef).

Labrisomidae
Labrisomus albigenys Beebe and Tee-Van, 1928 — whitecheek blenny
Barrier Reef: USNM 274924 (Carrie Bow); FMNH 93837 (Carrie Bow).

Labrisomus bucciferus Poey, 1868 — puffcheek blenny
Barrier Reef: USNM 329830, FMNH 89281 (Carrie Bow); FMNH 90376 (Sergeants); FMNH 90377 (Goff's); FMNH 94057 (Ambergris); AMNH 224957 (Carrie Bow).
Offshore Banks: FMNH 90374 (Glovers Reef); FMNH 89409 (Lighthouse).

Labrisomus filamentosus Springer, 1960 — quillfin blenny
Barrier Reef: USNM 328245 (Carrie Bow).

Labrisomus gobio (Valenciennes, 1836) — palehead blenny
Barrier Reef: USNM 321012, FMNH 89295 (Carrie Bow); FMNH 90387 (Sergeant's); FMNH 90388 (Goff's).
Mid-Shelf: USNM 360580 (Douglas, 2000); USNM 360301 (SE Lagoon, 2000); USNM 365163 (Tarpum, 2001).
Pelican Cays: USNM 360574 (Cat, 2000).
Offshore Banks: FMNH 77604 (Glovers Reef).

Labrisomus guppyi (Norman, 1922) — mimic blenny
Barrier Reef: USNM 276041, FMNH 89388 (Carrie Bow); FMNH 90396 (Sergeant's); FMNH 90398 (Goff's); FMNH 90472 (Ambergris); FMNH 70921 (Gallows Point Reef).
Mid-Shelf: USNM 346486 (Lagoon, 1997); USNM 364834 (Tarpum, 2001).
Offshore Banks: FMNH 90391, 77609 (Glovers Reef); FMNH 90397 (Turneffe); FMNH 77608 (Lighthouse).

Labrisomus haitiensis Beebe and Tee-Van, 1928 — longfin blenny
Barrier Reef: USNM 276040 (Carrie Bow); FMNH 90411 (English); FMNH 93853 (Carrie Bow); FMNH 94078 (Ambergris).
Mid-Shelf: USNM 360635 (Douglas, 2000); USNM 365161 (North Elbow, 2001); USNM 365162 (Tarpum, 2001).
Offshore Banks: FMNH 86044 (Glovers Reef); FMNH 90409 (Turneffe); FMNH 77614 (Lighthouse).

Labrisomus kalisherae (Jordan, 1904) — downy blenny
Barrier Reef: USNM 320996 (Carrie Bow).
Coastline Marine: FMNH 86051 (Placentia); FMNH 79293 (Punta Gorda).

Labrisomus nigricinctus Howell Rivero, 1936 — spotcheek blenny
Barrier Reef: USNM 327605, FMNH 89293 (Carrie Bow); FMNH 86026 (Gallows Point Reef).
Offshore Banks: FMNH 86053 (Glovers Reef).

Labrisomus nuchipinnis (Quoy and Gaimard, 1824) — hairy blenny
Barrier Reef: FMNH 90421 (South Water); FMNH 90424 (Carrie Bow); FMNH 90420 (Goff's); FMNH 90419 (Sergeant's); FMNH 94086 (Ambergris); AMNH 224964 (Carrie Bow).
Mid-Shelf: USNM 360579 (Douglas, 2000); USNM 364835 (sand spit between Spruce and Wee Wee, 2001); FMNH 90417 (Spanish).
Coastline Marine: FMNH 86060 (Placentia); FMNH 87830 (Punta Gorda).
Offshore Banks: FMNH 86058 (Glovers Reef); FMNH 94337 (Turneffe).

Malacoctenus aurolineatus Smith, 1957 — goldline blenny
Barrier Reef: USNM 317474, FMNH 89283 (Carrie Bow); FMNH 94089 (Ambergris); FMNH 90271 (Sergeant's); FMNH 90272 (Goff's); FMNH 77626 (Gallows Point Reef).
Offshore Banks: FMNH 85988 (Glovers Reef); FMNH 77621 (Lighthouse).

Malacoctenus boehlkei Springer, 1959 — diamond blenny
Barrier Reef: FMNH 89311 (Carrie Bow); FMNH 90278 (English); FMNH 94094 (Ambergris).
Pelican Cays: SR JCT et al. (Cat, 1995).
Coastline Marine: FMNH 86023 (Frenchman's).
Offshore Banks: FMNH 85981 (Glovers Reef); FMNH 90277 (Turneffe); FMNH 77622 (Lighthouse).

Malacoctenus delalandii (Valenciennes in Cuvier and Valenciennes, 1836) — banded blenny
Mid-Shelf: FMNH 90279 (Spanish).
Pelican Cays: USNM 360582 (Co-Cat, 2000).
Coastline Marine: FMNH 85986 (Belize City); FMNH 85984 (Placentia); FMNH 78146 (Punta Gorda).

Malacoctenus erdmani Smith, 1957— imitator blenny
Barrier Reef: FMNH 89285 (Carrie Bow); FMNH 94095 (Ambergris); FMNH 89411 (Gallows Point Reef); FMNH 90282 (Sergeant's); FMNH 90283 (Goff's).
Offshore Banks: FMNH 90281 (Glovers Reef).

Malacoctenus gilli (Steindachner, 1867) — dusky blenny
Barrier Reef: FMNH 90289 (South Water); FMNH 94101 (Ambergris); FMNH 89299 (Carrie Bow); FMNH 90291 (Sergeant's).
Pelican Cays: USNM 360527 (Co-Cat, 2000); USNM 364847 (Cat, 2001).
Coastline Marine: FMNH 85991 (Placentia); FMNH 78150 (Punta Gorda).
Offshore Banks: FMNH 85993 (Glovers Reef); FMNH 94338 (Turneffe); FMNH 77624 (Lighthouse).

Malacoctenus macropus (Poey, 1868) — rosy blenny
Mid-Shelf: USNM 346487 (Lagoon, 1997); USNM 360312 (Spruce, 2000); USNM 360311 (SE Lagoon, 2000); USNM 365165 (Channel, 2001); FMNH 93856 (Blue Ground Range); USNM 365375 (North Elbow, 2001); SR J/S (Elbow, 2001).
Pelican Cays: USNM 344847 (Cat, 1997); USNM 346460 (Manatee, 1997); USNM 360528 (Co-Cat, 2000); USNM 360575 (Cat, 2000); USNM 364848 (Fisherman's 2001); USNM 365166 (Cat, 2001); SR CLS (Manatee, 2000).
Coastline Marine: FMNH 78155 (Punta Gorda); FMNH 94339 (Northern Lagoon); FMNH 86005 (Tarpon).
Offshore Banks: FMNH 90290, 77620 (Glovers Reef); FMNH 94351 (Turneffe).

Malacoctenus triangulatus Springer, 1959 — saddled blenny
Barrier Reef: USNM 274938 (Carrie Bow); FMNH 89299 (Carrie Bow); FMNH 94109 (Ambergris); FMNH 70922 (Gallows Point Reef); FMNH 86000 (Buttonwood); FMNH 90298 (Goff's); SR RSJ (Carrie Bow, 2000, 2001).
Mid-Shelf: USNM 364850, 365374 (North Elbow, 2001).
Pelican Cays: SR J/S (Manatee, 2000).
Coastline Marine: FMNH 85999 (Placentia); FMNH 79217 (Punta Gorda).
Offshore Banks: FMNH 85997 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 90297 (Turneffe); FMNH 86067 (Lighthouse).

Malacoctenus versicolor (Poey, 1876) — barfin blenny
Barrier Reef: USNM 349071 (Carrie Bow).
Mid-Shelf: USNM 364849 (Quamino, 2001) .
Pelican Cays: USNM 360306 (Co-Cat, 2000).

Paraclinus barbatus Springer, 1955 — goatee blenny
Barrier Reef: USNM 267819 (Carrie Bow); FMNH 94019 (Ambergris).
Offshore Banks: FMNH 90299 (Glovers Reef); FMNH 94401 (Turneffe).

Paraclinus cingulatus (Evermann and Marsh, 1899) — coral blenny
Barrier Reef: USNM 306528 (Carrie Bow); FMNH 90305 (Sergeant's); FMNH 90304 (Goff's).
Offshore Banks: FMNH 90302 (Glovers Reef).

Paraclinus fasciatus (Steindachner, 1876) — banded blenny
Barrier Reef: FMNH 94117 (Ambergris).
Mid-Shelf: FMNH 93858 (Blue Ground Range); USNM 364844 (North Elbow, 2001).
Pelican Cays: USNM 346459 (Manatee, 1997).
Coastline Marine: FMNH 90306 (Belize City); FMNH 86030 (Placentia); FMNH 87834 (Punta Gorda).
Offshore Banks: FMNH 87838 (Glovers Reef); FMNH 94373 (Turneffe).

Paraclinus infrons Böhlke, 1960 — bald blenny
Barrier Reef: USNM 267820, FMNH 89414 (Carrie Bow); FMNH 90311 (English); FMNH 94119 (Ambergris).
Pelican Cays: USNM 364845 (Avicennia, 2001).
Offshore Banks: FMNH 71116 (Glovers Reef); FMNH 94402 (Turneffe).

Paraclinus marmoratus (Steindachner, 1876) — marbled blenny
Barrier Reef: USNM 327607 (Carrie Bow).
Mid-Shelf: USNM 364846 (North Elbow, 2001).
Offshore Banks: FMNH 86027 (Glovers Reef).

Paraclinus naeorhegmis Böhlke, 1960 — surf blenny
Barrier Reef: FMNH 94020 (Ambergris).

Paraclinus nigripinnis (Steindachner, 1867) — blackfin blenny
Barrier Reef: USNM 354545, FMNH 90317 (Carrie Bow); FMNH 90314 (Spanish); FMNH 90315 (Sergeant's); FMNH 90316 (Goff's); FMNH 94123 (Ambergris); USNM 364843 (3.1 mi. south of Carrie Bow, 2001).
Mid-Shelf: USNM 360581 (Douglas, 2000); USNM 364842 (North Elbow, 2001); USNM 360465 (SE Lagoon, 2000); USNM 360466 (Spruce, 2000); USNM 364839 (sand spit between Spruce and Wee Wee, 2001); USNM 364840 (Channel, 2001).
Pelican Cays: USNM 347315 (Cat, 1997); USNM 360529 (Co-Cat, 2000); USNM 364841 (Cat, 2001).
Coastline Marine: FMNH 86038 (Placentia); FMNH 87846 (Punta Gorda).

Offshore Banks: FMNH 86034 (Glovers Reef); FMNH 94396 (Turneffe); FMNH 86033 (Lighthouse).

Starksia atlantica Longley, 1934 — smootheye blenny

Barrier Reef: USNM 274892, FMNH 89298 (Carrie Bow); FMNH 89405 (Gallows Point Reef); FMNH 94129 (Ambergris); FMNH 94128 (Hol Chan).

Pelican Cays: USNM 364832 (Ridge, 2001).

Offshore Banks: FMNH 90336 (Glovers Reef); FMNH 94334 (Turneffe); FMNH 77630 (Lighthouse).

Starksia elongata Gilbert, 1971 — barred blenny

Barrier Reef: FMNH 89386 (Carrie Bow).

Offshore Banks: FMNH 90342 (Glovers Reef); FMNH 94335 (Turneffe).

Starksia sp. nov. — dice blenny (This allopatric sister species of *Starksia fasciata* is being described by J. Williams and J. Mount.)

Barrier Reef: USNM 349080 (Carrie Bow).

Starksia hassi Klausewitz, 1958 — ringed blenny

Offshore Banks: FMNH 86014 (Glovers Reef); FMNH 96872 (Turneffe).

Starksia lepicoelia Böhlke and Springer, 1961— blackcheek blenny

Barrier Reef: USNM 274922, FMNH 89296 (Carrie Bow); FMNH 94136 (Ambergris); AMNH 225081 (Carrie Bow).

Offshore Banks: FMNH 90347 (Glovers Reef); FMNH 90357 (Turneffe); FMNH 77702 (Lighthouse).

Starksia nanodes Böhlke and Springer, 1961 — dwarf blenny

Barrier Reef: FMNH 94568 (Carrie Bow); USNM 267824, FMNH 90366 (English); FMNH 94149 (Hol Chan); FMNH 94150 (Ambergris).

Offshore Banks: FMNH 90361, 86018 (Glovers Reef); FMNH 90365 (Turneffe).

Starksia occidentalis Greenfield, 1979 — barredlip blenny

Barrier Reef: USNM 321068 (Carrie Bow); FMNH 90367 (Sergeant's); FMNH 90304 (Goff's); FMNH 84385 (Gallows Point).

Mid-Shelf: USNM 360303 (Douglas, 2000); USNM 364604 (North Elbow, 2001); USNM 364829 (Quamino, 2001); USNM 360831 (Tarpum, 2001); USNM 360304 (SE Lagoon, 2000).

Pelican Cays: USNM 360310 (Little Cat, 2000); USNM 364603 (Fisherman's, 2001); USNM 364605 (Cat, 2001); USNM 364830 (Avicennia, 2001).

Coastline Marine: FMNH 84386 (Placentia); FMNH 87871 (Punta Gorda).

Starksia ocellata (Steindachner, 1876) — checkered blenny
Barrier Reef: USNM 276039 (Carrie Bow).

Starksia sluiteri (Metzelaar, 1919) — pallid blenny
Barrier Reef: USNM 317476, FMNH 89394 (Carrie Bow); FMNH 90421 (Ambergris); FMNH 90371 (Sergeant's); FMNH 90372 (Goff's); FMNH 86021 (Gallows Point).
Offshore Banks: FMNH 86022 (Glovers Reef).

Starksia starcki Gilbert, 1971 — key blenny
Barrier Reef: FMNH 93834 (Carrie Bow); FMNH 94024 (Ambergris).
Offshore Banks: FMNH 94023 (Glovers Reef).

Chaenopsidae

Acanthemblemaria aspera (Longley, 1927) — roughhead blenny (Figure 12)
Barrier Reef: USNM 274915, FMNH 89350 (Carrie Bow); FMNH 93967 (Ambergris); FMNH 86101 (Buttonwood).
Mid-Shelf: USNM 360308 (Douglas, 2000); USNM 360309 (SE Lagoon, 2000).
Pelican Cays: USNM 347316 (Cat, 1997); USNM 346461 (Manatee, 1997); USNM 344843 (Manatee, 1997); USNM 360307 (Manatee, 2000); SR JCT et al. (Cat, 1995).
Coastline Marine: FMNH 86099 (Placentia); FMNH 87908 (Punta Gorda); FMNH 86098 (Middle Snake).
Offshore Banks: FMNH 90482 (Glovers Reef); FMNH 90489 (Turneffe).

Acanthemblemaria greenfieldi Smith-Vaniz and Palacio, 1974 — stalk blenny
Barrier Reef: USNM 276042, FMNH 90862 (Carrie Bow); FMNH 93973 (Ambergris); FMNH 90492 (Sergeant's); FMNH 90495 (Goff's).
Pelican Cays: USNM 344841 (Manatee, 1997).
Offshore Banks: FMNH 90490 (Glovers Reef); FMNH 90494 (Turneffe).

Acanthemblemaria maria Böhlke, 1961 — secretary blenny
Barrier Reef: USNM 290670 (Carrie Bow).

Acanthemblemaria medusa Smith-Vaniz and Palacio, 1974 — medusa blenny
Barrier Reef: USNM 321071 (Carrie Bow).

Acanthemblemaria paula Johnson and Brothers, 1989 — dwarf spinyhead
Barrier Reef: USNM 290669, FMNH 89328 (Carrie Bow); FMNH 98295 (Ambergris); FMNH 107501 (Sergeant's); FMNH 86085 (Buttonwood).
Offshore Banks: FMNH 77558 (Glovers Reef).

Acanthemblemaria spinosa Metzelaar, 1919 — spinyhead blenny
Barrier Reef: USNM 308398 , FMNH 90864 (Carrie Bow); FMNH 90500 (Sergeant's); FMNH 93979 (Hol Chan).
Mid-Shelf: USNM 364600 (Quamino, 2001); USNM 364602 (Tarpum, 2001); USNM 364598 (North Elbow, 2001).
Pelican Cays: USNM 344842 (Manatee, 1997); USNM 364601 (ridge between Little Cat and Co-Cat, 2001).
Offshore Banks: FMNH 86087 (Glovers Reef); FMNH 90592 (Turneffe).

Chaenopsis limbaughi Robins and Randall, 1965 — yellowface pikeblenny
Mid-Shelf: AMNH 225006 (Twin Cays shot hole).

Chaenopsis ocellata (Poey, 1865) — bluethroat pikeblenny
Offshore Banks: FMNH 83930 (Glovers Reef).

Coralliozetus cardonae Evermann and Marsh, 1899 — twinhorn blenny
Barrier Reef: USNM 308441, FMNH 89395 (Carrie Bow); FMNH 94017 (Ambergris).

Emblemaria caldwelli Stephens, 1970 — Caribbean blenny
Barrier Reef: USNM 267823, FMNH 89303 (Carrie Bow); FMNH 93983 (Ambergris); FMNH 90509 (English).
Offshore Banks: FMNH 86069, 90505 (Glovers Reef); FMNH 94385 (Turneffe); FMNH 77589 (Lighthouse).

Emblemaria pandionis Evermann and Marsh, 1900 — sailfin blenny
Barrier Reef: USNM 308399 (Carrie Bow); SR J/S (Carrie Bow, 2000); FMNH 93989 (Ambergris); AMNH 220560 (Carrie Bow).
Offshore Banks: FMNH 90510, 82521 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Emblemaria piratula Ginsburg and Reid, 1942 — pirate blenny
Barrier Reef: USNM 296362 (Carrie Bow).

Emblemariopsis bahamensis Stephens, 1961 — blackhead blenny
Barrier Reef: USNM 317464 (Carrie Bow).

Emblemariopsis sp. nov. — redflag blenny (Figure 13) (This species is being described by J. Tyler and D. Tyler.)
Mid-Shelf: USNM 365355 (North Elbow, 2001); USNM 365365 (Blue Ground Range).
Pelican Cays: USNM 365356 (coral ridge between Little Cat and Co-Cat, 2001).

Emblemariopsis diaphana Longley, 1927— glass blenny
Offshore Banks: FMNH 108697 (Glovers Reef).

Emblemariopsis leptocirris Stephens, 1970 — thinfrill blenny
Barrier Reef: USNM 274928 (Carrie Bow); FMNH 89417 (Carrie Bow); FMNH 94801 (English).
Pelican Cays: USNM 344848 (Cat, 1997).
Offshore Banks: FMNH 86178 (Glovers Reef); FMNH 94360 (Turneffe).

Emblemariopsis occidentalis Stephens, 1970 — redspine blenny
Barrier Reef: USNM 345355 (Carrie Bow).

Emblemariopsis pricei Greenfield, 1975 — seafan blenny
Barrier Reef: USNM 276061, FMNH 89419 (Carrie Bow); FMNH 90518 (Sergeant's); FMNH 93997 (Ambergris).
Offshore Banks: FMNH 86180 (Glovers Reef); FMNH 90519 (Turneffe).

Emblemariopsis ruetzleri Tyler and Tyler, 1997 — Carrie Bow blenny
Barrier Reef: USNM 325489 (Carrie Bow).

Emblemariopsis signifera (Ginsburg, 1942) — highfin blenny
Barrier Reef: USNM 2760878, FMNH 89421 (Carrie Bow); FMNH 94005 (Ambergris); FMNH 94007 (Hol Chan); FMNH 86072 (Buttonwood).
Offshore Banks: FMNH 87927 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Hemiemblemaria simulus Longley and Hildebrand, 1940 — wrasse blenny
Barrier Reef: USNM 308395 (Carrie Bow); FMNH 94010 (Ambergris); FMNH 90534 (Sergeant's).
Offshore Banks: FMNH 90523 (Glovers Reef); FMNH 94386 (Turneffe).

Lucayablennius zingaro (Böhlke, 1957) — arrow blenny
Barrier Reef: USNM 267826, FMNH 89302 (Carrie Bow); FMNH 90532 (English); FMNH 94013 (Ambergris); AMNH 225021 (Carrie Bow).
Mid-Shelf: SR CLS (Douglas, 2000); SR J/S (Quamino, 2001).
Pelican Cays: USNM 347306 (Cat, 1997); USNM 364836 (Manatee, 2001); SR J/S (Little Cat, 2000); SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 86176, 90527 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 94382 (Turneffe); FMNH 77565 (Lighthouse).

Stathmonotus gymnodermis Springer, 1955 — smoothskin blenny
Offshore Banks: FMNH 86010 (Glovers Reef).

Stathmonotus hemphillii Bean, 1885 — blackbelly blenny
Barrier Reef: FMNH 94026 (Ambergris).
Offshore Banks: FMNH 90319 (Glovers Reef).

Stathmonotus stahli (Evermann and Marsh, 1899) — eelgrass blenny
Barrier Reef: USNM 276218 (Carrie Bow); FMNH 89317 (South Water); FMNH 90330 (Carrie Bow); FMNH 94157 (Ambergris); FMNH 90323 (Sergeant's); FMNH 90324 (Goff's).
Mid-Shelf: USNM 360313 (Douglas, 2000); USNM 365159 (North Elbow, 2001); USNM 360314 (SE Lagoon, 2000); USNM 365160 (Quamino, 2001).
Coastline Marine: FMNH 86008 (Placentia).
Offshore Banks: FMNH 86007 (Glovers Reef); FMNH 94323 (Turneffe).

Blenniidae

Entomacrodus nigricans Gill, 1859 — pearl blenny
Barrier Reef: USNM 276035 (Carrie Bow); FMNH 89282 (Carrie Bow); FMNH 93951 (Ambergris); FMNH 90467 (Sergeant's); FMNH 90469 (Goff's).
Mid-Shelf: FMNH 90466 (Spanish).
Offshore Banks: FMNH 86074 (Glovers Reef); FMNH 90468 (Turneffe); FMNH 77573 (Lighthouse).

Hypleurochilus pseudoaequipinnis Bath, 1994 — oyster blenny
Barrier Reef: FMNH 93956 (Ambergris).
Pelican Cays: USNM 365036 (Ridge, 2001).
Coastline Marine: FMNH 87952 (Punta Gorda); FMNH 86170 (Frenchman's).
Offshore Banks: FMNH 94292 (Glovers Reef); FMNH 96873 (Turneffe).

Hypleurochilus springeri Randall, 1966 — orangespotted blenny
Barrier Reef: FMNH 89386 (Carrie Bow); FMNH 87959 (Sergeant's); FMNH 93957 (Ambergris).
Offshore Banks: FMNH 86167 (Glovers Reef); FMNH 87960 (Turneffe).

Lupinoblennius vinctus (Poey, 1867) — mangrove blenny
Barrier Reef: FMNH 93958 (Ambergris).
Coastline Marine: FMNH 89412 (Belize City); FMNH 86080 (Southern Lagoon).

Ophioblennius atlanticus macclurei (Silvester, 1915) — redlip blenny
Barrier Reef: USNM 276044, FMNH 89310 (Carrie Bow); SR CLS (Carrie Bow, 2000, 2001); FMNH 93961 (Ambergris); FMNH 90478 (Goff's); FMNH 86078 (Gallows Point).
Pelican Cays: SR CLS (Manatee, 2000).
Coastline Marine: FMNH 86159 (Placentia); FMNH 87941 (Punta Gorda).
Offshore Banks: FMNH 89516 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 90477 (Turneffe); FMNH 77577 (Lighthouse).

Parablennius marmoreus (Poey, 1876) — seaweed blenny
Mid-Shelf: USNM 365157 (Quamino, 2001).
Coastline Marine: FMNH 87948 (Punta Gorda); FMNH 86165 (Frenchman's).

Scartella cristata (Linnaeus, 1758) — molly miller
Coastline Marine: FMNH 87950 (Punta Gorda).

Gobiesocidae

Acyrtops beryllinus (Hildebrand and Ginsburg, 1926) — emerald clingfish
Barrier Reef: FMNH 84633 (Carrie Bow); FMNH 84320 (Cay Caulker).

Acyrtus artius Briggs, 1955 — papillate clingfish
Barrier Reef: USNM 274895, MNH 84334 (Carrie Bow); FMNH 83938 (Ambergris); FMNH 84327 (Sergeant's).
Offshore Banks: FMNH 84323 (Glovers Reef).

Gobiesox barbatulus Starks, 1913 — lobelip skilletfish
Coastline Marine: FMNH 83895 (Placentia); FMNH 83896 (Belize City).

Gobiesox punctulatus (Poey, 1876) — stippled clingfish
Barrier Reef: USNM 353633, FMNH 83901 (Carrie Bow).
Coastline Marine: FMNH 83909 (Punta Gorda); FMNH 83900 (Middle Snake).
Offshore Banks: FMNH 83899 (Glovers Reef).

Gobiesox sp.
Pelican Cays: USNM 360530 (Co-Cat, 2000).

Tomicodon sp. nov. — broadhead clingfish (This species is being described by J. Williams and J. Tyler.)
Barrier Reef: FMNH 93758 (Carrie Bow).

Tomicodon sp. nov. — coral clingfish (This species is being described by J. Williams and J. Tyler.)
Barrier Reef: USNM 358693 (Carrie Bow).

Tomicodon sp. nov. — reticulate clingfish (Figure 14) (This species is being described by J. Williams and J. Tyler.)
Mid-Shelf: FMNH 93759 (Twin); USNM 276185 (Twin).
Pelican Cays: USNM 364369 (Co-Cat, 2001).
Coastline Marine: FMNH 93754 (Punta Gorda).

Tomicodon rupestris (Poey, 1860) — barred clingfish
Barrier Reef: FMNH 94187 (Ambergris).
Offshore Banks: FMNH 93755 (Glovers Reef).

Callionymidae
Paradiplogrammus bairdi (Jordan, 1888) — lancer dragonet
Barrier Reef: USNM 276224 (Carrie Bow).

Eleotridae
Dormitator maculatus (Bloch, 1792) — fat sleeper
Coastline Marine: FMNH 95585 (Belize City).

Eleotris amblyopsis (Cope, 1871) — weakeye sleeper
Barrier Reef: FMNH 105599 (St. George's).
Coastline Marine: FMNH 107512 (Belize City); FMNH 107513 (Southern Lagoon).

Eleotris perniger (Cope, 1871) — spinycheek sleeper (formerly known as *E. pisonis*)
Barrier Reef: FMNH 103792 (St. George's).

Erotelis smaragdus (Valenciennes, 1837) — emerald sleeper
Barrier Reef: USNM 276354, FMNH 95587 (Carrie Bow).
Mid-Shelf: FMNH 96464 (Twin).
Coastline Marine: FMNH 95588 (Belize City); FMNH 95590 (Punta Gorda).
Offshore Banks: FMNH 98046 (Turneffe).

Gobiidae
Barbulifer ceuthoecus (Jordan and Gilbert, 1884) — bearded goby
Barrier Reef: FMNH 100642 (Carrie Bow); USNM 365018 (sand spit 3.1 mi. south of Carrie Bow).
Mid-Shelf: USNM 360564 (Spruce, 2000); USNM 365014 (sand spit between Spruce and Wee Wee, 2001); USNM 365016 (Channel, 2001).
Pelican Cays: USNM 347313 (Cat, 1997); USNM 346468 (Manatee,1997); USNM 360563 (Cat, 2000); USNM 360526 (Co-Cat, 2000); USNM 360563 (Cat, 2000); USNM 347347 (Manatee, 1997); USNM 365015 (Fisherman's, 2001); USNM 365017 (Cat, 2001).

Coastline Marine: FMNH 87907 (Punta Gorda).
Offshore Banks: FMNH 94279 (Turneffe).

Bathygobius curacao (Metzelaar, 1919) — notchtongue goby
Barrier Reef: USNM 351295 (Carrie Bow).
Mid-Shelf: USNM 365012 (sand spit between Spruce and Wee Wee, 2001).
Pelican Cays: USNM 347467 (Manatee, 1997).

Bathygobius mystacium Ginsburg, 1947 — island frillfin
Barrier Reef: USNM 349049 (Carrie Bow).

Bathygobius soporator (Valenciennes, 1837) — frillfin goby
Barrier Reef: AMNH 84327 (Ambergris).
Pelican Cays: USNM 360525 (Co-Cat, 2000).
Coastline Marine: FMNH 103790 (Temash River).
Offshore Banks: FMNH 86604 (Glovers Reef).

Chriolepis imswe (Greenfield, 1981) — whiteband goby (formerly *Varicus imswe*)
Barrier Reef: USNM 328243, FMNH 83894 (Carrie Bow).
Offshore Banks: FMNH 100499 (Glovers Reef).

Coryphopterus alloides Böhlke and Robins, 1960 — barfin goby
Barrier Reef: USNM 267843 (Carrie Bow); FMNH 99578 (Curlew).
Offshore Banks: FMNH 99577 (Glovers Reef); FMNH 99575 (Turneffe).

Coryphopterus dicrus Böhlke and Robins, 1960 — colon goby
Barrier Reef: USNM 276124, FMNH 99598 (Carrie Bow); FMNH 99604 (Ambergris); AMNH 225079 (Carrie Bow).
Mid-Shelf: USNM 360643 (SE Lagoon, 2000).
Coastline Marine: FMNH 99600 (Punta Gorda).
Offshore Banks: FMNH 99609 (Glovers Reef); FMNH 99585 (Turneffe).

Coryphopterus eidolon Böhlke and Robins, 1960 — pallid goby
Barrier Reef: USNM 267838, FMNH 99695 (Carrie Bow); FMNH 99707 (Ambergris); FMNH 99706 (English).
Mid-Shelf: SR CLS (Lagoon, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Quamino, 2001) .
Pelican Cays: USNM 347398 (Cat, 1997); USNM 347402 (Cat, 1997); USNM 347380 (Manatee, 1997); USNM 360539 (Cat, 2000); USNM 347467 (Cat, 1997); USNM 360538 (Cat, 2000); USNM 360540 (Little Cat, 2000); USNM 360541 (Little Cat, 2000); USNM 365004 (Cat, 2001); USNM 365005 (Manatee, 2001); USNM 365006 (Avicennia, 2001); USNM 365010 (Fisherman's, 2001); SR J/S (Little Cat, 2000); SR CLS

(Cat, 2000,2001); SR J/S (Manatee, 2001); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Offshore Banks: FMNH 103724, 70952 (Glovers Reef); FMNH 99696 (Turneffe); FMNH 99686 (Lighthouse).

Coryphopterus glaucofraenum Gill, 1863 — bridled goby

Barrier Reef: FMNH 108249 (Carrie Bow); SR J/S (Carrie Bow, 2000); FMNH 108251 (Sergeant's); AMNH 225073 (Carrie Bow); AMNH 83091 (Ambergris).

Mid-Shelf: USNM 360548 (Douglas, 2000); SR J/S (Channel, 2001); USNM 365007 (North Elbow); USNM 360550 (SE Lagoon, 2000); SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001); FMNH 108254 (Twin); FMNH 100571 (Blue Ground Range).

Pelican Cays: USNM 347399 (Cat, 1997); USNM 347405 (Cat, 1997); USNM 347405 (Cat, 1997); USNM 347345 (Manatee, 1997); USNM 360547 (Cat, 2000); USNM 360549 (Little Cat, 2000); USNM 365008 (Cat, 2001); USNM 365009 (Manatee, 2001); SR J/S (Cat, 2000); SR J/S (Little Cat, 2000); SR J/S (Avivennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Coastline Marine: FMNH 99574 (Punta Gorda); FMNH 103791 (Frenchman's).

Offshore Banks: FMNH 86608, 77672 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 108256 (Turneffe).

Coryphopterus hyalinus Böhlke and Robins, 1962 — glass goby

Barrier Reef: USNM 267835 (Carrie Bow); FMNH 107594 (Carrie Bow); FMNH 105602 (Ambergris); FMNH 105597 (English).

Offshore Banks: FMNH 107574 (Glovers Reef); FMNH 105604 (Turneffe); FMNH 107590 (Lighthouse).

Coryphopterus lipernes Böhlke and Robins, 1962 — peppermint goby

Barrier Reef: USNM 267833, FMNH 107605 (Carrie Bow); FMNH 105636 (Ambergris).

Offshore Banks: FMNH 107606, 107619 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 105631 (Turneffe).

Coryphopterus personatus (Jordan and Thompson, 1905) — masked goby (Figure 15)

There is a question as to whether this species is distinct from *C. hyalinus* and in our sight records we list all as *C. personatus*.

Barrier Reef: USNM 267841, FMNH 107685 (Carrie Bow); FMNH 107654 (Ambergris); SR J/S (Carrie Bow, 2000, 2001); FMNH 107624 (English); FMNH 107651 (Hol Chan); AMNH 225083 (Carrie Bow).

Mid-Shelf: FMNH 107644 (Twin); SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).

Pelican Cays: USNM 347312 (Cat, 1997); USNM 360542 (Cat, 2000); USNM 365002 (Cat, 2001); USNM 347381 (Manatee, 1997); USNM 365003 (Manatee, 2001); USNM 347466 (Little Cat, 2000); USNM 365001 (Fisherman's, 2001); SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR JCT et al. (Cat, 1995); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Offshore Banks: FMNH 107626 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 107658 (Turneffe); FMNH 107682 (Lighthouse).

Coryphopterus thrix Böhlke and Robins, 1960 — bartail goby

Barrier Reef: FMNH 103707 (Carrie Bow); FMNH 83989 (Ambergris).

Offshore Banks: FMNH 103708, 103706 (Glovers Reef).

Coryphopterus tortugae (Jordan, 1904) — sand goby

The status of this species is unclear and we did not distinguish it from *C. glaucofremum* in our sight records.

Barrier Reef: FMNH 99708 (Carrie Bow); FMNH 99561 (Ambergris); FMNH 99675 (Hol Chan); FMNH 99538 (Gallows Point).

Coastline Marine: FMNH 99572 (Middle Snake).

Offshore Banks: FMNH 99551 (Glovers Reef); FMNH 99564 (Turneffe); FMNH 99569 (Lighthouse).

Elacatinus atronasus Böhlke and Robins, 1968 — blacknose goby

Barrier Reef: USNM 274932 (Carrie Bow).

Elacatinus evelynae Böhlke and Robins, 1968 — sharknose goby

Barrier Reef: USNM 276146 (Carrie Bow); SR J/S (Carrie Bow, 2001).

Mid-Shelf: SR RSJ (Lagoon, 2000).

Pelican Cays: USNM 347299 (Cat, 1997).

Elacatinus horsti (Metzelaar, 1922) — yellowline goby

Barrier Reef: USNM 329554 (Carrie Bow).

Pelican Cays: USNM 360645 (Little Cat, 2000).

Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Elacatinus louisae Böhlke and Robins, 1968 — spotlight goby

Offshore Banks: FMNH 105686 (Glovers Reef).

Elacatinus oceanops Jordan, 1904 — neon goby (Figure 16)
Barrier Reef: USNM 274918, FMNH 100555 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 100576 (Ambergris); FMNH 100581 (Hol Chan); AMNH 225069 (Carrie Bow).
Mid-Shelf: USNM 360648 (Douglas, 2000); USNM 365030 (North Elbow, 2001); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); USNM 360649 (SE Lagoon, 2000); SR J/S (Douglas, 2000); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347400 (Cat, 1997); USNM 347407 (Cat, 1997); USNM 360470 (Little Cat, 2000); USNM 365028 (Cat, 2001); USNM 365029 (Manatee, 2001); SR J/S (Cat, 2000); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).
Coastline Marine: FMNH 100546 (Punta Gorda).
Offshore Banks: FMNH 100562 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 100512 (Turneffe); FMNH 100528 (Lighthouse).

Elacatinus prochilos Böhlke and Robins, 1968 — whiteline goby
Barrier Reef: FMNH 107714 (Carrie Bow).
Offshore Banks: FMNH 107712 (Glovers Reef); FMNH 107713 (Turneffe).

Elacatinus xanthiprora Böhlke and Robins, 1968 — yellowprow goby (Figure 17)
Barrier Reef: USNM 347301, FMNH 105685 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Mid-Shelf: SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Tarpum, 2001).
Pelican Cays: USNM 347401 (Cat, 1997); USNM 360560 (Cat, 2000); USNM 360561 (Little Cat, 2000); USNM 360562 (Little Cat, 2000); USNM 365031 (Manatee, 2001); SR J/S (Cat, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Co-Cat, 2001).

Evorthodus lyricus (Girard, 1858) — lyre goby
Coastline Marine: FMNH 77680 (Belize City).

Gnatholepis thompsoni Jordan, 1902 — goldspot goby
Barrier Reef: USNM 276130 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 225080 (Carrie Bow).
Pelican Cays: USNM 347379 (Manatee, 1997); USNM 360608 (Little Cat, 2000); SR JCT et al. (Cat, 1995).
Offshore Banks: FMNH 70956 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988); FMNH 94881 (Turneffe).

Gobiosoma yucatanum (Dawson, 1971) — Yucatan goby
Coastline Marine: FMNH 104727 (Belize City); FMNH 104728 (Southern Lagoon).

Gobionellus saepepallens (Gilbert and Randall, 1968) — dash goby
Barrier Reef: USNM 353875 (Carrie Bow).
Offshore Banks: FMNH 86618 (Glovers Reef).

Gobulus myersi Ginsburg, 1939 — paleback goby
Pelican Cays: USNM 347348 (Manatee, 1997).

Lophogobius cyprinoides (Pallas, 1770) — crested goby
Barrier Reef: FMNH 103793 (Sr. George's).
Mid-Shelf: FMNH 96463 (Twin).
Offshore Banks: FMNH 98041 (Glovers Reef); FMNH 86661 (Turneffe).

Lythrypnus crocodilus (Beebe and Tee-Van, 1928) — mahogany goby
Barrier Reef: USNM 274936 (Carrie Bow); FMNH 96607 (Carrie Bow); FMNH 96612 (Ambergris); FMNH 96611 (Hol Chan).
Offshore Banks: FMNH 96609 (Glovers Reef).

Lythrypnus elasson Böhlke and Robins, 1960 — dwarf goby
Barrier Reef: FMNH 83971 (Carrie Bow); FMNH 83967 (Goff's); FMNH 83968 (English); FMNH 83987 (Ambergris).
Offshore Banks: FMNH 83950 (Glovers Reef); FMNH 83966 (Turneffe); FMNH 96492 (Lighthouse).

Lythrypnus heterochroma Ginsburg, 1939 — diphasic goby
Barrier Reef: USNM 274913 (Carrie Bow); FMNH 83988 (Ambergris).
Offshore Banks: FMNH 83953 (Glovers Reef); FMNH 84000 (Turneffe).

Lythrypnus minimus Garzon and Acero P., 1988 — pygmy goby.
Pelican Cays: USNM 347382 (Manatee, 1997); USNM 365032 (Cat, 2001).

Lythrypnus nesiotes Böhlke and Robins, 1960 — island goby
Barrier Reef: USNM 274904 (Carrie Bow); FMNH 96596 (Ambergris).
Mid-Shelf: USNM 360558 (SE Lagoon, 2000).
Pelican Cays: USNM 360559 (Little Cat, 2000).
Offshore Banks: FMNH 96591 (Glovers Reef); FMNH 96599 (Turneffe).

Lythrypnus okapia Robins and Böhlke, 1964 — okapi goby
Barrier Reef: FMNH 99654 (Ambergris).
Offshore Banks: FMNH 99653 (Glovers Reef).

Lythrypnus spilus Böhlke and Robins, 1960 — bluegold goby
Barrier Reef: USNM 267845, FMNH 83970 (Carrie Bow).
Pelican Cays: USNM 347408 (Cat, 1997); USNM 365033 (Cat, 2001).
Coastline Marine: FMNH 96421 (Punta Gorda).
Offshore Banks: FMNH 83951 (Glovers Reef); FMNH 83999 (Turneffe); FMNH 96494 (Lighthouse).

Lythrypnus sp.
Mid-Shelf: USNM 360473 (Douglas, 2000); USNM 360475 (SE Lagoon, 2000).
Pelican Cays: USNM 360471 (Cat, 2000); USNM 360474 (Little Cat, 2000).
Offshore Banks: FMNH (Glovers Reef).

Microgobius microlepis Longley and Hildebrand, 1940 — banner goby
Pelican Cays: USNM 347307 (Cat, 1997).
Offshore Banks: FMNH 107720 (Glovers reef).

Nes longus (Nichols, 1914) — orangespotted goby
Mid-Shelf: USNM 350189, AMNH 225005 (Twin Cays shot hole).
Offshore Banks: FMNH 77688 (Glovers Reef).

Oxyurichthys stigmalophius (Meade and Böhlke, 1958) — spotfin goby
Offshore Banks: FMNH 86619 (Glovers Reef).

Priolepis hipoliti (Metzelaar, 1922) — rusty goby
Barrier Reef: USNM 267829 (Carrie Bow); FMNH 103700 (Ambergris); AMNH 225070 (Carrie Bow).
Offshore Banks: FMNH 70947 (Glovers Reef).

Psilotris amblyrhynchus Smith and Baldwin, 1999 — bluntsnout goby
Barrier Reef: USNM 347250 (Carrie Bow).

Psilotris batrachodes Böhlke, 1963 — toadfish goby
Barrier Reef: USNM 274946 (Carrie Bow); FMNH 101789 (Carrie Bow); FMNH 101791 (Hol Chan); FMNH 101788 (Ambergris).
Offshore Banks: FMNH 101793 (Glovers Reef); UF 209460 (Lighthouse Reef).

Psilotris celsus Böhlke, 1963 — highspine goby
Pelican Cays: USNM 360607 (Little Cat, 2000).

Pycnomma roosevelti Ginsburg, 1939 — presidents goby
Barrier Reef: USNM 346493 (Carrie Bow).

Risor ruber (Rosén, 1911) — tusked goby
Barrier Reef: USNM 267830 (Carrie Bow); SR JCT (Carrie Bow, 2000).
Mid-Shelf: USNM 360556 (SE Lagoon, 2000).
Pelican Cays: USNM 344844 (Cat, 1997); USNM 360554 (Cat, 2000); USNM 360555, (Little Cat, 2000); USNM 365019 (Cat, 2001); USNM 365020 (Ridge, 2001).
Offshore Banks: FMNH 82592 (Glovers Reef); FMNH 107721 (Turneffe).

The following four species, elsewhere assigned to *Gobiosoma*, *Garmannia*, or *Elacatinus,* are tentatively placed in the genus *Tigrigobius* by Van Tassell, 1998.

Tigrigobius dilepis Robins and Böhlke, 1964 — orangeside goby (formerly *Gobiosoma dilepis*)
Mid-Shelf: USNM 365184 (Quamino, 2001).
Pelican Cays: USNM 347300 (Cat, 1997); USNM 365027 (North Elbow, 2001); SR J/S (Avicennia, 2001).
Offshore Banks: FMNH 86620 (Glovers Reef).

Tigrigobius gemmatum (Ginsburg, 1939) — frecklefin goby (formerly *Garmannia gemmatum*)
Barrier Reef: USNM 321082 (Carrie Bow).

Tigribobius pallens (Ginsburg, 1939) — wall goby (formerly *Gobiosoma pallens*)
Barrier Reef: USNM 336874 (Carrie Bow).
Offshore Banks: FMNH 104418 (Glovers Reef).

Tigrigobius saucrum (Robins, 1960) — leopard goby (formerly *Gobiosoma saucra*)
Humann (1994: 243) presents an excellent photograph under the name *Gobiosoma dilepsis* [sic] and states it is uncommon in the Bahamas and Caribbean. Böhlke and Smith-Vaniz (1993), in their additions to the b Fishes of the Bahamas, list no *G. dilepsis* so we assume that this is a misspelling of *dilepis*. Humann's photograph, however, is not *dilepis* but appears to be *Gobiosoma saucrum*.
Mid-Shelf: USNM 360551 (Douglas, 2000); USNM 365021 (North Elbow, 2001); USNM 360552 (SE Lagoon, 2000); USNM 365025 (Quamino, 2001); USNM 365026 (Tarpum, 2001).
Pelican Cays: USNM 347469 (Cat, 1997); USNM 360553 (Little Cat, 2000); USNM 365022 (Cat, 2001); USNM 365023 (Manatee, 2001); SR RSJ (Avicennia, 2001).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Varicus fisheri (Herre, 1942) — translucent goby (formerly *Chriolepis fisheri*)
Offshore Banks: FMNH 71115 (Glovers Reef).

Vomerogobius flavus Gilbert, 1971 — lemon goby
Offshore Banks: FMNH 100488 (Glovers Reef).

Microdesmidae

Cerdale floridana Longley, 1934 — pugjaw wormfish
Barrier Reef: USNM 276202 (Carrie Bow); FMNH 101098 (Goff's); FMNH 101097 (South Water).
Pelican Cays: USNM 347349 (Manatee, 1997); USNM 365185 (Avicennia, 2001).
Coastline Marine: FMNH 101099 (Punta Gorda).

Microdesmus bahianus Dawson, 1973 — reef wormfish
Barrier Reef: USNM 350592 (Carrie Bow).

Microdesmus carri Gilbert, 1966 — brown wormfish
Barrier Reef: USNM 350900 (Carrie Bow).

Microdesmus longipinnis (Weymouth, 1910) — pink wormfish
Barrier Reef: USNM 350894 (Carrie Bow).

Ptereleotris helenae (Randall, 1968) — hovering goby
Barrier Reef: SR J/S (Carrie Bow, 2000).
Mid-Shelf: SR CLS (Twin Cays shot hole, 1997).

Ephippidae

Chaetodipterus faber (Broussonet, 1782) — Atlantic spadefish
Mid-Shelf: SR J/S (Tarpum, 2001).
Pelican Cays: USNM 360523 (Co-Cat, 2000); SR J/S (Cat, 2000); SR JCT et al. (Cat, 1995); SR J/S (Little Cat, 2000); SR J/S (Manatee, 2001).
Coastline Marine: AMNH 83653 (Bahia de Amatique).

Acanthuridae

Acanthurus bahianus Castelnau, 1855 — ocean surgeonfish
Barrier Reef: USNM 276244 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 86512 (Gallows Point Reef); AMNH 93321 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Offshore Banks: FMNH 39798 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Acanthurus chirurgus (Bloch, 1787) — doctorfish

Barrier Reef: USNM 327618 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); AMNH 83088 (Ambergris); AMNH 224967 (Carrie Bow).

Mid-Shelf: USNM 360604 (Spruce, 2000); SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001).

Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000, 2001); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Offshore Banks: FMNH 86518 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Acanthurus coeruleus Bloch and Schneider, 1801 — blue tang

Barrier Reef: USNM 276153 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 86520 (Gallows Point Reef); AMNH 93325 (Carrie Bow).

Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001).

Pelican Cays: SR J/S (Cat, 2000, 2001); SR J/S (Manatee, 2000); SR J/S (Little Cat, 2000); SR J/S (Avicennia, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2001).

Offshore Banks: FMNH 39797 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Sphyraenidae

Sphyraena barracuda (Walbaum, 1792) — great barracuda

Barrier Reef: USNM 353139 (Carrie Bow); FMNH 77873 (St.Georges); SR J/S (Carrie Bow, 2000, 2001).

Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Quamino, 2001).

Pelican Cays: USNM 347357 (Manatee 1997); SR J/S (Cat, 2000); SR J/S (Manatee, 2000); SR J/S (Little Cat, 2000); SR JCT et al. (Cat, 1995); SR J/S (Co-Cat, 2001).

Offshore Banks: FMNH 77669 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Scombridae

Scomberomorus cavalla (Cuvier, 1829) — king mackerel

Barrier Reef: RD (Carrie Bow, 2001).

Scomberomorus regalis (Bloch, 1793) — cero

Barrier Reef: RD (Carrie Bow, 2001).

Mid-Shelf: SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000); SR J/S (Quamino, 2001); SR J/S (Tarpum, 2001).
Pelican Cays: SR J/S (Manatee, 2000, 2001); SR J/S (Cat, 2001); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR JCT et al. (Cat, 1995).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Thunnus alalunga (Bonnaterre, 1788) — albacore
Offshore Banks: FMNH 39863 (Glovers Reef).

Thunnus atlanticus (Lesson, 1831) — blackfin tuna
A larva of this species was collected at Carrie Bow Cay and identified by W. Richards. A photograph of the specimen has been posted on the Smithsonian Website (www.nmnh.si.edu./vert/fish.html).

Achiridae
Achirus declivis Chabanaud, 1940 — plainfin sole
Coastline Marine: FMNH 89532 (Belize City).

Achirus lineatus (Linnaeus, 1758) — lined sole
Barrier Reef: USNM 353970 (Carrie Bow).
Mid-Shelf: FMNH 89534 (Drowned).
Coastline Marine: FMNH 89535 (Belize City).

Bothidae
Bothus lunatus (Linnaeus, 1758) — peacock flounder
Barrier Reef: USNM 349048 (Carrie Bow); SR J/S (Carrie Bow, 2000).
Offshore Banks: FMNH 39762 (Glovers Reef).

Bothus maculiferus (Poey, 1860) — maculated flounder
Offshore Banks: FMNH 104643 (Glovers Reef).

Bothus ocellatus (Agassiz, 1831) — eyed flounder
Barrier Reef: USNM 353145 (Carrie Bow).
Coastline Marine: FMNH 89651 (Belize City).
Offshore Banks: FMNH 77533 (Glovers Reef).

Paralichthyidae
Citharichthys macrops Dressel 1885 — spotted whiff
Coastline Marine: FMNH 77534 (Belize City); FMNH 103799 (Pelican Beach, Dangriga).

Citharichthys spilopterus Günther, 1862 — bay whiff
Coastline Marine: FMNH 103798 (Belize City).

Syacium sp., larva
Barrier Reef: USNM 363537 (Carrie Bow).

Cynoglossidae
Symphurus arawak Robins and Randall, 1965 — Caribbean tonguefish
Barrier Reef: USNM 267784 (Carrie Bow).
Offshore Banks: FMNH 104681 (Glovers Reef); FMNH 97497 (Lighthouse).

Symphurus ommaspilus Böhlke, 1961 — ocellated tonguefish
Offshore Banks: FMNH 94820 (Glovers Reef).

Symphurus plagiusa (Linnaeus, 1766) — blackcheek tonguefish
Coastline Marine: FMNH 97494 (Belize City); FMNH 97490 (Pelican Beach, Dangriga).

Symphurus rhytisma Böhlke,1961 — patchtail tonguefish
Offshore Banks: FMNH 94821 (Glovers Reef).

Symphurus tessellatus (Quoy and Gaimard, 1824) — tesselated tonguefish
Barrier Reef: USNM 356243 (Carrie Bow).

Balistidae
Balistes capriscus Gmelin, 1789 — gray triggerfish
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).
Coastline Marine: AMNH 83651 (Bahia de Amatique).

Balistes vetula Linnaeus, 1758 — queen triggerfish
Barrier Reef: USNM 327619 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001).
Pelican Cays: SR MT (Cat, 1997).
Offshore Banks: FMNH 39732 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Melichthys niger (Bloch, 1786) — black durgon
Barrier Reef: SR J/S (Carrie Bow, 2000).
Offshore Banks: SR CLS and JCT (Glovers Reef, 1988).

Monacanthidae
Aluterus schoepfi (Walbaum, 1792) — orange filefish
Barrier Reef: USNM 353144 (Carrie Bow).
Coastline Marine: FMNH 86523 (Belize City).

Aluterus scriptus (Osbeck, 1765) — scrawled filefish
Barrier Reef: USNM 349042 (Carrie Bow).

Cantherhines pullus (Ranzani, 1842) — orangespotted filefish
Barrier Reef: USNM 349050 (Carrie Bow); SR RSJ (Carrie Bow, 2000); AMNH 224966 (Carrie Bow).
Offshore Banks: FMNH 86527 (Glovers Reef).

Monacanthus ciliatus (Mitchill, 1818) — fringed filefish
Barrier Reef: USNM 327995 (Carrie Bow).
Pelican Cays: USNM 347359 (Manatee, 1997); USNM 360567 (Cat, 2000); USNM 364871 (Cat, 2001).
Coastline Marine: FMNH 86528 (Belize City).
Offshore Banks: FMNH 77522 (Glovers Reef).

Monacanthus tuckeri Bean, 1906 — slender filefish
Barrier Reef: USNM 327620 (Carrie Bow); SR JCT (Carrie Bow, 2000).
Offshore Banks: FMNH 77793 (Glovers Reef).

Stephanolepis setifer (Bennet, 1831) — pygmy filefish
Coastline Marine: FMNH 86534 (Belize City).
Offshore Banks: FMNH 86533 (Glovers Reef).

Ostraciidae
Acanthostracion polygonius Poey, 1876 — honeycomb cowfish
Offshore Banks: FMNH 86537 (Glovers Reef).

Acanthostracion quadricornis (Linnaeus, 1758) — scrawled cowfish
Mid-Shelf: SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Lagoon, 2000).
Pelican Cays: SR J/S (Cat, 2000); SR J/S (Kitten, 2001); SR J/S (Ridge, 2001); SR J/S (Co-Cat, 2000).
Coastline Marine: FMNH 86536 (Belize City).

Lactophrys bicaudalis (Linnaeus, 1758) — spotted trunkfish
Barrier Reef: AMNH 224985 (Carrie Bow).
Pelican Cays: SR J/S (Co-Cat, 2001).
Offshore Banks: FMNH 39723 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Lactophrys trigonus (Linnaeus 1758) — trunkfish
Offshore Banks: FMNH 86538 (Glovers Reef).
Coastline Marine: AMNH 83655 (Bahia de Amatique).

Lactophrys triqueter (Linnaeus, 1758) — smooth trunkfish
Barrier Reef: USNM 349065 (Carrie Bow).
Mid-Shelf: SR J/S (Elbow, 2001).
Offshore Banks: FMNH 86541 (Glovers Reef).

Tetraodontidae

Canthigaster rostrata (Bloch, 1786) — sharpnose puffer
Barrier Reef: USNM 267792, FMNH 94567 (Carrie Bow); SR J/S (Carrie Bow, 2000, 2001); FMNH 93811 (Sergeant's); FMNH 93814 (English); FMNH 70924 (Gallows Point); AMNH 225001 (Carrie Bow).
Mid-Shelf: SR J/S (Douglas, 2000); SR J/S (Elbow, 2001); SR J/S (Channel, 2001); SR J/S (Quamino, 2001).
Pelican Cays: SR J/S (Kitten, 2001).
Offshore Banks: FMNH 93801 (Glovers Reef); FMNH 93813 (Turneffe); FMNH 77765 (Lighthouse); SR CLS and JCT (Glovers Reef, 1988).

Sphoeroides greeleyi Gilbert, 1900 — lappetskin puffer
Coastline Marine: AMNH 83658 (Bahia de Amatique).

Sphoeroides nephelus (Goode and Bean, 1882) — southern puffer
Offshore Banks: FMNH 86544 (Glovers Reef).

Sphoeroides spengleri (Bloch, 1785) — bandtail puffer
Barrier Reef: USNM 327622 (Carrie Bow); SR RSJ (Carrie Bow, 2000); AMNH 224993 (Carrie Bow).
Mid-Shelf: SR J/S (Elbow, 2001).
Pelican Cays: SR RSJ (Cat, 2000).
Coastline Marine: FMNH 86546 (Belize City); FMNH 93785 (Punta Gorda).
Offshore Banks: FMNH 93783 (Glovers Reef); SR CLS and JCT (Glovers Reef, 1988).

Sphoeroides testudineus (Linnaeus, 1758) — checkered puffer
Mid-Shelf: AMNH 225061 (Twin).
Coastline Marine: FMNH 77776 (Belize City); FMNH 93794 (Punta Gorda); FMNH 77778 (South Lagoon); AMNH 83635 (Bahia de Amatique).

Diodontidae

Chilomycterus antennatus (Cuvier, 1816) — bridled burrfish
Barrier Reef: USNM 349052 (Carrie Bow).
Pelican Cays: USNM 347358 (Manatee, 1997).

Chilomycterus antillarum Jordan and Rutter, 1897 — web burrfish
Coastline Marine: FMNH 86551 (Belize City).

Chilomycterus schoepfii (Walbaum, 1792) — striped burrfish
Coastline Marine: FMNH 86550 (Belize City).

Diodon holocanthus Linnaeus, 1758 — balloonfish
Offshore Banks: FMNH 86554 (Glovers Reef).

Diodon hystrix Linnaeus, 1758 — porcupinefish
Barrier Reef: SR J/S (Carrie Bow, 2001).
Coastline Marine: AMNH 83636 (Bahia de Amatique).

DISCUSSION

Because the Pelican Cays are mangrove islands with bases of live coral and are associated with deep lagoons, some with depths in excess of 15 meters (Urish, 2000), they support a highly diverse biota (Macintyre and Rützler, 2000). The objectives of this study have been to determine if there are any differences between the ichthyofauna of the Rhomboidal Cays and the other regions, and if there are any special characteristics of the Core Pelican Cays fish fauna as compared to that of the Peripheral Rhomboidal Cays.

Regional Comparisons

We begin our assessment of the uniqueness of the Rhomboidal Cays ichthyofauna by comparing the numbers of species known from the Rhomboidal Cays with the numbers recorded from adjacent regions. For this comparison we recognize the following major regions of the Belize Barrier Reef Complex: Coastline Marine; Mid-Shelf, exclusive of the Core Pelican Cays but including the Peripheral Rhomboidal Cays; the Core Pelican Cays; the Outer Barrier Reef; and the Offshore Banks. At the latitude of the Pelican Cays, the Coastline Marine, Mid-Shelf, and Outer Barrier Reef areas are clearly distinct from one another but as the shelf narrows northward these regions fuse and some species that otherwise occur only along the coast are found in collections from the Mid-Shelf islands. Thus, the limits of these regions are somewhat subjective but sufficiently distinct to provide a basis for further analysis.

Our list of fish species from the Coastline Marine, Mid-Shelf, Core Pelican Cays, Outer Barrier Reef, and Offshore Banks of Belize now includes 497 species. For comparison, the number of species reported from Bermuda is 433 (Smith-Vaniz et al., 1999), from the four western Caribbean oceanic atolls is 273 (Mejia et al., 1998), and from Navassa Island is 237 (Collette et al., in press).

The numbers of species from each of the regions of the Belize shelf are summarized in Table 1.

Not unexpectedly, substantially more species occur in the Outer Barrier Reef and Offshore Banks where there are deep-water and open-ocean habitats as well as shallow reef, sand bottom, and mangrove habitats. These two areas also have reefs that are exposed to vigorous wave action.

Together the Outer Barrier Reef (339; unique 60 or 17.6 %) and Offshore Banks (293; unique 38 or 13.0%) have a total of 399 species (many shared between the two regions), of which 196 (49.1%) occur only in one or both of these two areas. To some extent the large number of species recorded from the Outer Barrier Reef probably reflects intensive collecting in the vicinity of the Smithsonian Institution's research station at Carrie Bow Cay, whereas the large number of species from the Offshore Banks reflects intensive collecting by the staff of the Field Museum of Natural History.

Table 1. Numbers of species recorded from each of the major regions of the Belize Barrier Reef Complex, and numbers of species recorded only from those regions.

Region	Total Species	Unique Species	Percent Unique Species
Coastline Marine	150	58	38.7
Mid-Shelf, including the Peripheral Rhomboidal Cays	164	4	2.4
Peripheral Rhomboidal Cays	123	0	0
Core Pelican Cays	168	13	7.7
Outer Barrier Reef	339	60	17.6
Offshore Banks	293	38	13.0

The Coastline Marine environment with 150 recorded species contains the largest proportion (38.7 %) of species not recorded from the other regions. This includes species that live in areas of open sand bottom, reduced salinity, and higher turbidity.

The Mid-Shelf region lacks the deep-water and open-ocean habitats of the Outer Barrier Reef and Offshore Banks, and it also lacks the open sand bottom, low salinity, and turbid water habitats of the Coastline Marine region. The Mid-Shelf's unique habitats are quiet water coral reefs, mangroves, seagrass flats, and silty lagoons. Its known fauna comprises 164 species, of which four (2.4%) are reported only from the Mid-Shelf. One hundred and six species are recorded from the Mid-Shelf region exclusive of the Rhomboidal Cays. Our records from mud-based cays are scant, with 28 species from Twin Cays, 11 species from the Blue Ground Range, and 14 species from the non-coral area of Spruce Cay.

These low numbers probably reflect, in part, a lack of collecting effort but they undoubtedly also indicate an actual lack of species richness. In contrast, Douglas Cay, with a fringing coral reef, has 66 recorded species.

The Rhomboidal Cays

For comparative purposes, we grouped the northern islands of the Rhomboidal Cays into the Core Pelican Cays and Peripheral Rhomboidal Cays (Fig.1). The Core Pelican Cays are: Northeast Cay, Bird Cays, Ridge Cay, Fisherman's Cay, Co-Cat Cay, Manatee Cay, Avicennia Cay, Kitten Cay, Cat Cay, and Little Cat Cay. Northeast Cay and the Bird Cays were not sampled because they are inhabited, and our sample from Fisherman's Cay is too small to be considered representative.

The Peripheral Rhomboidal Cays are: the Elbow Cays, Channel Çay, Tarpum Cay, Quamino Cay, and the Lagoon Cays. Douglas Cay is technically outside of the Rhomboidal Cays but it is close enough to be included in the comparisons.

The total numbers of species recorded from each locality within the Rhomboidal Cays are shown in Tables 2 and 3. These numbers reflect collecting effort as well as an estimate of size of the resident fauna. For example, Cat Cay and Manatee Cay were sampled repeatedly over several years and the number of species recorded at those two cays was significantly higher than at other cays in the Pelicans: 112 and 78 respectively vs. the average of 50.4 species from localities sampled only two to four times. This is especially obvious in the number and percentage of species recorded from only those localities. Manatee Cay had 16 species unknown from other Core Pelicans Cays and 13 unknown from the Peripheral Rhomboidal Cays. Cat Cay with 112 species had 33 species unknown from other Core Pelican Cays and 20 species unknown from the Peripheral Rhomboidal Cays. Other cays sampled had fewer than 10 unique species except for Co-Cat with 14. Co-Cat has the only extensive sandy beach that we could locate.

Table 2. Numbers of species recorded from each locality in the Core Pelican Cays. In the number and type of samples column, the number of rotenone samples and sight records are given in parentheses. The first number is the number of rotenone samples and the second is the number of visual censuses. The third column is the number of species recorded from the Core Pelican Cays only at that cay. The fourth column is the number of species recorded from the all of the Rhomboidal Cays only at that cay.

	Number and Type of Samples	Total Number of Species	Unique in Core Pelican Cays	Unique in Rhomboidal Cays
Ridge	2 (1/1)	37	3	2
Co-Cat	3 (3/0)	72	14	9
Manatee	9 (4/5)	78	16	13
Avicennia	2 (1/1)	46	2	2
Kitten	2 (1/1)	45	5	2
Cat	18 (10/8)	112	33	20
Little Cat	4 (2/2)	52	3	3
Mean		63.1		

One hundred and ninety-three species of fishes have been reported from the Rhomboidal Cays, 168 from the Core Pelican Cays (99 species recorded from both the Core Pelican Cays and the Peripheral Rhomboidal Cays plus 69 species that were not found in the Peripheral Rhomboidal Cays), and 123 in the Peripheral Rhomboidal Cays (species found in both and 24 that were not found in the Core Pelican Cays).

Table 3. Numbers of species recorded from the Peripheral Rhomboidal Cays. Columns as in Table 2 except that column three is the number of species recorded from the Peripheral Rhomboidal Cays only at that cay.

	Number of Samples	Total Species	Unique in Peripheral Rhomboidal Cays	Unique in Rhomboidal Cays
Douglas	4 (3/1)	66	8	1
Elbow	5 (2/3)	73	10	0
Channel	3(2/1)	43	4	0
Tarpum	2 (1/)	54	6	0
Lagoon	3 (1/1 + dip net)	62	9	4
Quamino	3 (2/1)	51	7	4
Mean		58.2		

Interrelationships of the Core Pelican Cays and Peripheral Rhomboidal Cays

We attempted to examine the interrelationships of the Core Pelican Cays and the Peripheral Rhomboidal Cays using the program PAUP (Phylogenetic Analysis Using Parsimony by David L. Swofford, 1998). This program is designed for examining large sets of taxonomic characters to analyze taxonomic similarities. In this study, we used the presence or absence of species as "characters" and individual localities as "taxa." Our hypothesis was that if the Core Pelican Cays had characteristic special faunas they would fall out as a group, relative to the Peripheral Rhomboidal Cays. Although limitations of the program precluded using the entire faunal list, runs with a large subsample yielded no clear-cut grouping of the Core Pelican Cays in any of the resulting trees and we conclude that our data do not suggest that the Core Pelican Cays are distinct from the Peripheral Rhomboidal Cays. Hence, what are commonly called the Pelican Cays are biogeographically simply the northernmost of the Rhomboidal Cays.

Special Features of the Rhomboidal Cays

The Rhomboidal Cays do, however, have some special faunal characteristics. First of all, there are some species that are either confined to the Rhomboidal Cays or appear to reach their maximum abundance there. Second, there are species that are conspicuously absent from the Rhomboidal Cays. Third, there are species whose microhabitats in the Rhomboidal Cays differ from their microhabitats in other major regions.

Eleven species, *Aetobatus narinari*, *Myrophis anterodorsalis*, *Porichthys pauciradiatus*, *Epinephelus morio*, *Lonchopisthus micrognathus*, *Caranx crysos*, *Lutjanus cyanopterus*, *Equetus lanceolatus*, *Gobulus myersi*, *Lythrypnus minimus*, and *Psilotris celsus*, were seen or collected in the Core Pelican Cays but not in the other parts of the Belize Barrier Reef Complex. However, all of these have wide distributions in the Caribbean and we can attach no special significance to their apparent absence in the surrounding regions, other than sampling error.

Two species, however, appear to characterize the Rhomboidal Cays in that they are abundant there and absent or rare elsewhere. The Mayan hamlet (*Hypoplectrus* sp.) is common and abundant at Manatee, Cat, and Little Cat Cays in the Core Pelican Cays. We have not collected or observed it outside of the Rhomboidal Cays, but Philip Lobel (pers. comm.) has taken it at Wee Wee Cay. The schooling wrasse (*Halichoeres* sp.) has been reported from the Core Pelican Cays and from Channel, Tarpum, Lagoon, and Quamino Cays. It appears to be one of the most abundant species in the Rhomboidal Cays.

Species Notably Absent from the Rhomboidal Cays

One hundred sixteen species occur in both the Offshore Banks and the Barrier Reef collections but are absent from the Core Pelican Cays and the Peripheral Rhomboidal Cays. Perhaps the most conspicuous by its absence is the bluehead wrasse (*Thalassoma bifasciatum*), which is extremely common on the Barrier Reef and Outer Banks, but does not occur in the Coastal Marine, Rhomboidal Cays, or in Mid-Shelf samples. This species is especially common in flourishing coral-reef areas and its absence from grass and mangrove habitats is not unexpected, but its absence from the Core Pelican Cays quiet water coral reefs is noteworthy. Other species conspicuous by their absence are: *Myripristis jacobus*, *Scorpaena plumieri*, *Epinephelus guttatus*, *Serranus baldwini*, *Heteropriacanthus cruentatus*, *Apogon townsendi*, *Malacanthus plumieri*, *Gerres cinereus*, *Mulloidichthys martinicus*, *Holacanthus tricolor*, *Microspathodon chrysurus*, *Bodianus rufus*, *Acanthemblemaria paula*, *Bothus lunatus*, *Cantherhines pullus*, and *Monacanthus tuckeri*.

Species with Unique Microhabitats in the Rhomboidal Cays

Of special interest is the habitat of the roughhead blenny (*Acanthemblemaria aspera*, Figure 12). At Carrie Bow Cay and most other Caribbean localities, this small species is confined to depths of 15 to 50 feet, especially in the groove-and-spur formations (Clarke, 1989, 1994). In the Core Pelican Cays it lives at depths of less than one foot. *Acanthemblemaria aspera* was the only species of *Acanthemblemaria* found at Cat Cay. At Manatee Cay it lives with two other much less common species, the false papillose blenny (*Acanthemblemaria greenfieldi*) and the spinyhead blenny (*A. spinosa*). The latter two species occur in shallow water at Carrie Bow Cay, where they are well separated from the deeper water habitat of *A. aspera*. Possibly the subdued water movement in the Rhomboidal Cays is important to these distribution patterns, but there may be other factors as well.

CONCLUSIONS

The Rhomboidal Cays have a rich ichthyofauna of 193 known species. We have not found any reliable ichthyofaunal differences between the Core Pelican Cays and the Peripheral Rhomboidal Cays, but the Rhomboidal Cays have many more species of fishes than the Mid-Shelf mangrove cays with mud bases such as Twin Cays. The Mayan hamlet (*Hypoplectrus* sp.) and the schooling wrasse (*Halichoeres* sp.) appear to be almost restricted to the Rhomboidal Cays and certainly reach their maximum abundance there. One hundred sixteen species that occur in both the Offshore Banks and the Barrier Reef have not been reported from the Rhomboidal Cays. A particularly striking example is the bluehead wrasse (*Thalasoma bifasciatum*), which is conspicuously absent in spite of the presence of flourishing coral reefs along most of the Rhomboidal Cays.

Finally, there are differences in microhabitat utilization by hole dwelling blennies of the genus *Acanthemblemaria*.

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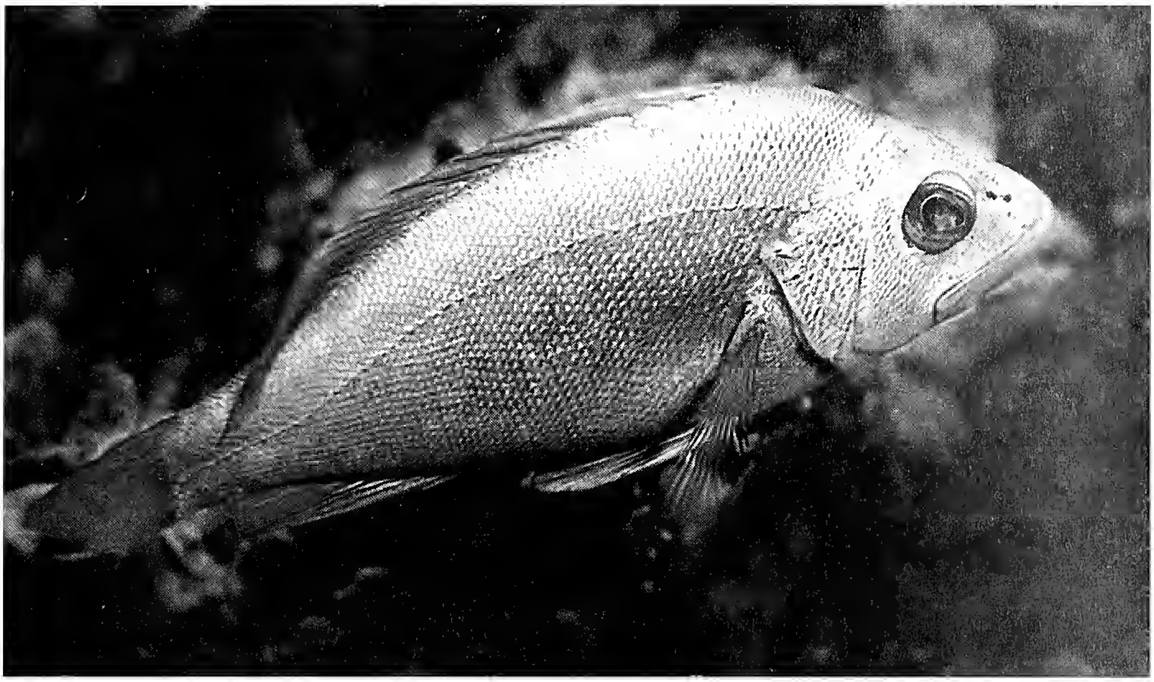

Figure 2. Mayan hamlet (*Hypoplectrus* sp. nov.). This distinctive species is presently known only from the Pelican Cays, with one record from Wee Wee Cay.

Figure 3. Two-spot bass (*Serranus flaviventris*). This secretive species is common in the Rhomboidal Cays.

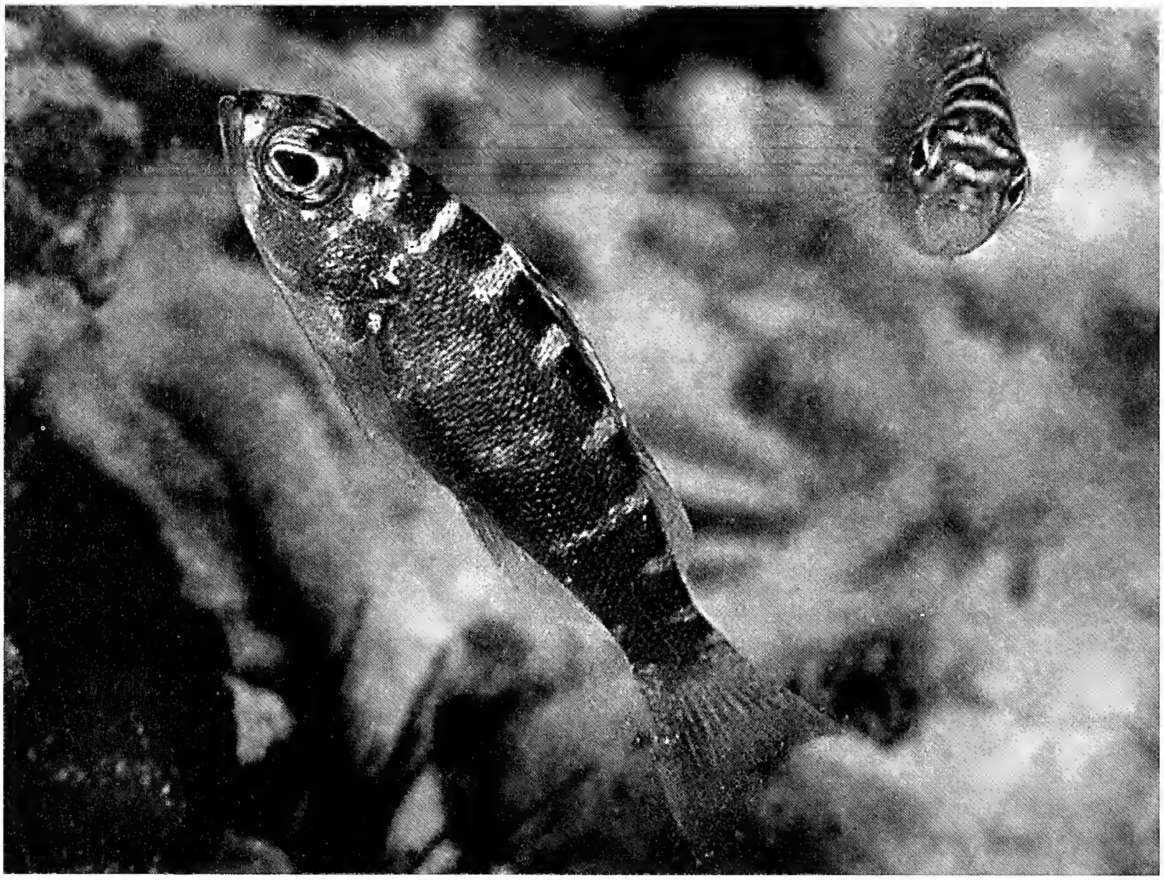

Figure 4. Chalk bass (*Serranus tortugarum*). Usually this species is found on the outer slope of reefs facing open water at depths of more than 15 meters. Its presence in the confined waters of the Pelican Cays is of interest.

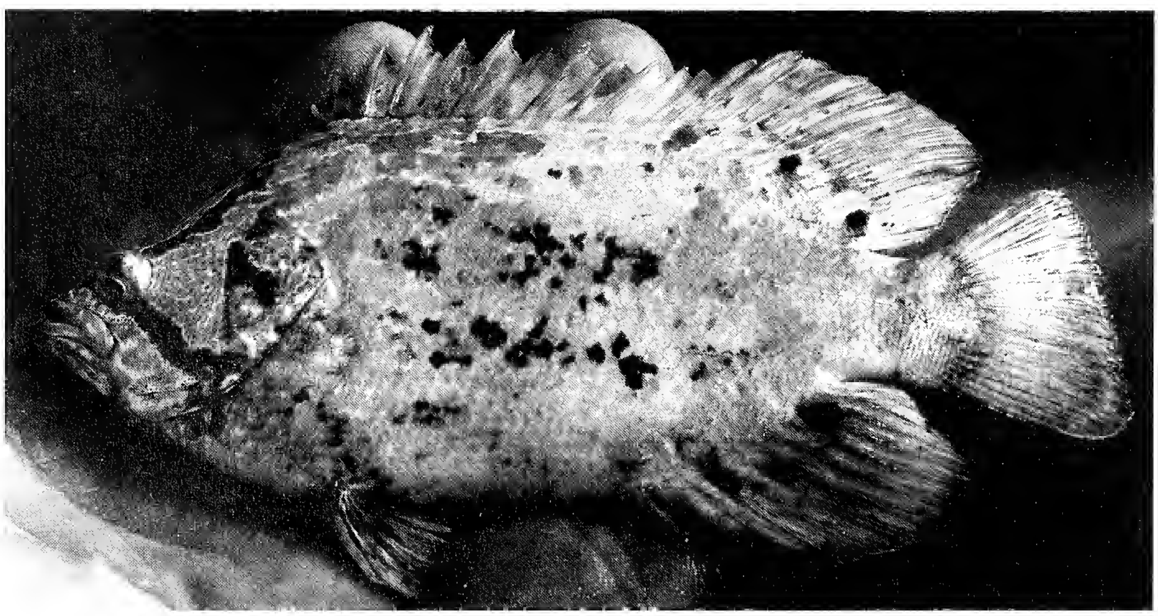

Figure 5. Tripletail (*Lobotes surinamensis*). This juvenile drifted onto the beach at Carrie Bow Cay on 6 February 2001, and has not been recorded from the Rhomboidal Cays.

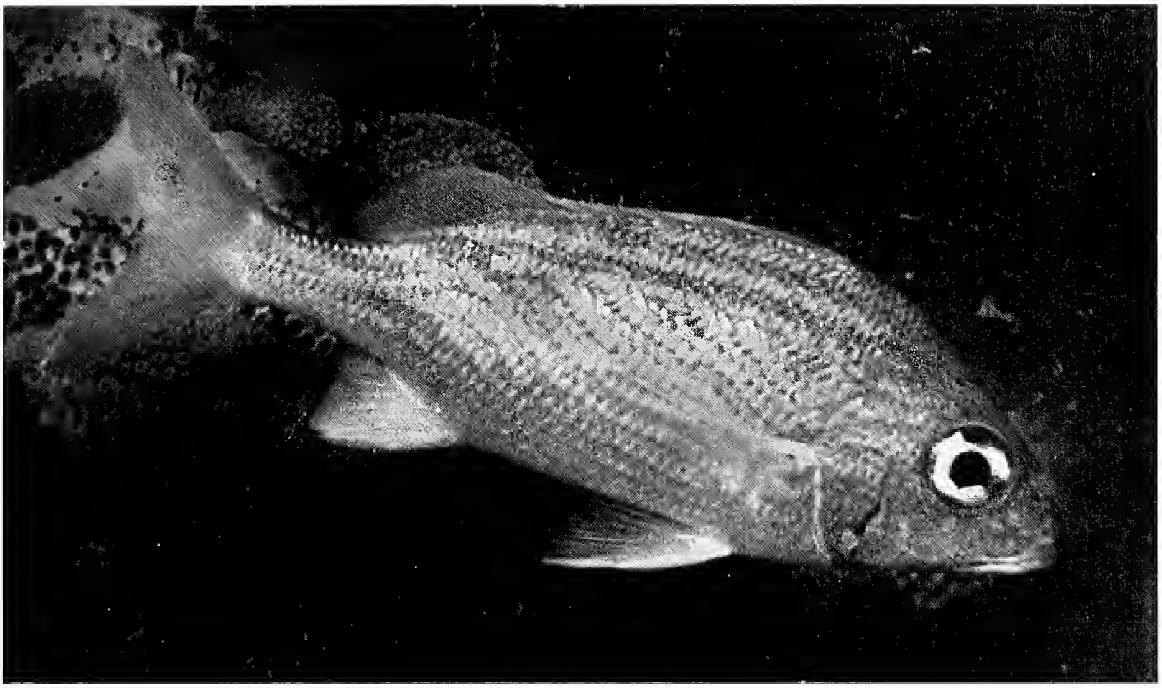

Figure 6. French grunt (*Haemulon flavolineatum*). As it is elsewhere throughout its range, the French grunt is abundant along the top of the reef and among mangrove roots in the Rhomboidal Cays.

Figure 7. Yellowcheek wrasse (*Halichoeres cyanocephalus*). This species is found in the groove and spur zone off Carrie Bow Cay, and has not been recorded from the Rhomboidal Cays.

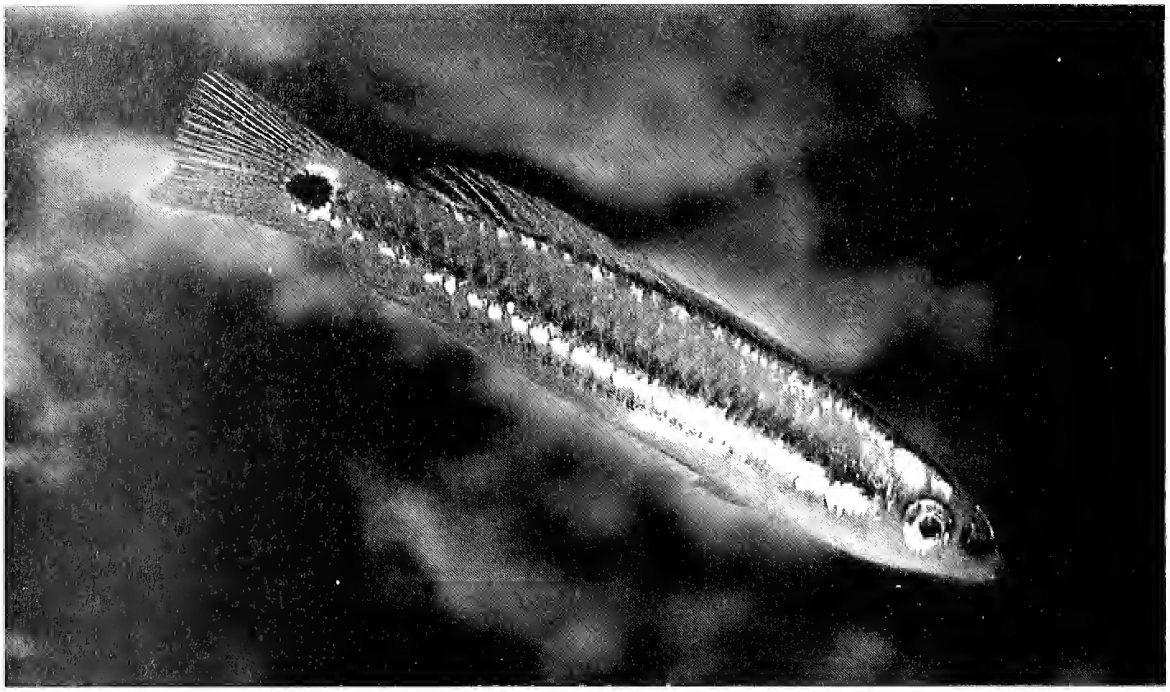

Figure 8. Schooling wrasse (*Halichoeres* sp. nov.). This is a very common wrasse that is known only from the Rhomboidal cays. Unlike most species of the genus, it occurs in large schools.

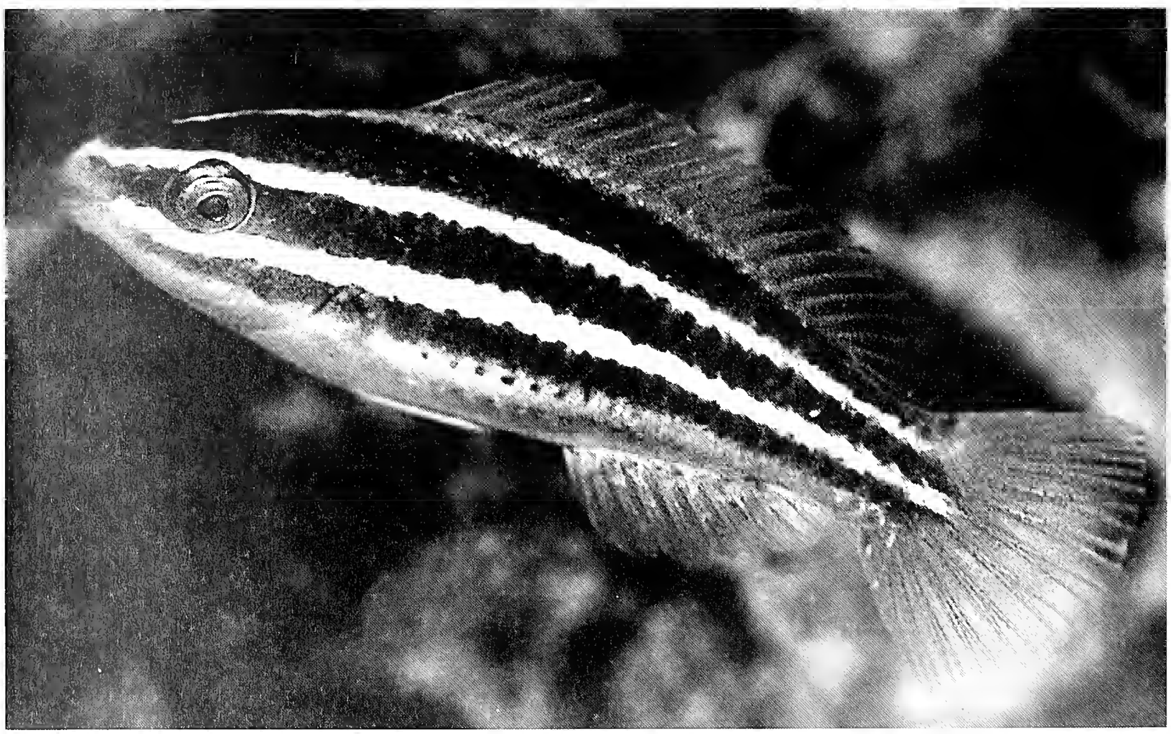

Figure 9. Striped parrotfish (*Scarus iserti*). This parrotfish is almost ubiquitous in the Pelican Cays. Although this juvenile has a complete white stripe across the snout, there are no dark dorsal and ventral margins on the base of the caudal fin as there would be in juveniles of the closely related princess parrotfish.

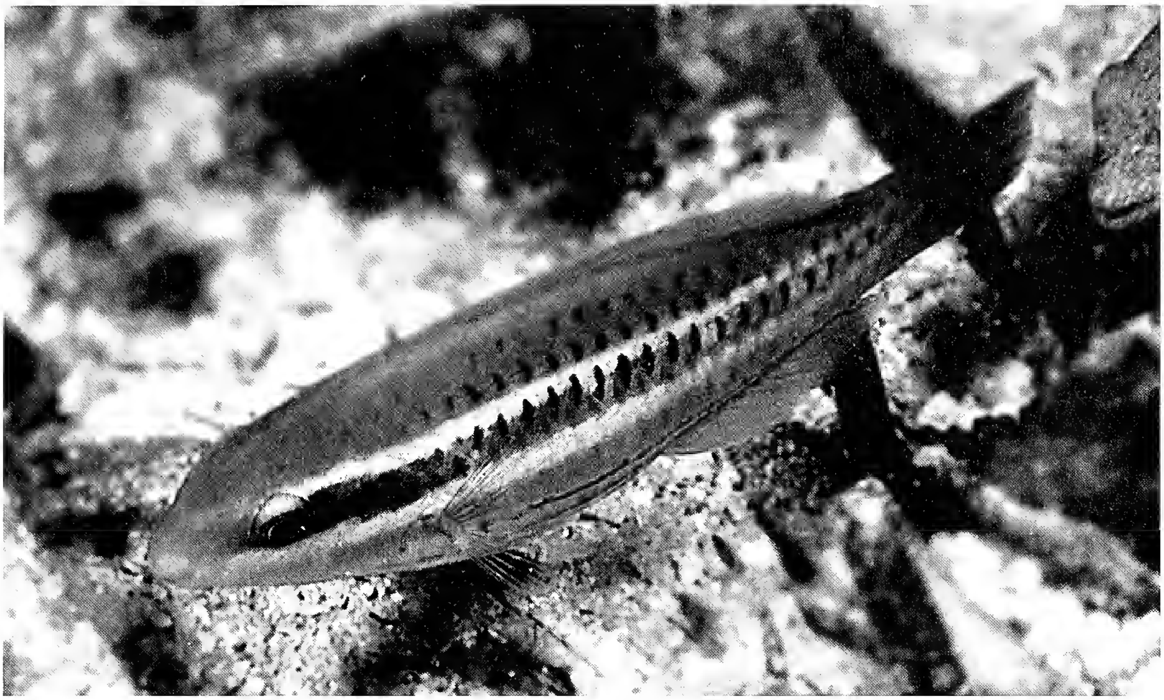

Figure 10. Striped parrotfish (*Scarus iserti*) from the Pelican Cays. Female.

Figure 11. Striped parrotfish (*Scarus iserti*) from the Pelican Cays. "Super-male."

Figure 12. Roughhead blenny (*Acanthemblemaria aspera*). In the Pelican Cays this species is found in much shallower water than in areas near Carrie Bow Cay and most other Caribbean localities.

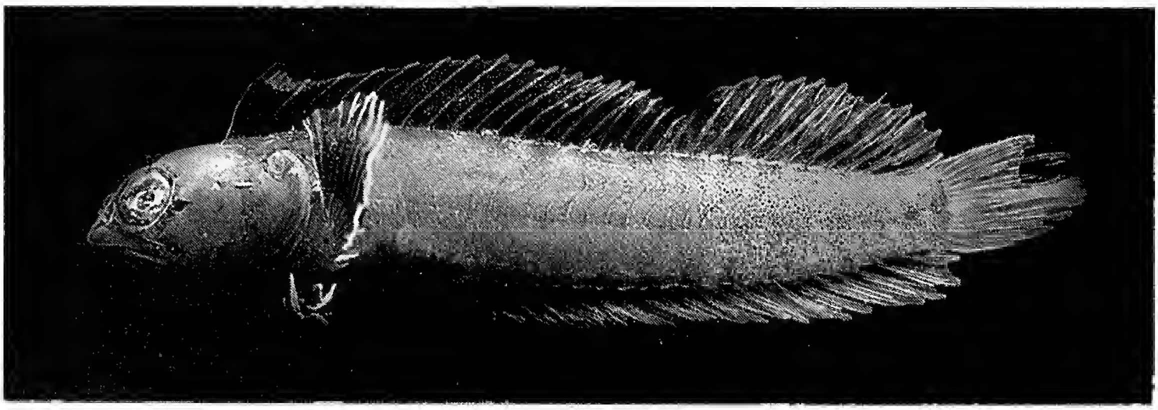

Figure 13. Redflag blenny (*Emblemariopsis* sp. nov.). To date this distinctive species is known only from the Rhomboidal Cays, Wee Wee Cay, and the Blue Ground Range.

Figure 14. Reticulate clingfish (*Tomicodon* sp. nov.). This is an uncommon species that is widespread on the Belize shelf but in the Pelican Cays it is known only from a small sand and rubble area along the northeast shore of Co-Cat Cay.

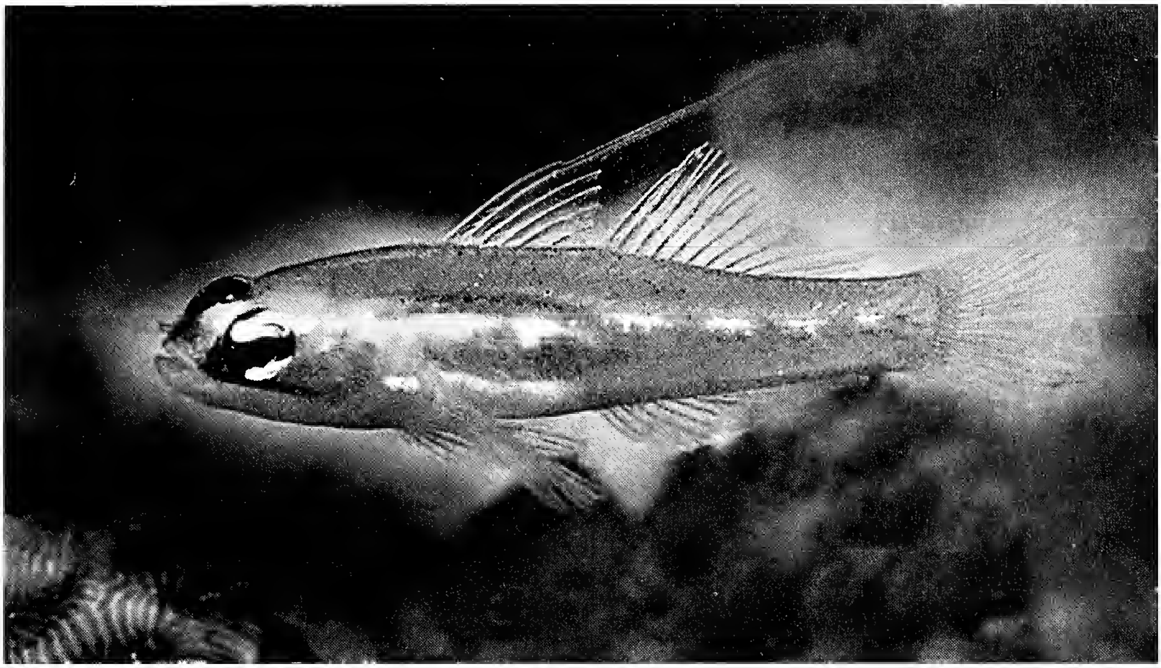

Figure 15. Masked goby (*Coryphopterus personatus*). This species can only be separated from the glass goby (*Coryphopterus hyalinus*) on the basis of minute features. We did not distinguish them in our visual surveys in the Pelican Cays.

Figure 16. Neon goby (*Elacatinus oceanops*). A common goby in the Pelican Cays that lives on the surface of living corals.

Figure 17. Yellowprow goby (*Elacatinus xanthiprora*). A common species of coral-dwelling goby in the Pelican Cays.

ATOLL RESEARCH BULLETIN

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STONY CORALS AND REEFS OF DOMINICA

BY

SASCHA C.C. STEINER

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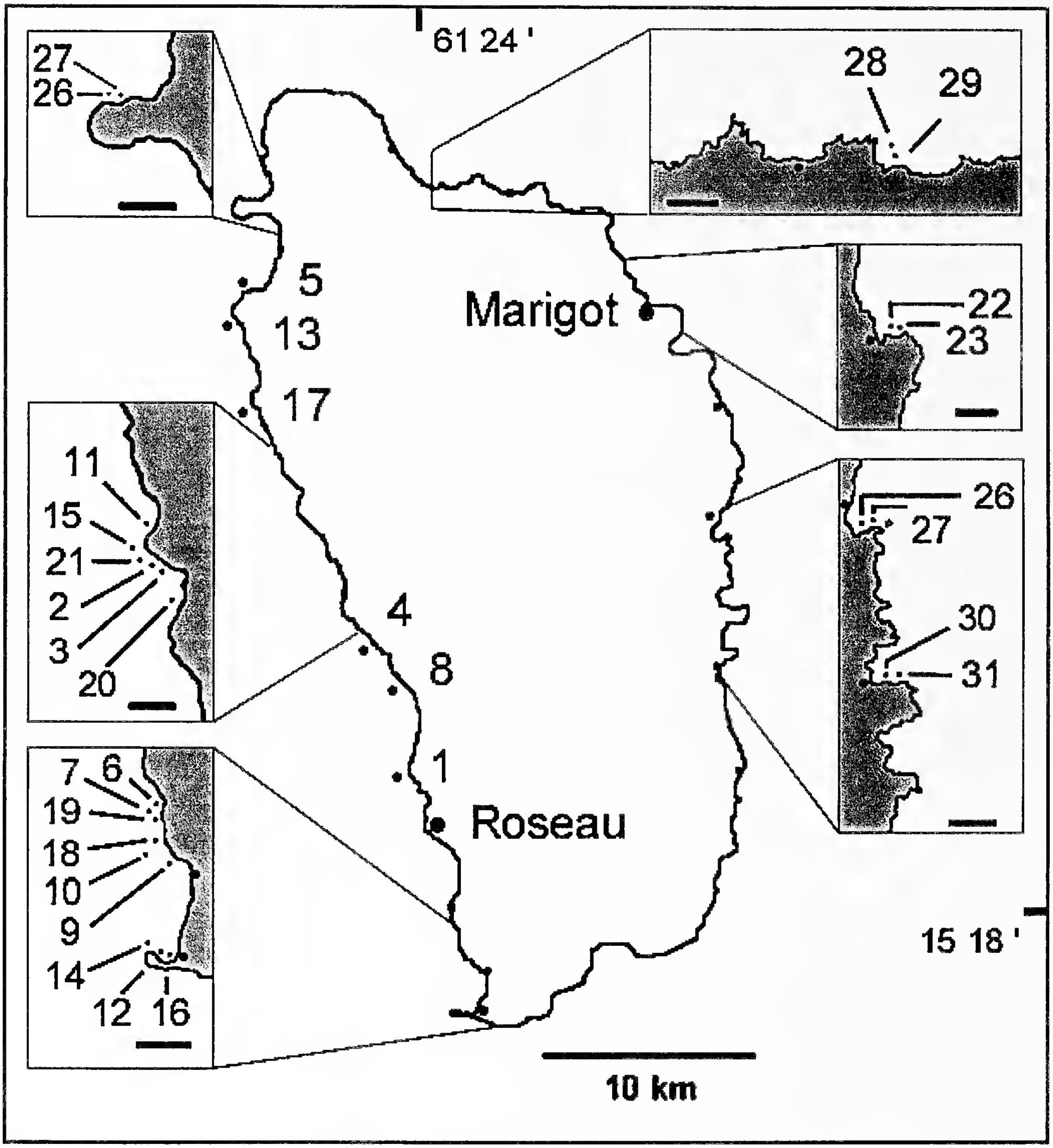

Figure 1. Commonwealth of Dominica, Lesser Antilles. Study sites. Scale bars in area boxes are 1 km.

STONY CORALS AND REEFS OF DOMINICA, LESSER ANTILLES

BY

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ABSTRACT

Thirty-six scleractinian coral species were identified *in situ* during the first comprehensive quantitative survey of reefs around the Commonwealth of Dominica. *Porites astreoides* dominated most assemblages within the 1,146 m^2 area examined, constituting 29.7 % of the total live coral recorded (166 m^2). The abundance of constructional, yet non-reef-building, species along the west coast may be one of the reasons for the paucity of reef accretion. Coral reefs in the strictest sense are found along the narrow shelf of the west coast where they are sheltered from turbulence by depth and coves. *Madracis mirabilis* was among the main reef builders, forming mono-, as well as bi-specific banks with *Porites porites*. East-coast reefs were characterized by patch and fringing reefs whose main scleractinan component were built by *A. palmata* frameworks. However, these reefs had a comparatively low live cover (9.25%). East-coast reefs (windward) were also significantly less diverse (ANOVA, F=9.1, P=0.01) than west-coast reefs (leeward), among which shallow sites (1-5 m) were significantly less diverse (ANOVA, F=16.2, P=0.01) than deeper sites (6-18 m).

A negative correlation was detected between the live cover of Scleractinia and other sessile invertebrate groups, mostly sponges, hydrocorals and zooanthids. No correlation between the presence of Scleractinia and algae was found. Given Dominica's young and narrow shelf, the assemblage types are harbored within a relatively small area suitable for reef development and lie in close proximity to the shoreline where coastal developments are the source of many disturbances. Coral reefs of Dominica can be considered as marginal systems yet a historically important artisanal fishing resource. Although it is doubtful that these reefal habitats have remained unaffected by human activities, new user groups are targeting Dominica's marine resources and thus the justification for conservation measures is suggested.

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INTRODUCTION

Dominica lies within the western and geologically younger arc of the Lesser Antillean volcanic islands, which include Saba, St. Eustasius, St. Kitts, Redonda, Montserrat, western portions of Guadeloupe, northern Martinique, central St. Lucia, and St. Vincent (see Martin-Kay, 1971). With an area of 750 km^2 and several mountain peaks above 1,000 meters, Dominica is among the least eroded islands of the region and characterized by a narrow shelf. Approximately 150 km^2 of shelf lie in waters shallower than 50 m. This is the extent of potentially suitable habitats for zooxanthellate Scleractinia, based on depth alone. However, given the island's many rivers and fluvial sediment outfalls, the area with stable substrates suitable for reef development is far smaller.

Until recently, reefs of Dominica have only been explored marginally by biologists. In the 1960s the Bredin-Archbold-Smithsonian expeditions to the island included studies on boring sponges (Rützler, 1971), archiannelids (Kristeuer, 1967), balanomorph barnacles (Ross, 1968), decapods (Raymond, 1970), and echinoids (Porter, 1966). Since then, only a few reports on the marine benthos have been produced (see Smith *et al.,* 1997), primarily consisting of non-peer-reviewed documents (Evans, 1997; Goodwin, 1985; Summers, 1985) focusing on a single area, the Soufriere Bay located in the south of the island.

Comprehensive surveys of Dominican reefal communities began in 1999 with surveys along the narrow shelf (50-300 m) of the west coast (leeward). Preliminary results showed coral assemblages with a mean live cover of 15% and a paucity of reef accretion (Steiner and Borger, 2000). In contrast, the northern and eastern (windward) shelf is wider (200–1200m) providing more potential coral habitat than the west coast. Given the trade-wind-driven surface currents, east- and north-coast coral populations may play an important role in reseeding leeward communities which are currently under the heaviest fishing pressure. Prior to this study, the exploration of coral communities along the Atlantic coast, notorious for its treacherous waters, had not taken place.

The assessment of Dominica's coral environments is in its infancy, yet the future holds renewed and increased disturbance levels, posing a variety of threats to this narrow band of coastal marine resources which have traditionally been areas of artisanal reef fisheries (line fishing, traps, seine nets). With the decline of the island's agro industries, following a series of boom and bust cycles over the past two centuries, Dominicans are migrating towards the increasingly crowded coastal settlements (Honychurch, 1995). Rain forests have reclaimed abandoned agricultural lands (Honychurch, 1995; pers com A. James, Forestry Division) and sediment runoff enhanced by deforestation is expected to decrease. The imminent sources of disturbance on an already marginal reef system include increased reef-fishing pressure, construction, and sewage fallouts. Furthermore, the marine environment has recently been targeted by the tourism industry to complement better established land-based tourism.

In light of this situation, and the fact that Dominica still represents a gap in our "upstream" (surface currents) Caribbean coral data base, this ongoing survey of live coral cover has the following objectives: (a) to establish the occurrence and geographic distribution of zooxanthellate constructional (*sensu* Schuhmacher and Zibrowius, 1985) scleractinian corals; (b) to ascertain site-specific scleractinian assemblage structure based on live cover of individual coral species, as well as the live benthic cover of other sessile invertebrates and algae; and (c) to provide a comprehensive reference point for future investigations and conservation measures. These objectives were addressed based on the first 31 detailed quantitative and qualitative site surveys, encompassing 1,146 m^2 of benthos from Dominica's eastern, northern, and western coasts.

METHODS

Data Collection

A 1 m^2 quadrat subdivided into 100 squares of 100 cm^2 was used to estimate the percent live cover of individual scleractinian species, non-scleractinian sessile invertebrates (sponges, soft corals, and hydrocorals) and algae *in situ* at 31 sites (Fig. 1). Actinians, zoanthids, and sabellid polychaetes that formed patches were also included in the measurements. Encrusting calcareous algae such as *Porolithon* were not included in this survey. Coral species identification was based on Cairns (1982), Wells (1973), Humann (1994), Smith (1971) and Weil and Knowlton (1994). Counts of *Meandrina meandrites* may include *M. memorialis*. A few colonies of an unidentified *Porites sp.* were observed at sites 26, 27 (east), 28, and 29 (north). Similar to the general colony habitus of *P. astreoides*, this coral displays a whitish coloration with a pale blue tint. Tentacles of brown-to-reddish shades appear in stark contrast. All colonies observed formed more or less hemispheric mounds of up to 100 cm^2. In this study *Porites sp.* was included in the *P. astreoides* count.

Organisms ≥ 50 cm^2 were recorded and their benthic cover was estimated. Organisms and colonies smaller than 50 cm^2 were noted as present but not included in subsequent data analysis. Using a sample size of 20 m^2, the quadrat was placed at 1 m intervals along a transect line temporarily installed perpendicular to the shelf slope. The starting points were selected in a strategic manner so that sand patches larger than 3 m in diameter could be avoided. A total of 1,146 m^2 of live benthic cover across 31 sites (Fig.1) were thus quantitatively assessed. The field data were collected in May 1999, March-May 2000, June-Oct 2001, and May-Aug 2002. Sites deeper than 3 m were surveyed using scuba.

Data Analysis

The abundance of scleractinian species was categorized based on the percent live cover in order to create a semi-quantitative species reference list. Individual species making up $\geq$10% of the total live coral cover were considered abundant and those with 1-9.9% cover were regarded as common. Species that contributed less than 1% of the total coral cover were regarded as uncommon while those identified at the study sites, but not within the surveyed area, were considered to be rare (Table 1). Species identified outside of study sites also were recorded but their abundance was not weighed. The presence of individual species across all sites was expressed as percent site overlap. Scleractinian diversity (H') and evenness (J'), based on live cover at each site, were calculated using the Shannon and Wiener (1948) diversity and Pielou (1966) evenness indices respectively.

Similarity among sites, based on species-specific live cover at each site, was discerned with the Bray Curtis similarity cluster analysis. Non-metric multidimensional scaling was used to depict differences in the cover of Scleractinia, non-scleractinian invertebrates, and algae among all sites. All calculations were performed in Primer v5 (Clarke and Gorley, 2001). Coral-cover data were square-root transformed to reduce the masking patterns of rare species by common and to thus better depict the role of rare species in the differentiation of site-specific species assemblages.

RESULTS

Species Occurrence and Benthic Cover

Thirty-six species of stony corals were identified *in situ* (Table 1). Thirty of these species occurred within the 1,146 m^2 surveyed, and the others were identified outside the sample area. *Porites astreoides, Porites porites* and *Agaricia agaricites* occurred at all sites.

A total of 14.6% of the sample area, or 166.8 m^2, was covered by live coral tissue. The most abundant species in terms of live cover was *Porites astreoides* (Fig. 2) constituting 4.3% of the surveyed area or 29.7% of the total live cover recorded. *Porites astreoides, Madracis mirabilis, P. porites, A. agaricites,* and *Meandrina meandrites* made up 66% of the live coral cover. The remaining 54% was composed of 26 other coral species.

Live coral cover ranged from 2.25% to 31.88% (Table 2) with a mean cover of 9.25% for east-coast assemblages which differed significantly from the west coast assemblage with a mean cover of 16.68% (ANOVA, F=7.97, P=0.01). The overall mean coral cover was 14.77%. The mean evenness (J') of distribution of species-specific live cover (Fig. 3) was 0.78 (SD = 0.21). Excluding species that occurred at less than 20% of the sites resulted in a mean evenness (J') of distribution of 0.8 (SD =0.1).

Geographic differences in species occurrence were noted for *Acropora ormosa* which was one of the dominant corals on east-coast reefs but virtually absent along the west coast. Subtle differences in species occurrence were observed in *Isophyllia sinuosa* commonly found in northwestern and eastern reefs, yet rare in southwestern reefs. Alternatively, *Eusmilia fastigiata* was commonly found in southwestern reefs but was rare in other regions of Dominica. Other species displayed a more patchy occurrence. For example, *Dichocoenia stokesii* was commonly seen in northwestern and southwestern reefs but was less common in central-western regions of Dominica.

Table 1. Scleractinian abundance and site overlap. Abundant: ≥10 % of total live coral cover surveyed (166.7 m^2); common: 1 % - 9.9% of total live coral cover; uncommon: ≤ 0.9% of total coral cover; rare: not present within surveyed area. Only colonies with a size of 50 cm^2 or more were considered. The presence of species across sites is expressed as % site overlap.

	Species	Abundance	Site Overlap (%)
1	*Stephanocoenia intersepta* (Milne Edwards and Haime, 1848)	uncommon	73.3
2	*Madracis mirabilis* (Duchassaing and Michelotti, 1860)	abundant	53.3
3	*Madracis decactis* (Lyman, 1859)	common	46.7
4	*Madracis ormosa* (Wells , 1973)	rare	n/a
5	*Acropora palmata* (Lamarck, 1816)	uncommon	4.8
6	*Siderastrea siderea* (Ellis and Solander, 1786)	common	93.3
7	*Siderastrea radians* (Pallas, 1766)	uncommon	20.0
8	*Agaricia agaricites* forma *agaricites* (Linnaeus, 1758)	common	100.0
	Agaricia agarcites forma *purpurea* (Lesueur, 1821)	rare	n/a
9	*Agaricia fragilis* (Dana, 1884)	rare	n/a
10	*Agaricia humilis* (Verill, 1901)	rare	n/a
11	*Agaricia* spp. (mostly *A. lamarcki)*	common	33.3
12	*Leptoseris cucullata* (Ellis and Solander, 1786)	uncommon	33.3
13	*Meandrina meandrites* (Linnaeus, 1758)	abundant	86.6
14	*Dichocoenia stokesii* (Milne Edwards and Haime, 1848)	uncommon	46.7
15	*Dendrogyra cylindrus* (Ehrenberg, 1834)	uncommon	13.3
16	*Mussa angulosa* (Pallas, 1766)	uncommon	6.7
17	*Scolymia* sp.	rare	n/a
18	*Isophyllia sinuosa* (Ellis and Solander, 1786)	uncommon	26.7
19	*Isophyllastrea rigida* (Dana, 1848)	rare	n/a
20	*Mycetopyllia aliciae* (Wells, 1973)	uncommon	13.3
21	*Mycetophyllia ferox* (Wells, 1973)	rare	n/a
22	*Favia fragum* (Esper, 1797)	uncommon	26.7
23	*Colpophyllia natans* (Houttuyn, 1772)	common	80.0
24	*Diploria strigosa* (Dana, 1848)	common	80.0
25	*Diploria clivosa* (Ellis and Solander, 1786)	uncommon	46.7
26	*Diploria labyrinthiformis* (Linnaeus, 1767)	uncommon	20.0
27	*Montastraea annularis* (Ellis and Solander, 1786)	common	20.0
28	*Montastraea faveolata* (Ellis and Solander, 1786)	common	80.0
29	*Montastraea franksi* (Gregory 1895)	uncommon	6.7
30	*Montastrea cavernosa* (Linnaeus, 1767)	uncommon	66.7
31	*Eusmilia fastigiata* (Pallas, 1766)	uncommon	26.7
32	*Porites porites* (Pallas, 1760)	common	100.0
	Porites porites forma *divaricata*	rare	n/a
33	*Porites astreoides* (Lamarck, 1816)	abundant	100.0
34	*Porites* sp.	rare	n/a
35	*Porites colonensis* (Zlatarski, 1990)	uncommon	20.0
36	*Tubastrea coccinea* (Lessuer, 1829)	rare	n/a

Table 2: Dominican coral assemblages by geographic region. Assemblage types [WSN: windward, shallow (1-5m) and near-shore (within 100m); LSN: leeward, shallow and near-shore; LDN: leeward, deep (6-18 m) and near shore; LDO: leeward, deep and off-shore (beyond 100m)] in relation to area surveyed, live coral cover (%), species richness (n), species diversity and evenness expressed as H' and J' respectively. Values (n) include species present at the site in sizes less than 50 cm^2 which were not included in the calculation of H', but taken into account for the calculation of H' max.

Location	Type	Area	% Live Cover	n	H'	H'max	J'
North Coast							
Hodges Bay S (Site 28)	WSN	40m^2	14.39	9	1.23	1.20	1.03
Hodges Bay N (Site 29)	WSN	40m^2	9.98	7	1.21	1.95	0.62
East-Coast Northern Region							
Marigot Middle Bay W (Site 22)	WSN	40m^2	14.64	6 (7)	1.24	1.95	0.64
Marigot Middle Bay E (Site 23)	WSN	40m^2	11.93	8	1.14	2.08	0.55
East-Coast Central Region							
Castle Bruce SW (Site 26)	WSN	40m^2	3.98	5	1.31	1.61	0.80
Castle Bruce SE (Site 27)	WSN	40m^2	5.76	6	1.53	1.79	0.85
Saint Sauve W (Site 30)	WSN	40m^2	8.96	8	1.45	2.08	0.67
Saint Sauve E (Site 31)	WSN	40m^2	4.36	7	0.93	1.95	0.48
West-Coast Northern Region							
Tabby Bay S, (Site 5)	LSN	40m^2	7.58	13	1.71	2.56	0.67
Point Ronde S (Site 13)	LSN	40m^2	11.08	12	1.92	2.48	0.77
Coubari Bay (Site 17)	LSN	40m^2	6.75	15(18)	1.77	2.89	0.61
Cabrits NE (Site 24)	LDN	40m^2	17.13	14	1.85	2.64	0.70
Cabrits NW (Site 25)	LDN	40m^2	12.66	15	2.09	2.71	0.71
West-Coast Central Region							
Woodbridge Bay North (Site 1)	LSN	40m^2	21.01	14 (15)	1.26	2.71	0.46
Salisbury Bay North C (Site 2)	LSN	40m^2	21.55	13	1.33	2.56	0.52
Salisbury Bay North W (Site 3)	LSN	20m^2	21.28	13	1.40	2.56	0.55
Tarou Point (Site 4)	LSN	40 m^2	12.14	15	2.00	2.75	0.73
Les Point (Site 8)	LSN	36 m^2	2.25	6(7)	1.49	1.95	0.76
Floral Gardens NW (Site 11)	LSP	40 m^2	16.69	17(18)	2.10	2.89	0.73
Rena's (Site 15)	LDN	40 m^2	18.58	17(18)	1.93	2.89	0.67
Mero Mirabilis (Site 20)	LDO	30 m^2	29.95	6	0.48	1.79	0.44
Nose Reef (Site 21)	LDO	40 m^2	15.19	14(15)	2.07	2.75	0.75
West Coast Southern Region							
Champagne E (Site 6)	LSN	40m^2	17.79	12(14)	1.40	2.64	0.53
Champagne S (Site 19)	LSN	20m^2	19.68	9	1.15	2.20	0.52
Champagne W (Site 7)	LDN	20m^2	13.58	15(16)	2.13	2.77	0.77
Soufrière N (Site 9)	LDO	20m^2	11.63	11(12)	1.87	2.48	0.75
Pinnacles (Site 10)	LDO	40m^2	21.79	15(16)	1.85	2.77	0.67
Scotts Head N C (Site 12)	LSN	40m^2	31.88	10	1.51	2.30	0.66
Scotts Head NW (Site 14)	LDN	40m^2	12.83	10(11)	1.80	2.40	0.75
Scotts Head NE (Site 16)	LDN	40m^2	17.36	14(15)	1.96	2.75	0.71
Coral Gardens (Site 18)	LDO	40m^2	23.34	14(16)	1.86	2.77	0.67

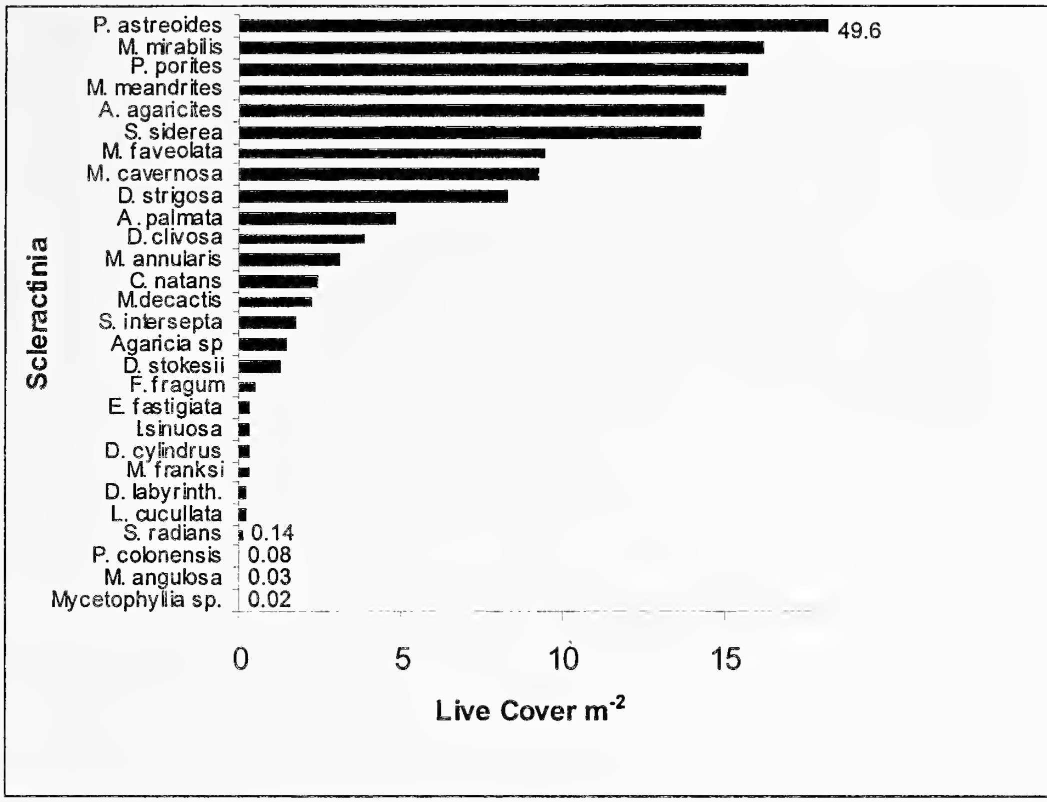

Figure 2: Total live cover (m^2) of individual Scleractinia.

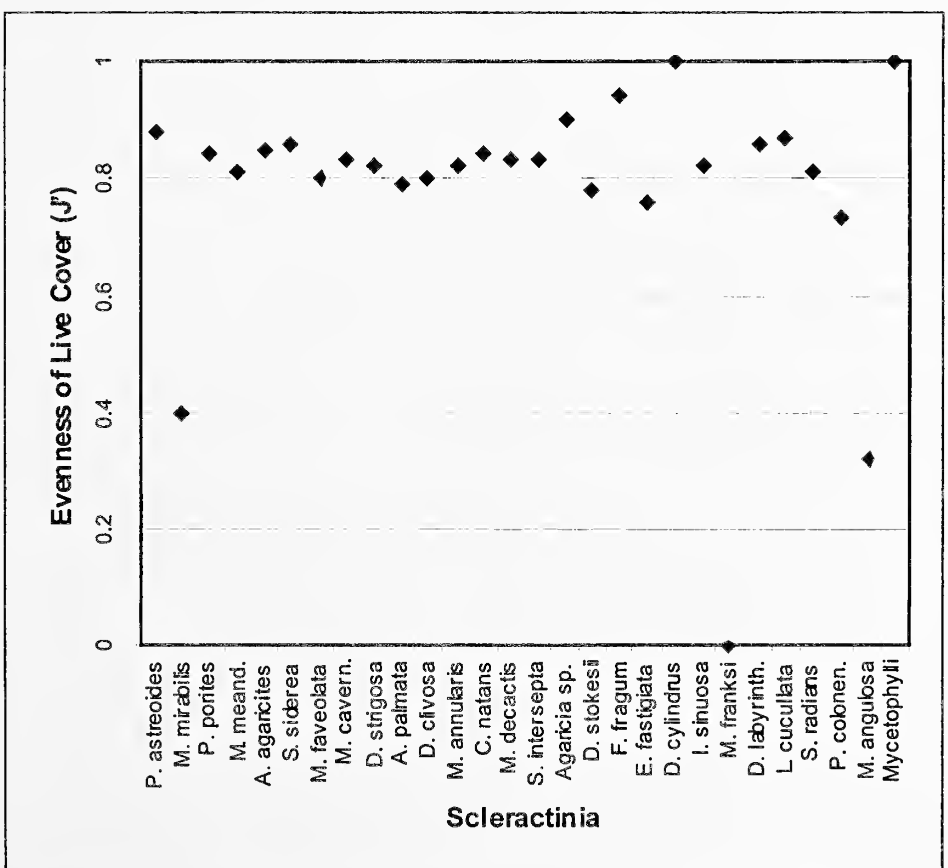

Figure 3: Evenness (J') of live cover distribution of individual Scleractinia.

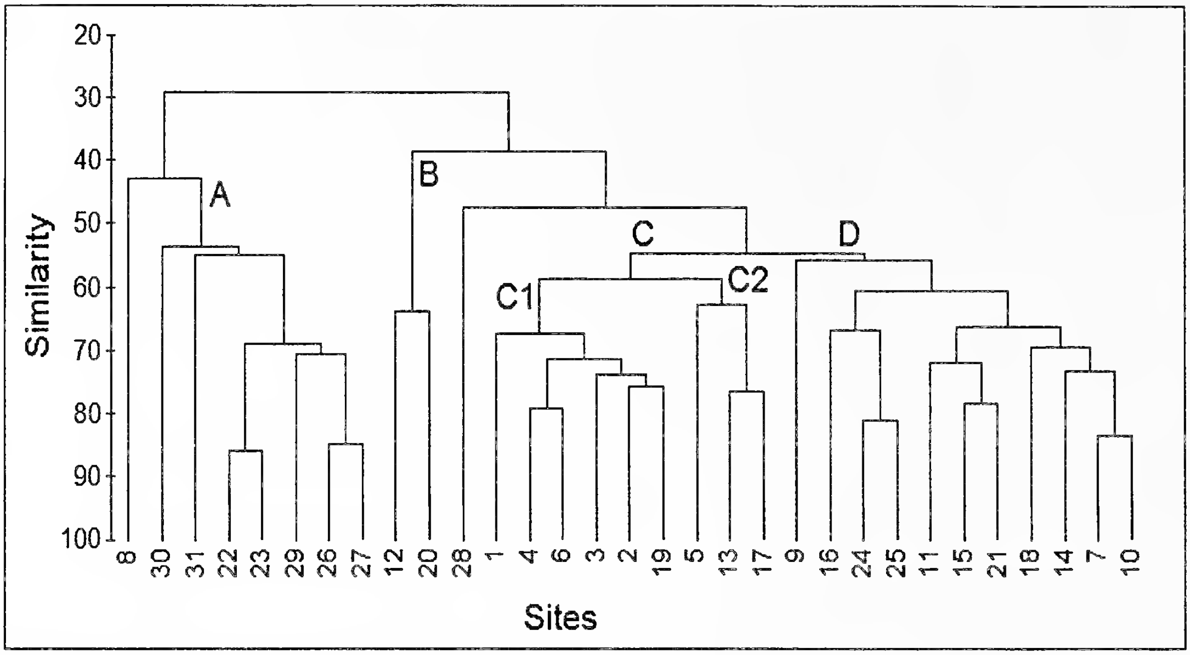

Figure 4: Bray-Curtis similarity among sites based on species-specific scleractinian cover.

Species Diversity

Species diversity expressed as H' ranged from 0.48 to 2.13 (Table 2). A significant difference (ANOVA, F=9.1, P=0.01) was noted between the diversity of east-coast assemblages (mean = 1.26) and those of the west coast (mean = 1.69). Among the west-coast assemblages, deeper sites (group D, 6-18m, Fig. 4) with a mean H' of 1.96 were more diverse than shallow sites (group C, 1-5m, Fig. 4) with a mean H' of 1.55 (ANOVA, F=16.2, P=0.01). Overall, comparatively high diversity values (H'>1.5) occurred at sites sheltered by depth or topographic features like coves.

Similarities Among Assemblages

Based on the comparison of species-specific live cover, east- and west-coast coral assemblages could be differentiated (Fig. 4). East-coast sites (Group A, Fig. 4) were characterized by comparatively low species richness and live cover and the presence of *A. ormosa* as one of the dominant corals. These sites also included *A. ormosa* frameworks, some of which have formed patch and fringing reefs. In contrast, the west-coast assemblages were characterized by higher coral cover, species richness, and diversity (see above).

Among the west-coast sites, two main groups (Groups C and D, Fig. 4) could be differentiated. Within Group C, subgroup C1 constitutes the assemblages in the southern and central regions of Dominica's west coast, while subgroup C2 constitutes those of the northern west coast. Group D contained assemblages that show signs of reef accretion, such as massive structures of carbonate buildup, which are absent at all but two other west-coast sites. The two exceptions were sites 12 and 20 (Group B, Fig. 4). Site 12 is dominated by large banks of bi-specific assemblages of *P. astreoides* and *M. mirabilis.*

Site 20 harbors mono-specific assemblages of *M. mirabilis*. Both of these sites are characterized by massive banks greater than 500 m^2 and have up to 3-5 meters of vertical (carbonate) accretion.

Two sites that did not fit the east-west differentiation were 8 and 28 (Fig. 4). Site 8 had comparatively few coral species with low benthic cover and was dominated by hydrocorals and sponges. Site 28, although a west-coast site harboring *A. ormosa*, was characterized by comparatively large amounts of *Siderastrea ormosa* and *Montastraea faveolata*, more typical for sheltered west-coast assemblages.

Scleractinia, Non-Scleractinian Sessile Invertebrates and Algae

Non-scleractinian sessile invertebrates were dominated by sponges and encrusting cnidarians such as the hydrocoral *Millepora* spp and the zooanthid *Playthoa caribeorum*. With the exception of *Sargassum* sp., fleshy macroalgae dominated the algal component at sheltered sites while filamentous turf algae dominated turbulent sites. A negative correlation was evident when comparing total coral cover to that of non-scelaractinian invertebrates ($r = -0.47$, $P = 0.05$). Similar comparisons to macroalgae rendered no significant correlation. Nevertheless, using MDS techniques, differences in the site-specific abundance presence of the three organism groups could be visualized (Figs. 5, 6, 7 and 8).

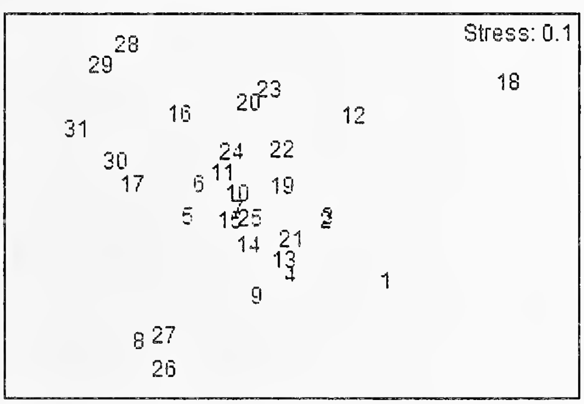

Figure 5: MDS Distribution

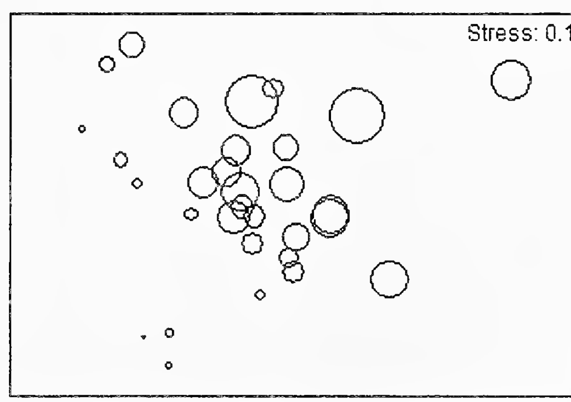

Figure 6: MDS Distribution of scleractinian cover

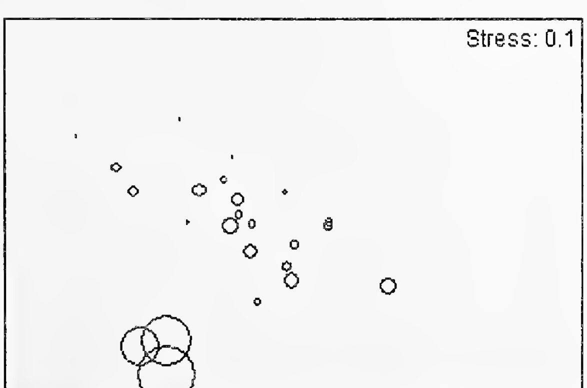

Figure 7: MDS Distribution on non-scleractinian sessile invertebrate cover.

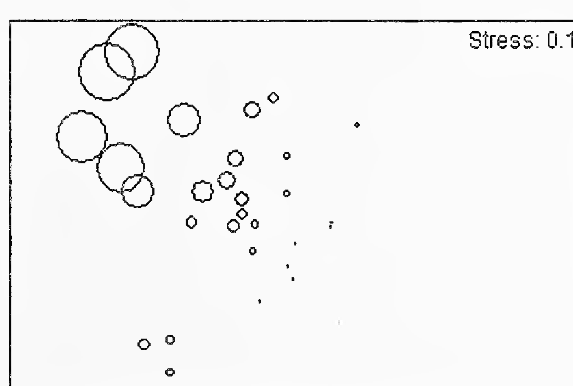

Figure 8: MDS Distribution of macroalgal cover.

DISCUSSION

Species Richness

Thirty-six species of Scleractinia were identified in this study. This represents the first comprehensive list and, so far, largest number reported for Dominica (compare to Summers, 1985). The species listed in this study include various formae and ecomorphs, which are considered to be separate species by some researchers. Hence, the species count for Dominica depends on the species differentiation applied. All but two species identified have a fairly broad geographic range of distribution across the wider Caribbean. *Tubastrea coccinea*, however, is known to have a random and isolated distribution (Cairns, 2000; Fenner, 2001). In Dominica, *T. coccinea* has been identified in only two locations near site 19 (Fig. 1). *Porites sp.* was found at several shallow and very turbulent sites on the east and north coasts. Corals fitting the general description of *Porites sp.* from Dominica were also observed in Los Roques (Venezuela), The Netherland Antilles, and Jamaica (E. Weil, pers. com.) Additional surveys may lead to the identification of further species such as *A. cervicornis* which has so far only been found in the form of skeletal remains.

Coral Assemblages

Dominica's zooxanthellate scleractinian assemblages are dominated by "constructional" species (*sensu* Schumacher and Zibrowius, 1985), such as *P. astreoides* and *M. meandrites*, rather than hermatypic species like *M. faveolata* (Fig. 2). This may account for the overall paucity of reef accretion observed in Dominica. In most reefal settings of the west coast, corals grow on volcanic rock. Carbonate frameworks are rare as are coral reefs in the strictest sense. Where reef accretion is evident, assemblages are sheltered from turbulence by depth or coves. These sites could be considered to have "intermediate disturbance levels" (*sensu* Connell,1978) with regard to turbulence.

Interestingly, one of the main reef-builders on the west coast is *M. mirabilis* (Fig. 2 and Group B, Fig. 4) which forms mono-specific as well as bi-specific assemblages with *P. porites* (Steiner and Borger, 2000). It appears that the delicate, branching colony morphology of *M. mirabilis* enhances the fallout of sediment. Analogous to the "race" between sedimentation and growth rates in sea-grass beds that lead to the formation of rhizome layers (Ott, 1988), sediments accumulate between the branches of *M. mirabilis* assemblages thus solidifying the bioherm and leading to the formation of large banks. Similar aggregations were reported for the Indo-Pacific and eastern Pacific (Cortés, 1997), the western Arabian Sea (Glynn, 1993) and the Gulf of Aden (Kemp and Benzoni, 1999). For the west coast as a whole, *M. mirabilis* is among the most successful reef-building corals (see also Fig. 4, Group B) and its role as part of Dominica's reefal communities deserves further attention.

In contrast to the west coast, *A. palmata* is the main hermatypic scleractinian component of east-coast fringing reefs. However, these reefs are marked by low live cover (Table 2), possibly associated with the wide-spread decline of *A. palmata* which was also reported for the eastern Caribbean island of Barbados (Lewis, 1984). So while the east coast does harbor “true coral reefs”, they are mostly dead.

Differences between the leeward (west, Groups B, C, and D, Fig. 4) and windward (east, Group A, Fig. 4) coral assemblages were also evident with regards to species richness, diversity and live cover (Fig. 4). The west coast harbors the more diverse assemblages with a higher live cover (Table 2). However, the surveys carried out along the east coast to date do not include sites deeper than 6m. It is therefore unknown whether the lower diversity and live cover seen in east-coast shallow reefs is an indication of the type of assemblages to be expected in deeper waters. In comparison to the west coast where deeper reefs (6-8 m) were more diverse and marked by a higher percent live cover (Table 2), deeper reefs of the east coast may also have greater diversity and live cover.

The question remains, why are there only few signs of reef accretion on the leeward side where larger number of species provide larger live benthic cover compared to east-coast reefs? One explanation is related to Dominica’s young volcanic topography. The western shelf of the island is narrow (50-500 meters) and steep, providing no energy-dissipating features. Storms thus impact coastal environments with full force. It is likely that entire coral colonies or fragments are either washed onto shore during storm events, as happened during Hurricane Lenny in November 1999 (pers. obs.), buried in the sandy shelf, or transported into aphotic depths. Thus, the survival of coral fragments would be minimal and the frequency and intensity of storm-related disturbances would be among the controlling forces of reef accretion. In addition, the close proximity of fluvial sediment fallouts have certainly also influenced reef development (Scleractinia, non-scleractinian invertebrates and macroalgae), especially during the 19^{th} century when agriculture–related deforestation was at its peak.

The comparison of scleractinian cover and that of other heterotrophic and autotrophic benthic groups may render valuable perspectives on the status of coral assemblages and reefs. Although not the main focus of this study, the non-scleractinian data serve as reference points for the detection of potential future phase shifts as described for Jamaica (Hughes 1994) and Panama (Lessios, 1995), and are evaluation factors in the density of algae and vagile reef consumers. In Dominica, the 18% increase of *Diadema antillarum* from 2001 to 2002 coincided with a 15% decrease of turf and macroalgae combined (Steiner and Williams, in prep). Should this trend continue an increase in coral cover may follow although increased echinoid grazing pressure may reduce coral recruitment rate.

CONCLUSIONS

The data presented here underline the fact that Dominica’s reefal environments are diverse in terms of species richness but not in terms of live cover and physical structure (reef accretion). Having a relatively small total surface area, these marginal systems are “clinging” to the narrow shelf and lie in close proximity to Dominica’s urban developments. There is no question that conservation measures are valid and necessary should this natural resource be protected. Furthermore, a patchy array of coral ssemblage types constitutes the reef resources of Dominica. The patchiness is evident in the scattered presence of stable substrates adequate for coral growth due to the extensive sandy areas produced by fluvial sediment outputs. It is also evident in the benthic cover and geographic distribution of individual species. Not all species that have an overall high percent of coral cover are present in a high number of locations (Table 1). Consequently, individual types of coral communities cover an even smaller surface area than the already limited scleractinian cover of the island. These features of Dominica's coral assemblages are key reference points in evaluating the adequacy of indiscriminate or "across-the-board" conservation measures such as site-use allocation.

Given the relatively small area suitable as coral-reef habitat and a coral cover that is influenced by the shelf morphology with its absence of energy-dissipating features, these coral communities represent a limited and fragile natural resource. Considering the effects of (a) hurricanes on narrow-shelved islands which have been poorly recorded in Dominica but were well-documented in the neighboring islands of Guadeloupe and Martinique (Bouchon and Laborel, 1986; Bouchon *et al.*, 1991), (b) deforestation between the late 18th and early 20th century (Honychurch, 1995), as well as (c) over-fishing on reefs throughout the 20th century (pers. com. H. Guiste; IRF/CCA, 1991), it is probable that such a system has been negatively affected by human activities and that it will not remain in its current condition. Statements such as "the low population level and lack of extensive coastal development has meant that reef communities have not been severely impacted by human activities" (Smith *et al.*, 1997) are not convincing and relay a false sense of security. On a small island like Dominica, the overall population may be low (~ 71,00 in 2001), yet approximately 90% of the population is living along the shores (Commonwealth of Dominica, census 2001) and is using the marine resources on a daily basis in extractive and intrusive ways. Thus, human impacts originating from past and current resource uses are to be expected (see Jackson, 1997). It is, and will be, challenging to conserve these reefal resources in light of their marginal scale and the array of natural and anthropogenic disturbances that are, and have been, affecting Dominica's marine environments.

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CORAL COMMUNITY STRUCTURE OFF THE PACIFIC COAST OF COLOMBIA: ONSHORE *VS* OFFSHORE CORAL REEFS

BY

BERNADO VARGAS-ÁNGEL

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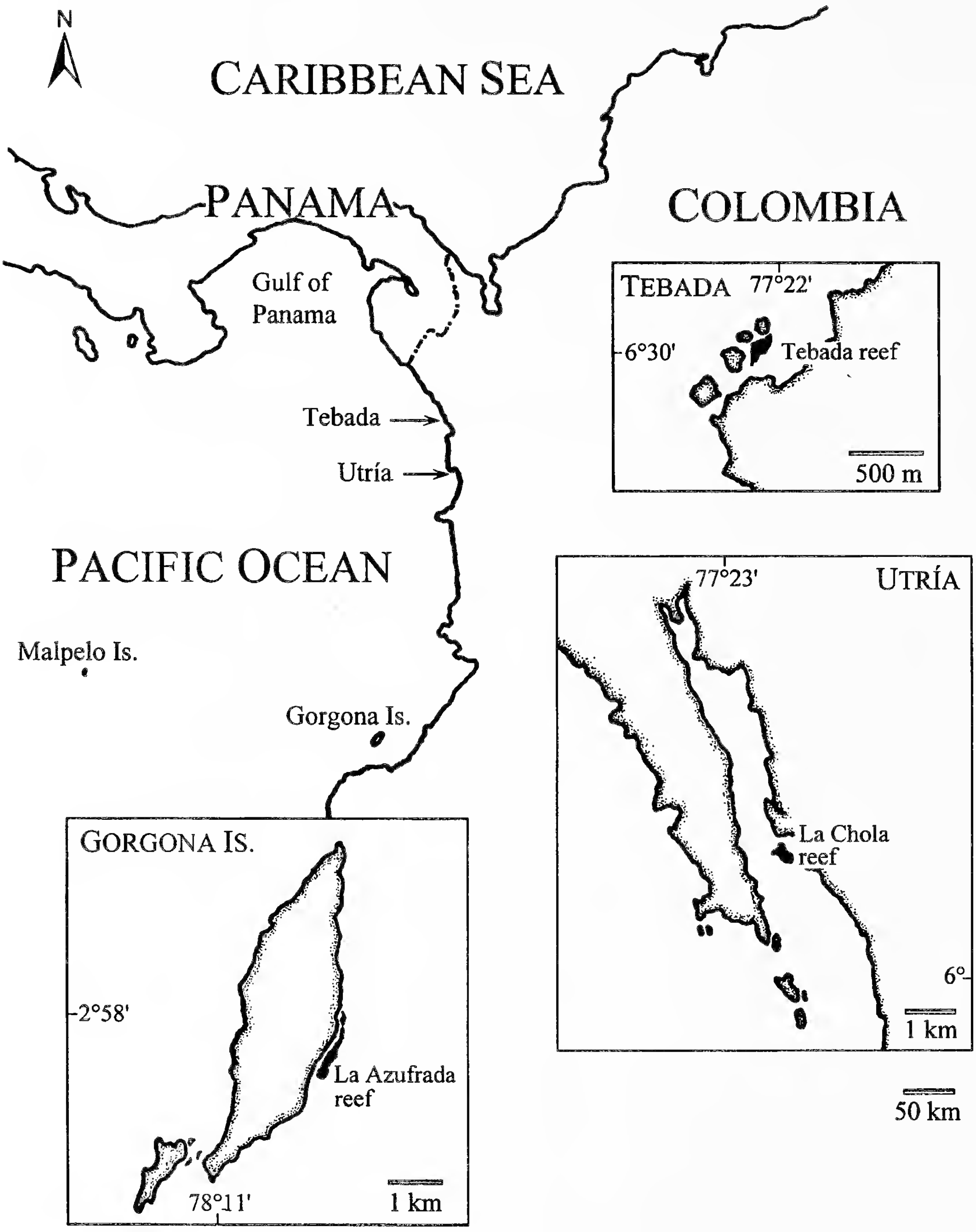

Figure 1. Location of study reefs surveyed on the Pacific coast of Colombia. In detail (inserts) Gorgona Island, Ensenada de Utría, and Tebada. Coral reefs are indicated in black (after Vargas-Ángel, 1996, 2001).

CORAL COMMUNITY STRUCTURE OFF THE PACIFIC COAST OF COLOMBIA: ONSHORE *VS* OFFSHORE CORAL REEFS

BY

BERNARDO VARGAS-ÁNGEL[1]

ABSTRACT

Between 1996 and 1998 a quantitative assessment of coral community composition was conducted for three coral reefs off the Pacific coast of Colombia: La Azufrada reef (offshore); and La Chola and Tebada reefs (onshore). Several parameters were measured, including percent live and dead coral cover, algal cover, species richness, as well as the population densities of the corallivorous pufferfish *Arothron meleagris* and the sea urchin *Diadema mexicanum*. These parameters were contrasted within and among reefs in order to quantitatively describe and evaluate coral community structure in the region. All reefs exhibited paucispecificity. Zooxanthellate scleractinian species richness was high at La Azufrada reef (11 species), and lower at Tebada and La Chola reefs (six and five species respectively). Differences in generic composition were observed among reefs; *Pocillopora* was dominant at La Azufrada and La Chola, and *Psammocora* at Tebada. Mean percent coral cover also differed significantly among reefs; it was nearly 40% at the onshore localities and over 70% at the offshore site. Population densities of pufferfish and sea urchins were higher offshore than onshore. La Azufrada was the only reef to exhibit ecological differences among reef zones, namely 1) percent live coral cover; 2) coral species richness; and 3) turf algal cover. Differences among reef zones at the onshore sites were not statistically significant; the variability within reef zones was greater than among reef zones.

The results of this study were related with data for sea-surface temperature, insolation, sedimentation, freshwater discharge (rainfall and river discharge) and ocean-circulation patterns, as these measures of environmental variability may affect coral community composition. Coral cover and degree of community complexity (e.g., ecological differences among reef zones) were highest at the offshore locality where insolation was high and sedimentation low. Elevated freshwater discharge may limit coral larval dispersal and recruitment to the downstream onshore coral communities. Finally, extreme high- and low-water temperatures (El Niño-Southern Oscillation) and terrestrial runoff also appear to be important community-structuring determinants.

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INTRODUCTION

Quantitative descriptions of coral-reef community ecological characteristics are desirable for studies of reef dynamics across spatial scales. Detailed knowledge of coral community structure is also important to evaluate cause-effect relationships during/after environmental disturbances (Dustan and Halas, 1987). The need for such data has stimulated the study and documentation of local coral community composition and the possible causes of ecological differences within and across regions.

Eastern Pacific coral reef biota can offer an advantage in interpretative ecological studies due to the often marginal environmental conditions in which they occur (Glynn and Ault, 2000). Zonation and ecological partitioning in these marginal systems can be caused by recurrent and/or chronic disturbances which result in mass mortalities or the suppression of otherwise dominant species (see Riegl, 1999; Riegl and Riegl, 1996). Extensive research conducted in Panama, Costa Rica, and the Galapagos Islands has contributed substantially to our understanding of eastern Pacific coral-reef ecology and biogeography (Glynn, 1976; Glynn and Wellington, 1983; Cortés, 1990; Guzmán and Cortés, 1993; Glynn and Maté, 1996; Fong and Glynn,1998; and Glynn and Ault, 2000). Coral reefs of the Pacific coast of Colombia so far have received little attention (Vargas-Ángel, 1996; Vargas-Ángel, 2001; and Zapata and Vargas-Ángel, in press), and a quantitative assessment of community status and variability across spatial and temporal scales is still needed.

The purpose of this study is to address coral community variability on the Pacific coast of Colombia as it relates to onshore and offshore localities. It provides information pertaining to: 1) coral cover, species richness and abundance; 2) community differentiation within reefs and among reefs; and 3) the possible role of local environmental conditions and disturbances as determinants of coral-reef community structure.

MATERIALS AND METHODS

Coral-Reef Community Structure

Coral reef community composition was studied at three sites: one offshore (La Azufrada reef, Gorgona Island); and two onshore (La Chola reef, Utría and Tebada reef, Cupica Fig. 1). Surveys were conducted between January 1996 and June 1998. Using haphazardly selected marks on the beach as a reference, 100-m long tape measures were extended under water perpendicular to the long-shore axis of the reefs from the shallowest areas of coral growth to the reef base where coral development ceased (hereafter referred as survey stations). Three survey stations were laid at each site. Sampling points along the survey stations were previously selected from a random number table. At each preselected point, a transect, consisting of a 10 m-long chain, was laid perpendicular to the tape measure following the bottom contour. Between 21 and 26 transects were surveyed at each station (total number of transects: La Azufrada reef, 78; La Chola reef, 61; and Tebada reef 67). Chain links were marked every 10 cm with flag tape (see Rogers et al., 1994). Bottom type (i.e., dead coral, coral/rubble, live coral, and algae) was recorded only at labeled chain links. Scleractinian coral species were identified following Wells (1983). Depth was recorded using depth gauges (accuracy ~0.3 m) and values were adjusted to mean sea level. Data sets meeting parametric statistical requirements were analyzed using one-way Analyses of Variance (ANOVA). Transformations, including ln and e^n, were applied to some data sets. When necessary, Kruskal-Wallis tests were used in lieu of single classification ANOVA.

Faunal Assemblages

Population densities of the corallivorous pufferfish *Arothron meleagris* (Bloch and Sneider) were estimated from man-hour counts by swimming along the reef flat. Individuals per man-hour (ind man-hr^{-1}) data were converted to individuals per hectare (ind ha^{-1}) according to Guzmán and Robertson (1989). In addition, the abundance of the sea urchin *Diadema mexicanum* Agassiz was determined by placing two 1 m^2 quadrats (one on each side of the tape measure) at each of the randomly selected points used in the bottom type surveys. The numbers of sea urchins were recorded and correlated with percent coral cover, percent dead coral/rubble, and macroalgae. Additionally, densities of pufferfish and sea urchins were compared among reefs using non-parametric Kruskal-Wallis tests and Mann-Whitney rank-sum tests respectively.

Environmental Data Sets

Sea surface temperature (SST) records between 1950 and 1992 were obtained from the ship-based Comprehensive Ocean-Atmosphere Data Set (COADS) on a 2×2° grid, centered at 5°N; 77°W for Utría-Tebada and 3°N; 77°W for Gorgona Island. SSTs between 1993 and 1998 were obtained from satellite-derived data series (Advanced Very High Resolution Radiometer, AVHRR) centered at 3°N; 78°W for Gorgona Island and 6°N; 77.5°W for Utría-Tebada.

Meteorological data sets were provided by the Colombian Meteorological Authority, based on instrumental measurements (Instituto de Hidrología, Meteorología y Estudios Ambientales, IDEAM 1999a,b). Rainfall, solar irradiance and cloud-cover data for Gorgona Island were derived from the Gorgona Island meteorological station (3°2'N; 78°09'W) for the period 1986–1999. Rainfall at Utría-Tebada was obtained from the Utría meteorological station (6°5'N; 77°23'W) for the period 1993–1997. Solar irradiance and cloud cover for Utría-Tebada were obtained from the Bahía Solano meteorological station (6°14'N; 78°25W) between 1965–1998.

Average river discharge rates (m^3 s^{-1}) on the Pacific watershed of Colombia were obtained from Lobo-Guerrero (1993). Snapshot measurements of sediment accumulation rates were obtained from Vargas-Ángel (2001), based on 1 L cylindrical traps (3:1 height to diameter ratio, ~7.5 cm diameter), placed on the reef edge at each site, approximately 5–10 cm above the substrate (see Gardner, 1980 a,b).

RESULTS

A schematic representation of coral species distributions and profiles of percent live coral cover and species richness are presented in Figure 2. All the coral reefs in this study can be classified as fringing reefs (see Kinzie and Buddemeier, 1996). They were separated from the shore by a shallow channel, considerably deeper than the reef itself, and generally covered with mud and/or fine sand. Reefs exhibited several topographical zones: back reef, reef flat, reef edge and reef slope (following Glynn, 1976; Cortés, 1990). The back reef was transitional between the sandy channel and the living reef flat. This zone was usually characterized by sparsely distributed corals intermingled with bioclastic sand and rubble. The reef flat was commonly the best-developed reef zone with the highest coral cover. Some reef flats were subject to periodic subaerial exposure during extreme low tides. The reef front marked the transition between the shallow reef flat and the reef slope. The reef slope descended gently to a fine sand and mud bottom at approximately 8–10 m depth.

Inter-reef Comparisons

All reefs exhibited high levels of paucispecificity. *Pocillopora damicornis* represented 91% of all living corals at La Azufrada and La Chola reefs. At Tebada reef, *Psammocora stellata* and *Psammocora ?brighami* accounted for nearly 90% of the live cover. Live coral cover was highest at La Azufrada reef, with mean cover of over 72% (Table 1). Values as high as 100% cover were observed on the reef flat, mainly due to monospecific stands of *P. damicornis*. Mean live coral cover at La Chola reef was 41% and coral cover was patchy. At Tebada reef, live coral cover was slightly lower than at La Chola (39%), but differences in percent cover between these two reefs were not statistically significant (Table 1). During extreme low tides (~ −0.4 m or lower) large sections of the reef flat at La Azufrada and La Chola were subaerially exposed. Fleshy brown macroalgae and crustose coralline algae (CCA) were common growing on the dead coral surfaces. The reef flat at Tebada was substantially deeper (~0.5 m) than at La Chola and La Azufrada and was not subject to recurrent subaerial exposure during extreme low tides.

Dead coral cover and unoccupied substratum were nearly three times higher at Tebada reef than at La Azufrada and those differences were statistically significant ($P<0.05$, Kruskal-Wallis test). By contrast, differences in dead coral cover between La Chola and Tebada reefs were not statistically significant (Table 1). Algal cover was higher at La Azufrada than at La Chola reef, but differences between reefs were also nonsignificant (Table 1). This occurred due to high variability in algal cover within reef zones at both sites.

The total number of scleractinian corals was higher at La Azufrada reef (11 species) than at La Chola and Tebada reefs (five and six species respectively). Branching *Pocillopora elegans* and *Pocillopora eydouxi* were common at La Azufrada reef but absent at La Chola and Tebada reefs. Similarly, the massive species *Pavona clavus* and *Pavona gigantea* were also common (but not abundant) at La Azufrada reef, but noticeably rare or absent at La Chola and Tebada reefs. Nearly 65% of the transects

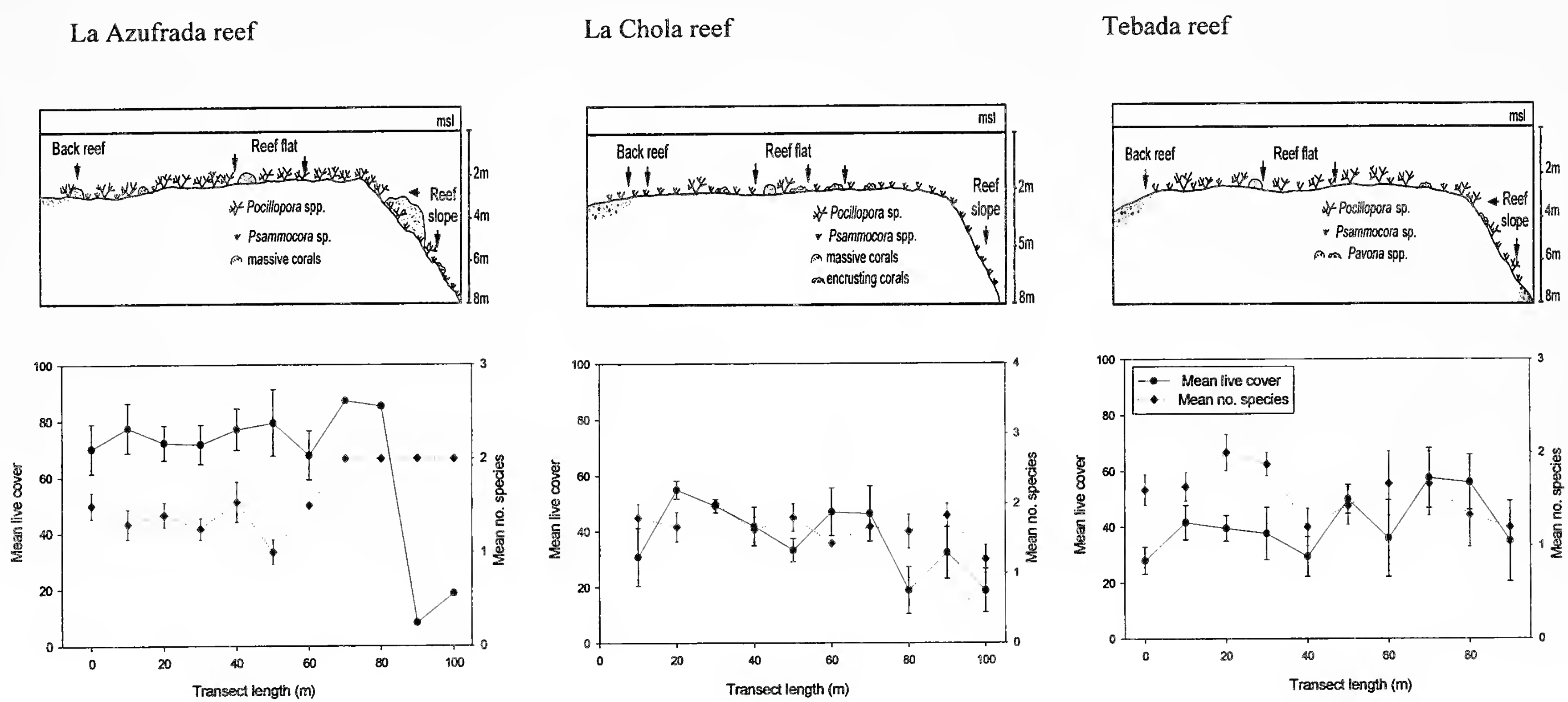

Figure 2. Profiles of coral-reef species distributions (upper panels), and percent live coral cover and species richness (lower panels) at La Azufrada reef (left), La Chola reef (center), and Tebada reef (right). Coral community surveys conducted on randomly selected, 10 m-long chain transects, laid parallel to the beach, along three 100 m-long survey stations at each site. Twenty-one to 26 chain transects were surveyed at each station (Total number of transects per site: La Azufrada reef, 78; La Chola reef, 61; and Tebada reef, 67; surveys conducted between January 1996 and June 1998; msl = mean sea level; vertical lines indicate standard error of means).

Table 1. Summary statistics (mean±SE) of coral-reef community composition at La Azufrada reef (Gorgona Island), La Chola reef (Ensenada de Utría) and Tebada reef (Tebada). A, *Pocillopora damicornis*; B, *Pocillopora capitata*; C, *Pocillopora elegans*; D, *Pocillopora eydouxi*; E, *Psammocora stellata*; F, *Psammocora ?brighami*; G, *Pavona clavus*; H, *Pavona gigantea*; I, *Pavona varians*; J, *Porites lobata*; K, *Porites panamensis*; L, *Gardineroseris planulata*. Statistical comparisons: Azf = La Azufrada reef; Cho = La Chola reef; Teb = Tebada reef.

Community Parameter	La Azufrada reef	La Chola reef	Tebada reef	Statistical comparisons
Depth range (m)	0.5–8	0.5–7	1.0–8	no statistical comparison
Total reef extension (ha)	~15	~10.5	~4.5	no statistical comparison
Reef framework thickness (m)*	6–8	>4.5	~4.0	no statistical comparison
Coral species present**	ABCDEGHIJKL	ABEHI	AEFHIL	no statistical comparison
% Live coral cover	72.89±3.02	41.15±2.59	39.03±2.47	Azf>Cho, Teb; $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
% Dead coral cover	20.08±2.64	52.28±2.81	60.9±2.46	Azf<Cho, Teb; $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
% Fleshy macroalgae	6.95±1.65	4.92±1.56	<2%	$P>0.05$, Mann-Whitney rank sum
% *Pocillopora* spp.	66.52±3.14	37.81±2.7	4.19±0.85	Azf>Cho>Teb, $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
% *Psammocora* spp.	4.52±1.08	3.19±0.54	34.20±2.47	Teb>Azf, Cho, $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
% Massive corals	0.01±0.01	0	0.47±1.24	Teb>Azf, Cho, $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
Diadema mexicanum (ind m^2)	2.27±0.38	0.492±0.27	0	Azf>Cho>Teb, Mann-Whitney rank sum
Arothron meleagris (ind ha^{-1})	6.58±0.88	5.65±1.15	1.94±0.06	Azf, Cho > Teb, Kruskal-Wallis ANOVA, Dunn's test

*obtained from Glynn et al. (1982) and Vargas-Ángel (2001)

**including observation outside the sampling transects sampled at La Azufrada contained exclusively one coral species (i.e., *P. damicornis*) and only 2.5% contained more than two species. At La Chola reef, approximately 60% of the transects contained two coral species (i.e., *P. damicornis* and *P. stellata*) and at Tebada reef nearly 58% of the transects contained at least three species of scleractinian corals (i.e., *P. stellata*, *P. ?brighami* and *P. varians*).

La Azufrada was the only reef to exhibit structural differences among reef zones. These differences were due mainly to seaward changes in percent live coral cover and species composition (Table 2). The reef flat at La Azufrada was composed mainly of *P. damicornis*, while the reef slope exhibited higher cover of *P. stellata* and *P varians*, as well as massive corals such as *P. clavus* and *Gardineroseris planulata*. Such ecological differences among reef zones were not observed at La Chola and Tebada reefs (Table 2). At these sites, the variation in coral cover and species composition was greater within reef zones than among reef zones.

Faunal Assemblages

The abundances of selected macroconsumers also differed among the study sites. Population density of the corallivorous pufferfish *A. meleagris* was higher on offshore than onshore reefs and these differences were statistically significant ($P<0.05$, Kruskal-Wallis, Table 1). The mean population density of *D. mexicanum* was 2.27±0.38 ind m^{-2} (mean±std error) at La Azufrada reef and 0.49±0.27 ind m^{-2} at La Chola reef. Those differences between sites were also statistically significant ($P<0.05$, Mann-Whitney rank sum, Table 1). At La Azufrada and La Chola reefs, highest densities of sea urchins (6–12 ind m^{-2}) were associated with dense monospecific stands of *Pocillopora* where coral cover was >60%. Correlation analyses indicated that there was a statistical association between coral cover and density of sea urchins at La Azufrada reef ($r = 0.38$; $P<0.05$, Pearson's product moment correlation) but not at La Chola ($r = 0.29$; $P>0.05$, Pearson product moment correlation). The sea urchin *D. mexicanum* was absent at Tebada reef. Instead, other echinoids were observed, including *Centrostephanus coronatus* (Verrill) and the pencil sea urchin *Hesperocidaris asteriscus* Clark.

DISCUSSION

Coral-Reef Community Comparisons

Results showed that La Azufrada (offshore) was the largest, most diverse, and best developed coral reef. Ecological differences between the offshore (La Azufrada, Gorgona Island) and the onshore (Utría and Tebada) coral communities are based on the following criteria: 1) richness of the coral fauna; 2) coral species abundances; 3) percent of live coral cover; and 4) overall structural complexity (e.g., ecological differences among reef zones).

Coral species composition differed substantially between the onshore and offshore sites. Species richness and live cover were nearly twice as high at La Azufrada compared with the onshore reefs. Onshore reefs contained less than half (45%) of the

Table 2. Summary of coral-reef community structural statistics (mean±SE) based on 78 survey transects at La Azufrada reef, 61 at La Chola reef and 67 at Tebada reef. A, *Pocillopora damicornis*; B, *Pocillopora elegans*; C, *Psammocora stellata*; D, *Psammocora ?brighami*; E, *Pavona gigantea*; F, *Pavona varians*. Statistical comparisons: RF = reef flat, RS = reef slope, BR = back reef.

Reef/community parameter	Reef zone			Statistical comparison
	Back-reef	Reef-flat	Reef-slope	
La Azufrada reef				
No. of transects	12	58	8	no comparison
% live cover	56.87±13.7	76.12±2.9	44.48±16.4	RF>BR,RS; $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
species richness (No. coral species)	1.8±0.17 ABC	1.3±0.06 ABCE	1.7±0.15 ACF	RF<BR,RS; $P<0.05$, Kruskal-Wallis ANOVA, Dunn's test
La Chola reef				
No. of transects	12	36	13	no comparison
% live cover	44.2±5.01	43.7±3.60	34.0±5.11	$P>0.05$, Kruskal-Wallis ANOVA
# coral species	1.6±0.13 AC	1.6±0.09 AC	1.6±0.12 AC	$P>0.05$, Kruskal-Wallis ANOVA
Tebada reef				
No. of transects	20	39	8	no comparison
% live cover	33.79±4.31	39.75±3.09	51.14±8.81	$P>0.05$, Kruskal-Wallis ANOVA
# coral species	1.56±0.14 ACDF	1.62±0.09 ACDEF	1.60±0.24 ACDF	$P>0.05$, Kruskal-Wallis ANOVA

scleractinian species present at La Azufrada reef. Notable absences at La Chola and Tebada reefs were *P. clavus, P. elegans* and *P. eydouxi*, which were ubiquitous at La Azufrada reef. Similarly, no *Porites lobata* occurred at the onshore sites. *Pavona varians* was relatively abundant at La Azufrada and Tebada reefs but rare at La Chola. *Pocillopora damicornis* was common at all sites, but only dominant at La Azufrada and La Chola reefs. These results are surprising given the wide environmental tolerance, geographical distribution, and the rapid growth rate of this species (Glynn and Ault, 2000; Vargas-Ángel et al., 2001). Finally, *P. stellata* was common at all sites, but dominant only at Tebada. This situation may be related to the lower abundance of *P. damicornis* at this site. Like *Pocillopora*, *P. stellata* also exhibits a wide tolerance range for temperature extremes (Maté, 1997). However, on shallow well-illuminated substrates, *Psammocora* is generally out-competed by fast-growing *P. damicornis*.

The ecological zonation of the reef community along environmental gradients was relatively clear at La Azufrada. For example, the shallow reef flat exhibited higher cover of *P. damicornis* and reduced species richness. This shallowest area of the reef experienced warmer temperatures and higher light levels than other reef zones. Conversely, lower coral cover and greater abundance of non-pocilloporids were evident on the back reef and the slope. These areas experienced lower light levels. At La Chola and Tebada, community differentiation along gradients of depth and light was not clear. The variation of coral cover and species richness was greater within reef zones than among reef zones. This lack of zonation is probably an indicator of "instability". Environmental stress and disturbances can offset competitive interactions and biological processes among species, resulting in phase shifts in community structure (see Karlson 1999).

Possible Factors Determining Ecological Differences Between Reefs

Regional differences in coral community composition have been explained in terms of shallow-water habitat availability (Bellwood and Hughes, 2001). In low diversity regions, such as the eastern Pacific, patterns of coral species richness can also be influenced by local environmental differences as well as human impacts. For example, Carriquiri and Reyes-Bonilla (1997) found that the scleractinian coral fauna at Nayarit was 30% more diverse at insular localities as compared to mainland Mexico. They suggested that lower water transparency, higher river discharge and upwelling events may be the principal factors determining among-site coral community differences (Carriquiri and Reyes-Bonilla, 1997; Reyes-Bonilla, pers. comm). It is proposed that the ecological differences between the onshore and offshore coral communities observed in this study exist due to a gradient of environmental conditions in combination with natural and human perturbations. Some of these limiting factors are identified and discussed below.

Temperature. Sea-surface temperatures (SSTs) on the Colombian Pacific are relatively warm, ranging between 20–28°C, depending on location and season (Wyrtki, 1965). At Gorgona Island, sea surface isotherms range between 25–28°C year round. At Utría and Tebada, SSTs vary between 25–28°C during the rainy season (May–Dec) and between 24–26°C during the dry season (Jan–April). Recurrent anomalously high and low SSTs occur in the Colombian Pacific. During severe El Niño sea warming events, thermal anomalies can be as high as +2–3°C (i.e., 30–32°C) (in situ hand-held temperature measurements, as well as long-term temperature records derived from COADS and remotely-sensed data; see Prahl, 1985; Vargas-Ángel et al., 2001). Coincidentally, negative temperature excursions, as low as 16°C can occur during La Niña (sensu Philander, 1990) conditions (see Vargas-Ángel, 1996, 2001).

El Niño-Southern Oscillation (ENSO) disturbances during 1982–83, and more recently (1997–98), have demonstrated that prolonged warm sea conditions can have devastating and profound effects on coral reefs in the region. The 1982–83 ENSO

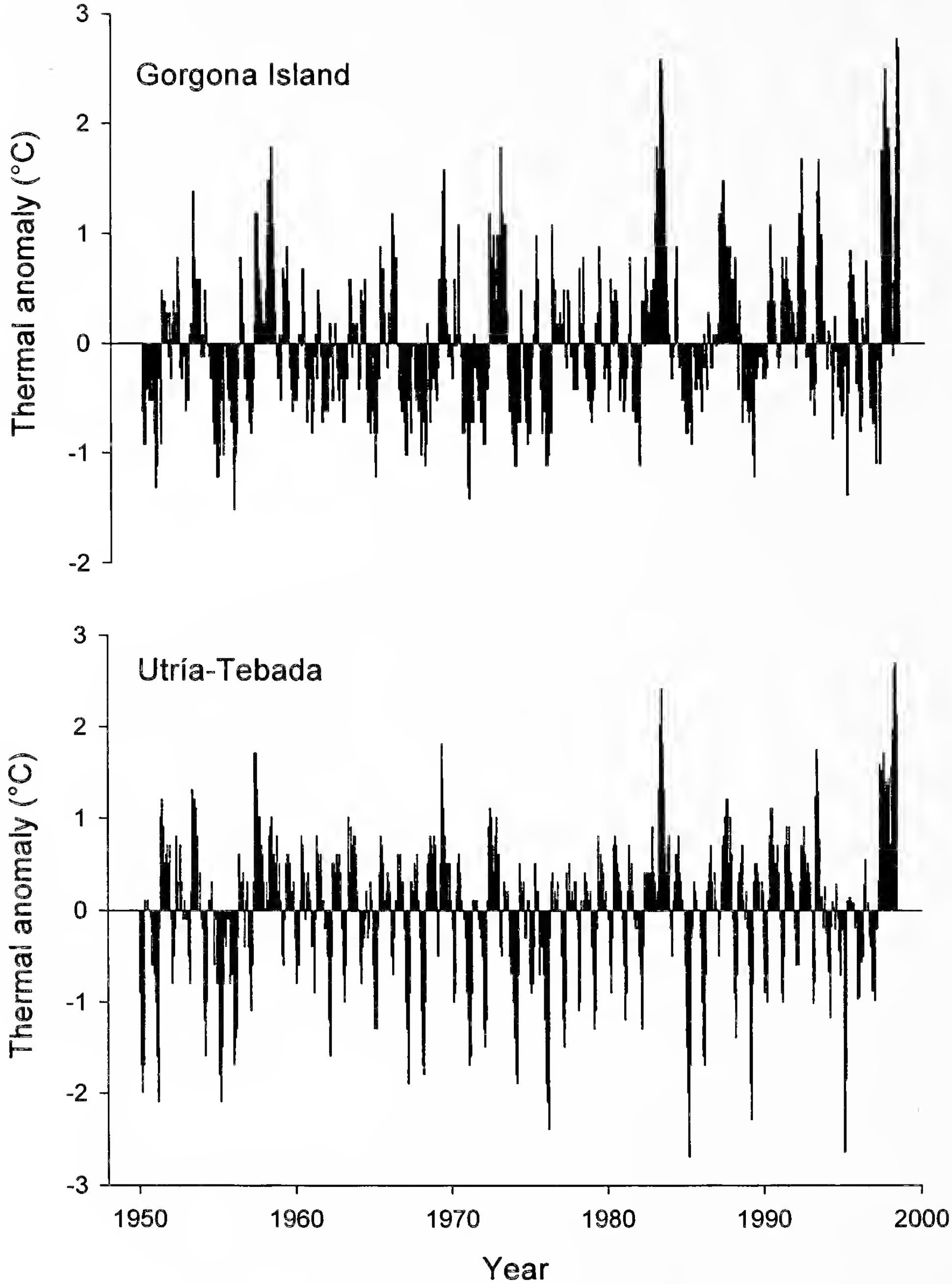

Figure 3. Time series of sea-surface temperature (SST) anomalies for two regions of the Pacific coast of Colombia; Gorgona Island, and Utría-Tebada. SSTs between 1950–1992 were obtained from the Comprehensive Ocean and Atmosphere Data Set (COADS) on a 2×2° grid, centered at 3°N; 77°W for Gorgona Island, and 5°N; 77°W for Utría-Tebada. SSTs between 1993–1998 were extracted from satellite data series centered at 3°N; 78°W for Gorgona Island, and 6°N; 77.5°W for Utría-Tebada.

resulted in catastrophic coral mortality and loss of diversity at La Azufrada reef. Live cover was reduced by ca. 85% (from surveys conducted in 1979; see Glynn et al., 1982), and massive species including *G. planulata*, *P. lobata* and *Porites panamensis* were nearly eliminated (see Prahl, 1985). By contrast, during the 1997–98 El Niño event, coral bleaching and mortality at La Azufrada did not reach the catastrophic proportions of the 1982–83 event. Despite the fact that thermal anomalies in 1997–98 were comparable to those of the 1982–83 event, only 24% of corals bleached and ~1–2% died in 1998 (Vargas-Ángel et al., 2001). One common aspect to both disturbances was that massive corals were the least resilient and thus exhibited the highest mortality rates. In light of these findings, Vargas-Ángel et al. (2001) proposed that preferential bleaching and mortality of massive corals during severe El Niño conditions may control the relative abundances and richness of these species at La Azufrada. Conversely, resilient species such as *P. damicornis* may promote rapid community regeneration and prevent framework erosion after El Niño disturbances. Thus, it is possible that under recurrent and severe El Niño conditions, thermally sensitive corals at La Azufrada reef may become eliminated, leaving behind more resilient species and resulting in loss of coral richness at this site.

The short-term and long-term effects of El Niño events on onshore reefs have been less studied. Based on the pre- and post-disturbance research by Prahl and Erhardt (1985) and Vargas-Ángel (1996) respectively, it can be inferred that the 1982–83 El Niño did not have catastrophic consequences on the onshore reef localities. Added evidence in support of this notion was obtained during the 1997–98 disturbance. Coral bleaching at La Chola and Tebada reefs during 1998 was minimal (<1%), and no coral mortality was observed. Additionally, in situ and remotely sensed data showed that positive thermal anomalies at La Chola and Tebada reefs were lower (~1°C) and extended for a shorter period of time than at Gorgona Island (Vargas-Ángel et al., 2001).

Long-term temperature records indicate that El Niño-related positive thermal anomalies have been consistently lower at La Chola and Tebada reefs than farther south (Fig. 3). This probably occurs because the effects of ENSO sea warmings are attenuated by normal seasonal oceanographic processes in the region, such as the mixing of water masses and the upwelling system in the Panama Bight.

By contrast, negative thermal excursions are greater at northern coastal localities than father south at Gorgona Island. These occur due to persistent and intense wind-driven upwelling in the neighboring Gulf of Panama. For example, in February 1989 unusually cold water (16–18°C) in association with blooms of *Gymnodinium* sp. resulted in widespread coral bleaching at La Chola reef. Underwater temperatures as low as 18–20°C were reported at Gorgona Island at this time. However, no coral bleaching was observed in association with this event.

During periods of intense upwelling, low sea-water temperature, eutrophication, algal overgrowth, and bioerosion acting alone or together can reduce coral cover and even cause local extinctions (Glynn and Ault, 2000). Thus, it is suggested that corals at La Chola and Tebada reefs may be more vulnerable to stress due to cold-water spells and intense upwelling than by sea-warming events. In contrast, corals at La Azufrada reef, located outside the influence of upwelling conditions, experience more bleaching and mortality from anomalous and recurrent high SST events.

Light. Light quality and quantity can be important determinants of coral community composition and structure at the study sites. Instrumental data sets indicate that solar irradiance is on average 10% higher at Gorgona Island than at Utría-Tebada and, during the dry season, differences between sites are twofold. Cloud cover also differs between onshore and offshore localities (Table 3) and it is nearly 10% higher at Utría-Tebada than at Gorgona Island. Decreased light quality and quantity conditions at La Chola and Tebada reefs may be unfavorable for coral metabolism and photosynthesis-driven calcification. Phototrophic species such as pocilloporids and agariciids largely depend on higher light levels to balance their energetic needs (Wellington, 1982). This condition may explain the lowered coral extension rates, species absences and reduced coral cover at the onshore sites compared to Gorgona Island (see Vargas-Ángel, 2001).

Table 3. Summary statistics (mean±SE) of selected environmental parameters at Gorgona Island and Utría-Tebada. Environmental parameters of rainfall, solar irradiance and cloud cover were obtained from instrumental records provided by the Colombian Meteorological Authority (Instituto de Hidrología, Meteorología y Estudios Ambientales, IDEAM 1999a,b), see materials and methods for details. Sediment accumulation rates were obtained from Vargas-Ángel (2001) based on 1 L tubular traps (3:1 height to diameter ratio, ~7.5 cm diameter) placed approximately 5–10 cm above the substrate.

Environmental variable	Location		Statistical comparisons
	Gorgona Is.	Utría-Tebada	
Rainfall (mm yr^{-1})	6725.62±178.87	7367±263.64	no comparison (low sample size)
Irradiance (hr d^{-1})	79.87±8.75	70.64±1.77	P<0.05, t-test
Cloud Cover (%)	72.60±0.58	79.92±1.53	P< 0.05 t-test
Sedimentation (mg cm^{-2} d^{-1})	4.07±0.35	6.46±1.13[a] 3.54±0.59[b]	Ch>Teb,Az; P<0.05, one-way Anova, Tukey Test

a = La Chola reef
b = Tebada reef

Sedimentation and Water Turbidity. High-water turbidity due to excessive runoff is notable at all the study areas. Increased terrigenous siltation and sediment loading due to forest clearing, indiscriminate land use and destructive subsistence farming have caused damage to reef corals at La Azufrada and La Chola (see Prahl et al., 1979; Vargas-Ángel, 1996, 2001). At La Chola reef, it is not uncommon for underwater visibility to be reduced to 1.0 m or lower during excessive rainfall and heavy runoff. Sediment accumulation rates at this site range between 3.1–7.9 mg cm^{-2} d^{-1} (Table 3; Vargas-Ángel, 2001, unpubl.data). These values are comparable to accumulation rates obtained by Rogers (1990) and Chansang et al. (1992) on chronically sediment-stressed reefs in the Caribbean and Thailand, respectively. Secondary evidence in support of siltation stress at la Chola reef is presented by Prahl and Estupiñán (1990), who suggest that the thin-branched ecomorph of *P. damicornis* prevalent at La Chola reef is a clear indication of stress due to increased sedimentation and turbidity. Thus, it is proposed that increased turbidity and sediment loading, together with reduced solar irradiance at La Chola reef, may result in lower coral extension and calcification rates as well as lowered coral cover and decreased reef-building potential at this site (Prahl and Vargas-Ángel, 1990; Vargas-Ángel, 1996, 2001).

Freshwater Input. Freshwater input on the Pacific coast of Colombia is high; rainfall is in the order of 5000–7500 mm yr^{-1} and total river discharge amounts to nearly 9200 $m^3 s^{-1}$. Both totals rank among the highest for the tropical eastern Pacific (Fig. 4). As a result, seawater surface salinity (SSS) can range between 30 and 35‰ offshore to less than 20‰ in coastal areas and near river mouths (Cantera, 1993). This low range of salinities can limit the occurrence of zooxanthellate corals in onshore localities. Waters reaching La Chola and Tebada originate from the south (Fig. 4), thus, freshwater dilution due to elevated river discharge may restrict coral larval dispersal from La Azufrada to farther north. Additionally, due to the presence of long stretches of mangrove forests, potential stepping stone habitats that could facilitate the interchange of coral species from the south to the north are scarce. Thereby, coral recruitment on onshore reefs may be highly dependent on local larval supply. Additionally, since most eastern tropical Pacific scleractinian corals spawn during the rainy season (see Glynn et al., 1991, 1994, 1996), rapid dilution of reef waters due to increased rainfall can also negatively affect coral larval viability, hence larval settlement and survival (see Coles and Jokiel, 1992). Thus, recurrent SSS reductions of reef waters at the onshore sites may further exacerbate the effects of limited allochthonous larval supply.

Species Interactions. Species interactions in concert with local environmental conditions have been central in explaining community regulation (Cornell and Karlson, 2000). For example, lower coral cover and reduced species abundances in coral-reef ecosystems have been attributed, among other factors, to competitive exclusion and predation. In the absence of the crown-of-thorns starfish *Acanthaster planci*, the pufferfish *A. meleagris* is an important coral predator on Colombian Pacific reefs (Glynn et al., 1982; see Glynn et al., 1972; Guzmán, 1988). In this study, densities of pufferfish differed among sites. However, there was no apparent relationship between puffer density and coral cover or puffer density and reef location (offshore vs onshore). Previous studies on other eastern Pacific coral reefs suggest that abundance of puffers may not be related to resource abundance but to juvenile recruitment (Guzmán and Robertson, 1989). In this study, densities of puffers were lowest at Tebada reef coincident with low abundance of *Pocillopora* spp. It is possible that low recruitment rates may determine the abundance of puffers at Tebada. However, even when uncommon, puffers at Tebada reef may impact the population of *Pocillopora* by selectively feeding on theses species (see Guzmán and Robertson 1989). Further research is needed in this matter.

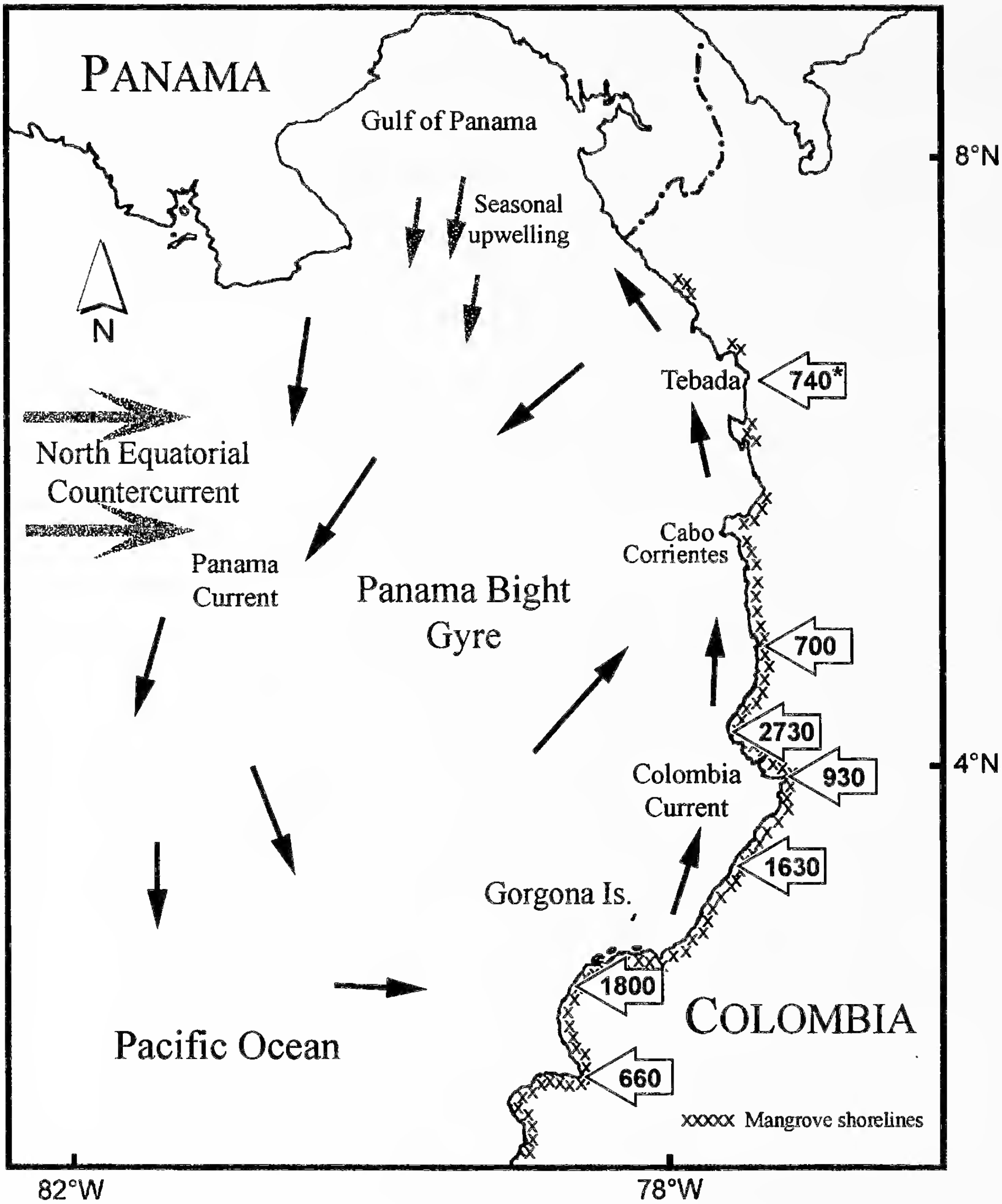

Figure 4. Schematized surface-water circulation in the Panama Bight (after Cromwell and Bennett, 1959; Wooster, 1959; Wyrtki, 1965; Fieldler, 1992) and freshwater discharge on the Pacific watershed of Colombia. Location and average freshwater discharge rate ($m^3 s^{-1}$) of major rivers is indicated by horizontal white arrows. Average river discharge for the region between Cabo Corrientes and the Panamanian border is indicated with an asterisk. River discharge data obtained from Lobo-Guerrero (1993). Distribution of mangrove shorelines (x); obtained from Sánchez-Páez and Álvarez-León (1997); Vargas-Ángel (pers. observ.).

Sea urchins have been recognized as important grazing bioeroders in coral-reef habitats (Glynn, 1988). Researchers have found that sea urchins may be responsible for extensive coral-reef framework erosion and reef destruction, especially after severe disturbances. Their grazing activity can alter the spatial differences in bioerosion thus influencing coral-reef morphology and development (Glynn, 1997). In this study, echinoid densities at La Azufrada reef were higher than at La Chola and Tebada reefs. Sea urchin abundances at La Azufrada were comparable to those reported at Caño Island, Costa Rica (Guzmán, 1988) but lower than those observed by Guzmán and Cortés (1993) and Glynn (1988) at Cocos Islands and Panama, respectively, where *Diadema* caused severe framework destruction after the 1982-83 El Niño event. At La Azufrada reef, high coral cover in concert with moderately high densities of urchins, probably maintain a balanced carbonate budget conducive to net reef accretion. At La Azufrada reef, *Pocillopora* is essential to the development of the surface bottom topography, which in turn provides habitat and shelter for numerous associated fauna and commensal symbionts (see Rios, 1986; Vargas-Ángel, 1989). Field observations indicated that there was a positive association between substratum complexity and the abundance of *Diadema* at La Azufada reef. The highest densities of sea urchins (7–12 ind m^{-2}) were found at localities with high live pocilloporid cover (mean cover >60%) (see also Glynn, 1988). It is possible that the absence of *D. mexicanum* at Tebada reef may be controlled in part by the limited abundance of suitable habitat (i.e., *Pocillopora*). In addition, low water salinities and sharp haloclines due to increased freshwater input may also affect *Diadema* larvae dispersal, survival and recruitment at Tebada (see Roller and Stickle, 1993; Metaxas and Young, 1998).

Finally, macroalgal proliferation can be another factor contributing to decreased coral cover, diminished scleractinian larval recruitment and reef development (Potts, 1977; Hughes, 1989; Tanner, 1995; Miller and Hay, 1998). In many cases, increased macroalgal cover has been preceded by drastic changes in the physical or biotic environment (Carpenter, 1990, 1997; Glynn and Colgan,1992; Hughes, 1994). In this study, macroalgal cover was relatively high and patchy, particularly on shallow substrata at La Azufrada and La Chola reefs. Algal cover in excess of 50% was observed in areas where corals experienced partial mortality due to recurrent subaerial exposure during extreme low tides. These algal patches were guarded by territorial damselfish. In contrast, in deeper areas where corals do not become subaerially exposed, algal cover was low (0–5%). The combined effects of subaerial exposure and territorial damselfish algal lawn expansion seem to be an important control of algal cover along shallow reef areas at the study sites. By contrast, in deeper reef habitats, algal cover may be determined by factors such as light penetration and herbivore grazing.

CONCLUSIONS

Based on their location and ecological structure, coral reefs of the Pacific coast of Colombia can be grouped into two types; offshore reefs at Gorgona Island are the largest and best developed. La Azufrada reef is characterized by high coral cover of *P. damicornis* along the shallow substrates and *P. stellata* on the periphery of the reef. Scattered colonies of encrusting and massive corals are present in all reef zones but these colonies only attain larger sizes on the deeper substrates of the reef slope. La Azufrada reef exhibits the highest number of zooxanthellate coral species and lowest percentage of dead coral cover.

By contrast, onshore fringing reefs at La Chola and Tebada are smaller in size and exhibit lower coral cover, reduced coral species richness, and ill-defined zonation patterns. They lack some of the aspects of the structural complexity present at La Azufrada. *Pocillopora damicornis* and *Psammocora* spp. are ubiquitous at la Chola and Tebada reefs, respectively, and massive corals are scarce.

It is proposed that these differences exist due to a gradient of environmental conditions in concert with natural and human impacts including: 1) recurrent thermal stress during El Niño and La Niña episodes; 2) increased sedimentation and elevated water turbidity; 3) increased terrestrial runoff and coastal erosion; 4) seasonal upwelling; and 5) increased freshwater inputs and low coastal salinities (Vargas-Ángel, 2001; Zapata and Vargas-Ángel, in press). These gradients and disturbances operate on a wide range of spatial and temporal scales and can selectively eliminate coral species, especially when impacts are chronic, act synergistically with other disturbances, or when they significantly alter the physical environment (see Karlson, 1999).

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ATOLL RESEARCH BULLETIN

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CRUSTACEA DECAPODA AND STOMATOPODA OF EASTER ISLAND AND SURROUNDING AREAS. A DOCUMENTED CHECKLIST WITH HISTORICAL OVERVIEW AND BIOGEOGRAPHIC COMMENTS

BY

JOSEPH POUPIN

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
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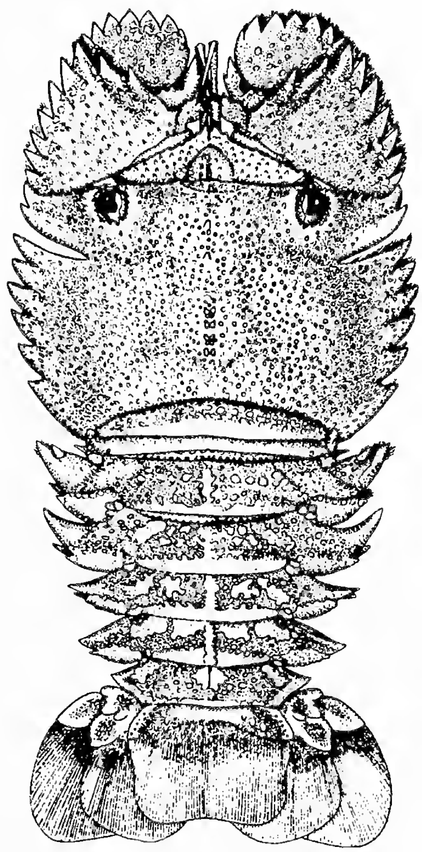
CONTENT



Parribacus perlatus Holthuis, 1967, described from Easter Island
(After Retamal, 1981: 51, Fig. 43)

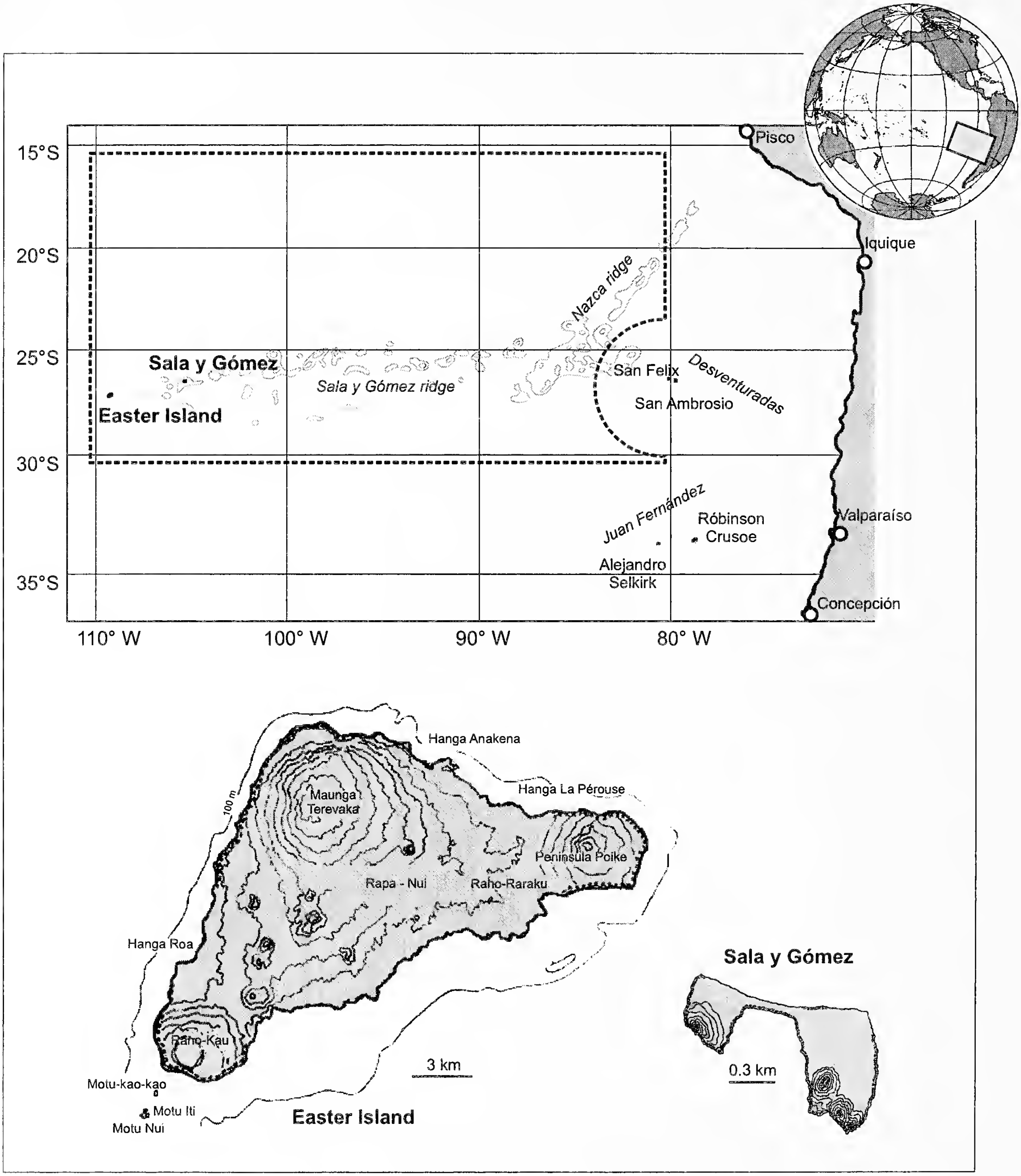


Figure 1. Top, delimited by the broken line: Easter Island and surrounding areas, abbreviated 'EIa' in this study. Bottom: details of Easter and Sala y Gómez Islands.

CRUSTACEA DECAPODA AND STOMATOPODA OF EASTER ISLAND AND SURROUNDING AREAS. A DOCUMENTED CHECKLIST WITH HISTORICAL OVERVIEW AND BIOGEOGRAPHIC COMMENTS

BY

JOSEPH POUPIN[1]

ABSTRACT

A documented checklist of the crustacea Decapoda and Stomatopoda is proposed for Easter Island and surrounding areas. The study area is situated between longitudes 80°-110° W and latitudes 15°-30° S. It includes Easter Island, the islet of Sala y Gómez and the submarine seamounts of Sala y Gómez and Nazca. The historical overview of Crustacea collections shows that this area has been predominantly explored by US, Chilean and Russian expeditions. The total number of taxa is 188, out of which 165 are determined to species level. These include 96 shrimps, 59 crabs, 23 anomuran crabs, seven lobsters, and three mantis shrimps. Most of the species are Indo-West Pacific (39.4%) while only some of them are linked with the eastern Pacific (8.5%). Overall the rate of endemism is 20.6%, but two different areas are distinguished: Easter Island (depth range 0-40 m) with a rate of endemism of 18%, and the seamounts situated west of 83° W (150-800 m) with a rate of endemism of 32%. Some species, such as *Calcinus imperialis*, *Panulirus pascuensis*, or *Leptograpsus variegatus*, indicate a link between the area studied and the islands that lie along the southern edge of the tropical Pacific (e.g. Pitcairn, Rapa, Kermadec). The species diversity decreases by a factor of five from west to east between French Polynesia and Easter Island.

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INTRODUCTION

The basic nature of the crustacean fauna of the tropical Pacific Ocean still remains imperfectly known, even for Decapoda and Stomatopoda despite being among the best studied groups. At least three reasons can explain this situation. The first one relates to the extent of the area and the inaccessibility of the many islands that are scattered over the western part. The second one is related to the way of life of the Crustacea. Most of the species master perfectly well the art of camouflage, have a nocturnal behavior, or occupy ecological niches that are difficult to sample such as interstices of corals, burrows, or depths of several hundred meters. The third one is related to the incredible biodiversity that characterizes the tropical ocean, many groups being rich with tens or even hundreds of species, whereas only a few species are found in temperate waters.

Despite the imperfection in our knowledge, the numerous scientific expeditions that have been carried out in the tropical Pacific for a hundred years, and the ceaseless work of the systematists to identify and describe taxa, have gradually increased knowledge of the regional faunas. Among the most recent and most intensive expeditions are the French campaigns carried out in the western Pacific by the *Institut de Recherche pour le Développement* (IRD) and the *Muséum national d'Histoire naturelle*, Paris (see, for example, Richer de Forges, 1990) followed up by numerous publications on the taxonomy of the Decapoda and Stomatopoda. Significant regional syntheses also have been compiled recently, for example for Taiwan (Lee *et al*, 1999 ; Ng *et al.*, 2001), Australia (Davie, 2002a, b), Mariana Islands (Paulay *et al.*, 2003), French Polynesia (Poupin, 1996, 1998), and the coasts of the Americas (Boschi, 2000).

The area of Easter Island occupies a privileged place because of its easterly location in the southern Pacific and is traditionally regarded as the eastern border of the Indo-West Pacific faunal province (IWP). The assessment of its crustacean fauna is thus of interest to check its affinities with the IWP, to measure the decrease in biodiversity that is generally noted from west to east in the tropical Pacific, and to determine the rate of endemism of this isolated area. Whereas certain groups have already been studied in that respect, such as algae (Santelices & Abbott, 1987), molluscs (Rehder, 1980), or fishes (Randall, 1998), no such study has been conducted on the Decapoda and Stomatopoda.

METHODS

This checklist has been compiled exclusively from a bibliographic search, and no crustacea collections from Easter Island and surrounding areas were examined. The exact origin of each record is indicated as clearly as possible to allow updates after this publication. Some references are included because they are useful to know the origin of a new generic combination, a synonymy, or a geographic distribution. Remarks and/or synonyms are added when necessary. The suprageneric classification follows that proposed by Martin & Davis (2002). The species are listed alphabetically in each genus.

The study area is situated between longitudes 80°-110° W and latitudes 15-30° S (Fig. 1). It includes Easter Island, Sala y Gómez[2] Islet and the submarine ridges of Sala y Gómez and Nazca. It does not include the Desventuradas archipelago (San Felix and San Ambrosio Islands) that is located at the southeastern part of this area, nor the Juan Fernández archipelago (Robinson Crusoe, Santa Clara, and Alejandro Selkirk Islands) that is situated under latitude 30° S.

The initial objective of this work was limited to Easter Island and the nearby islet of Sala y Gómez, 415 km in the east. However, as the Crustacea collected by the Russian expeditions on the seamounts of Sala y Gómez and Nazca are primarily of IWP origin, the study area was extended as far as 80° W in the east. This has caused the appearance in the list of a few taxa from the eastern Pacific, clearly identified in the biogeographic study.

Abbreviations used are as follows: AHF, Allan Hancock Foundation; AMNH, American Museum of Natural History, New York; CIMAR, Crucero de Investigación Científica Marina; cl., carapace length; det., determiner; EASTROPAC, Eastern Tropical Pacific; EIP, Expedición de la Isla de Pascua; EIa, Easter Island and surrounding areas, including Sala y Gómez Island and Sala y Gómez and Nazca submarine ridges (see Fig. 1); EP, East Pacific; IWP, Indo-West Pacific; LACM, Los Angeles County Museum; METEI, Medical Expedition to Easter Island; MNHN, Muséum national d'Histoire naturelle, Paris; MNHNS, Museo Nacional de Historia Natural, Santiago; pers. com., personal communication; POI, Programa Oceanopolítico Integrado of the Chilean Navy; R/V, research vessel; RMNH, Nationaal Natuurhistorisch Museum, Leiden; SIO, Scripps Institution of Oceanography; WD, widely distributed; ZMUM, Zoological Museum of the Moscow State University.

HISTORICAL OVERVIEW

Although Crustacea of Easter Island have been recorded well before the XIXth century (see Holthuis, 1972), the first specimens kept for museum collections seem to be those of the 1904-1905 US *Albatross* Expedition that visited the island in December 1904. This collection is deposited in the Smithsonian Institution, Washington DC, and was studied by Rathbun (1907) and, to a lesser extent, Holthuis (1972), Castro (1997), Castro *et al.* (in press), and Lemaitre (1998). Several decades later, two archeological expeditions,

[2] This is the spelling of the *Times Atlas of the World* but 'Salas y Gómez' is also indicated on some Chilean charts.

the 1934-1935 Franco-Belgian Expedition and the 1955-1956 Norwegian Thor Heyerdahl Expedition, once again collected some Crustacea at the Island. They are deposited in the museums of Bruxelles, Oslo and Paris and were studied by Gravier (1936), Holthuis (1972) and Garth (1973).

In 1958, the US Scripps Institution of Oceanography (SIO) organized the Downwind Expedition with dredge stations in La Pérouse Bay (40-100 m) and on the submarine ridges off San Ambrosio and San Felix Islands (Shoal Guyot). The crabs of this expedition were studied by Garth (1985, 1992). Other SIO expeditions brought a few additional Crustacea: the 1964 Carrousel II Expedition, with a crab described by Garth (1993); and the 1967 EASTROPAC Expeditions that collected plankton in the northwest of the area studied here, including the sergestids shrimps determined by Judkins (1978). Parts of the collections made during the SIO programs were deposited in the Allan Hancock Foundation (AHF) and were thereafter transferred to the Los Angeles County Museum (LACM).

In 1964-1965, Easter Island was visited by the Medical Expedition to Easter Island (METEI) with littoral collections made by I.E. Efford and J.A. Mathias. The Crustacea are deposited in AHF/LACM and RMNH museums, and were studied by Holthuis (1967, 1972), Garth (1973), Haig (1974), Kropp & Haig (1994), and Castro (1997). In 1969, J. Randall, ichthyologist at the Hawaiian Bishop Museum, collected a few coral-associated shrimps studied by Holthuis (1972).

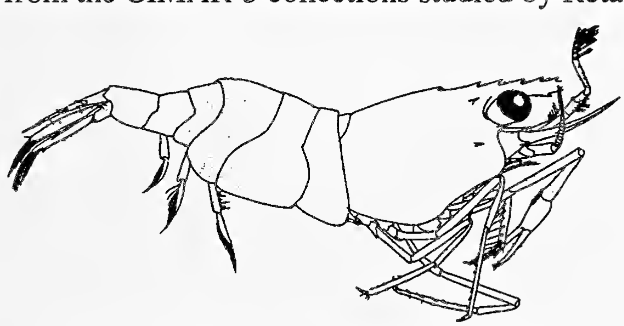
Several Chilean expeditions have also sampled the fauna of Easter Island and its surroundings. Seashore decapods were collected in 1972 during the Expedición de la Isla de Pascua (EIP), organized by the Instituto Central de Biología Universidad de Concepción. They were studied by Garth (1973) and Kropp & Haig (1994), and are deposited in the Universidad de Concepción. In 1985-1986, L.H. DiSalvo and colleagues made important collections while scuba diving between 15-60 m and also with a few baited traps at 100 m. It is not clear exactly where these collections are deposited but it seems that the Crustacea are distributed in several museums, including Chile Museo Nacional de Historia Natural de Santiago, RMNH, and AHF/LACM. These Crustacea were studied by Fransen (1987) and McLaughlin & Haig (1989), and a list of species that includes several new records was published by DiSalvo *et al.* (1998) with determinations made by Banner (Alpheidae), Fransen and Holthuis (Palaemonidae and Scyllaridae), Garth (Brachyura), Haig (Anomura), and Wicksten (Pandalidae). In 1995, the Programa Oceanopolítico Integrado (POI) of the Chilean Navy collected a few additional Crustacea studied by Castro (1997), Retamal (1999), and Retamal & Navarro (1996, 2001). In 1999, Easter Island and Sala y Gómez were once again visited by the R/V Vidal Gormaz during the CIMAR-5 Expedition. The Crustacea of this campaign were studied by Retamal (2001, 2002, in press), Retamal & Navarro (2001), Guzmán (2003), and Poupin *et al.* (2003). The CIMAR-5 collections are deposited in several institutions including Universidad de Concepción, Museo del Mar Iquique, and MNHN Paris. Few other sporadic Chilean visits have also been made at Easter

Island with specimens deposited in the crustacean collections of Concepción, Santiago, and Valparaíso (Reed, 1954; Saavedra, 1982; Báez & Ruiz, 1985).

Russian vessels have collected intensely on the submarine ridges of Sala y Gómez and Nazca, except on the 200 nautical miles of the Chilean Economic Zone. They have operated trawls, traps, and dredges, mainly between 200-800 m. The most important crustacean collection is that of the R/V Professor Shtokman (1987), with additional collections of R/V Ikhtiandr (1979-1980), R/V Professor Mesyatzev (1983-1984), and R/V Torok (1990). These collections are deposited in the Moscow P.P. Shirshov Institute of Oceanology and the Zoological Museum of the Moscow State University. They were studied by Burukovsky (1986, 1990, 1992, 2000a, b), Galil (1993, 2000), Parin *et al.* (1997), Rudjakov *et al.* (1990), Vereshchaka (1990), Zarenkov (1990), and Zhadan (1997). The importance of the Russian campaigns, in terms of new records added to the area, is illustrated on Figure 2.

More recently, C. Boyko and colleagues have collected again some decapods at Easter Island during the 1998-1999 US National Park Service Expedition. Their collections are deposited in the American Museum of Natural History, New York. They were studied for the hermit crabs of the genus *Calcinus* (Poupin *et al.*, 2003) and their bopyrid parasites (Boyko & Williams, 2001) and there is a study in progress on the Brachyura, including earlier collections made by L.H. DiSalvo and colleagues and predetermined by J. Garth (C.B. Boyko, pers. com.).

Figure 3 illustrates the increase in records of EIa Decapoda and Stomatopoda between 1900-2003, and reflects the history of the collections. Before 1970, less than 20 species of decapods and stomatopods were known from EIa. In the seventies and eighties, the number of species is increased significantly after the studies of Holthuis and Garth on the SIO and METEI collections. The number for the eighties is also influenced by the studies of Fransen and DiSalvo *et al* on the Chilean collections. In the nineties nearly 100 species are added to EIa fauna from the collections made by the Russian on the seamounts and studied by Burukovsky, Vereshchaka, Zarenkov, and Zhadan. From 2000 onward, a few new records come from the CIMAR-5 collections studied by Retamal and Guzmán.



Palaemonella disalvoi Fransen, 1987. Easter Island, in dead coral, 33-60 m (After Fransen, 1987: 512, Fig. 7)

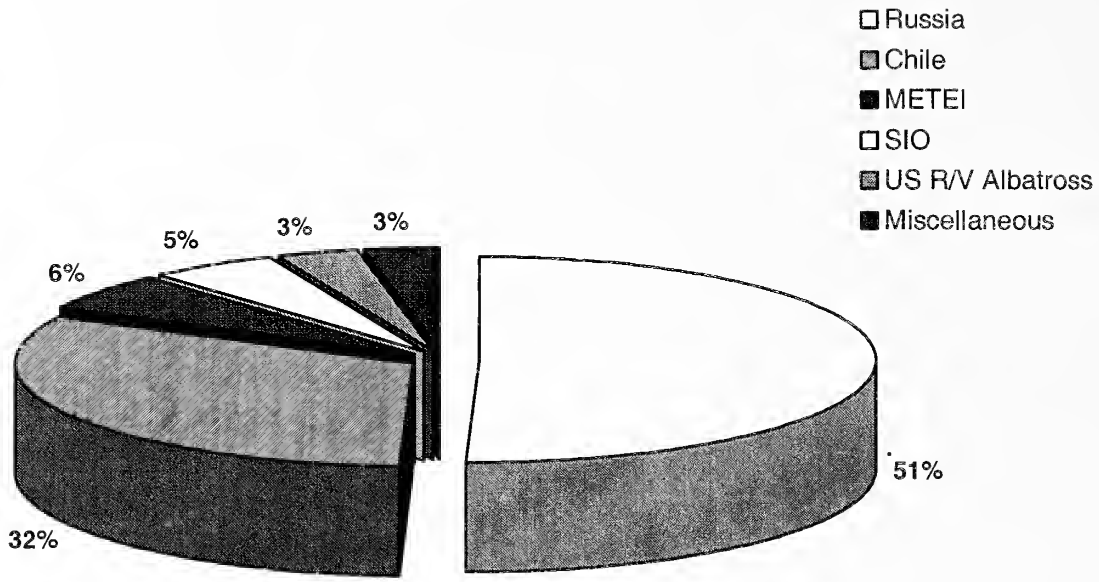


Figure 2. Decapoda and Stomatopoda of EIa: percentage of new records by expeditions (see Methods for abbreviations).

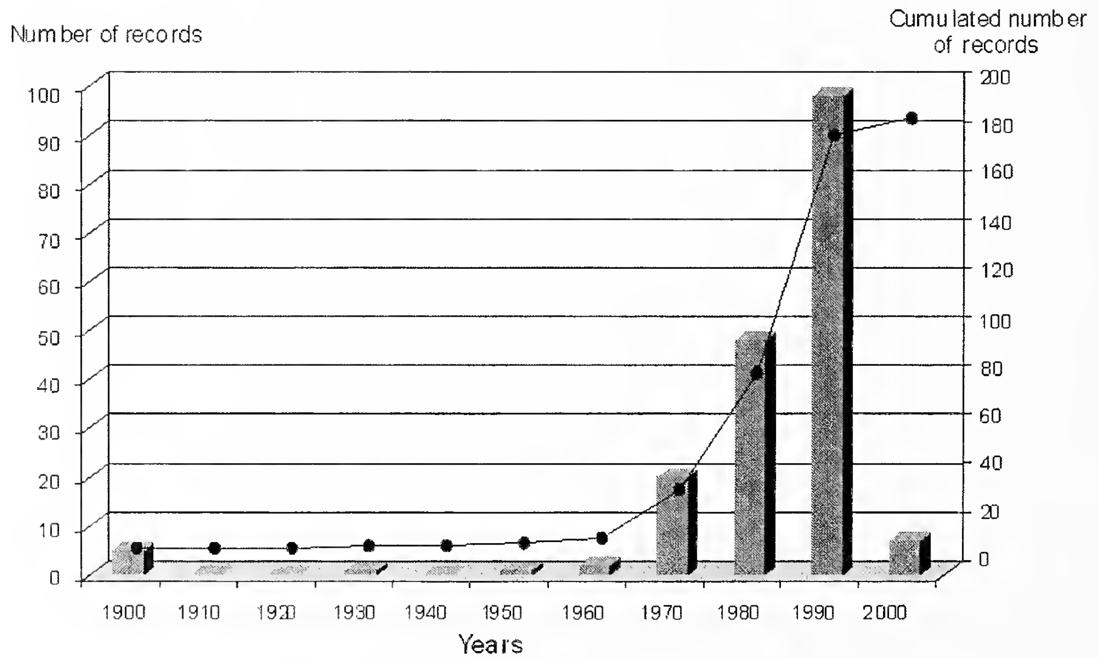


Figure 3. Decapoda and Stomatopoda of EIa: number of new records and cumulated number of new records every 10 years, between 1900-2003.

RESULTS

Statistics on Taxa

One hundred eighty-eight taxa are recorded from EIa among which 165 are determined to species level. Caridea (33%) and Brachyura (31%) are the two main groups (Table 1) followed by Dendrobranchiata (16%) and Anomura (12%). Palinuridae account for only 4% of the species. Stomatopoda, Stenopodidea, and Thalassinidea are each represented by only two-to-three species. Twenty-three taxa are still undetermined to species level. These are listed in Appendix A: shrimps (Callianassidae, Crangonidae, Hippolytidae, Palaemonidae); anomuran crabs (Albuneidae, Galatheidae, Parapaguridae); and crabs (Atelicyclidae, Calappidae, Cryptochiridae, Dynomenidae, Hymenosomatidae, Latreilliidae, Majidae, Pinotheridae, Portunidae, Xanthidae).

Ecology

The distribution of species according to depth range is presented in Figures 4 and 5. The larger groups are: shallow-water species, i.e. marine species collected from a few meters down to 100 m depth (75 species or 39%); deep species, i.e. benthic species collected on the seamounts, mainly between 150-800 m (59 species or 31%); and bathypelagic species, i.e. shrimps (Aristaeidae, Benthesicymidae, Nematocarcinidae, Oplophoridae, Pasiphaeidae, Sergestidae, Solenoceridae) collected by pelagic trawl between 100-2000 m (45 species or 24%).

Terrestrial species and species living on the coastline are scarce. They include: one freshwater crab, *Ptychognathus easteranus*; one grapsid crab with terrestrial affinities, *Geograpsus crinipes*; and seven grapsid or plagusiid crabs that are typical of rocky coasts, *Cyclograpsus longipes*, *Leptograpsus variegatus*, *Pachygrapsus transversus*, *Percnon pascuensis*, *Plagusia chabrus*, *Plagusia dentipes*, and *Plagusia integripes*.

Probably because of limited coral biodiversity at Easter Island latitudes, there are only eight coral-associated species: four crabs of the genus *Trapezia* (*T. areolata*, *T. ferruginea*, *T. punctimanus*, and *T. tigrina*); and four alpheids or palaemonids shrimps (*Alpheus lottini*, *Discias pascuensis*, *Harpiliopsis beaupressii*, and *Palaemonella spinulata*).

Species living in burrows, such as Stomatopoda or Thalassinidea, are poorly represented in this inventory, in part because of inadequate sampling techniques.

Table 1. Decapoda and Stomatopoda of EIa. Statistics on taxa expressed in number of species.

Dendrobranchiata	(16%) **30**
Aristaeidae	7
Benthesicymidae	1
Penaeidae	1
Sergestidae	18
Sicyoniidae	1
Solenoceridae	2
Stenopodidea	(1%) **2**
Spongicolidae	1
Stenopodidae	1
Caridea	(33%) **62**
Alpheidae	13
Crangonidae	4
Disciadidae	1
Glyphocrangonidae	1
Gnathophyllidae	1
Hippolytidae	4
Nematocarcinidae	2
Oplophoridae	11
Palaemonidae	8
Pandalidae	9
Pasiphaeidae	5
Processidae	1
Rhynchocinetidae	1
Stylodactylidae	1
Thalassinidea	(1%) **2**
Callianassidae	2
Palinuridea	(4%) **7**
Palinuridae	2
Polychelidae	2
Scyllaridae	3

Anomura	(12%) **23**
Albuneidae	1
Diogenidae	3
Galatheidae	3
Paguridae	3
Parapaguridae	11
Porcellanidae	2
Brachyura	(31%) **59**
Atelicyclidae	1
Calappidae	4
Carpiliidae	1
Cryptochiridae	1
Dromiidae	2
Dynomenidae	1
Geryonidae	1
Goneplacidae	1
Grapsidae	5
Homolidae	2
Hymenosomatidae	1
Latreilliidae	2
Leucosiidae	2
Majidae	5
Parthenopidae	4
Pinnotheridae	1
Plagusiidae	4
Portunidae	4
Trapeziidae	4
Xanthidae	13
Stomatopoda	(2%) **3**
Odontodactylidae	1
Pseudosquillidae	2

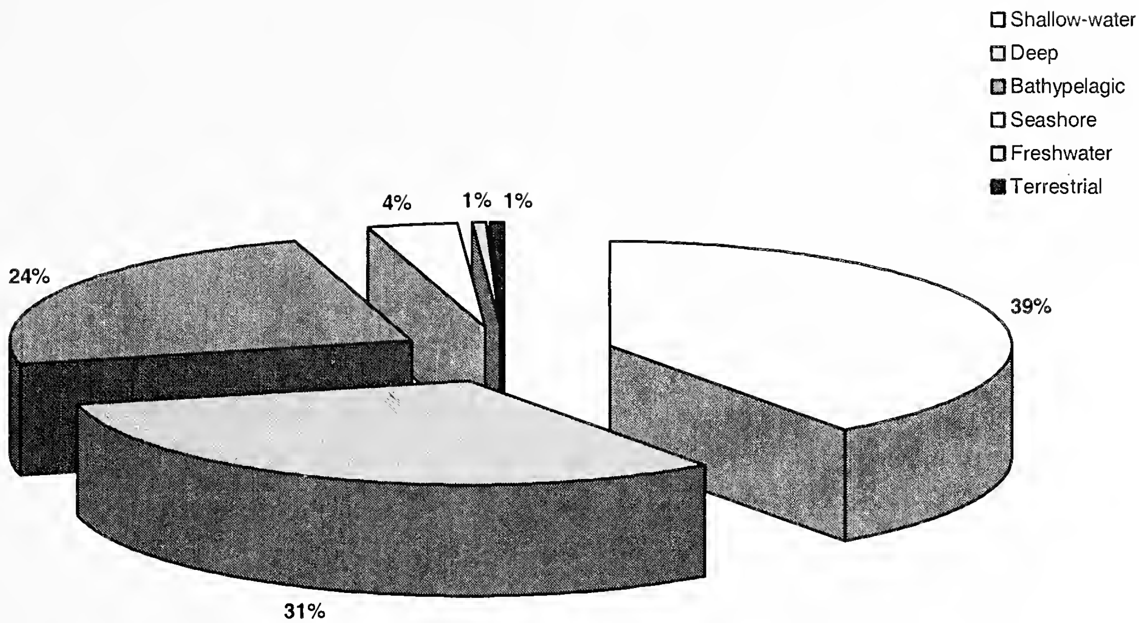


Figure 4. Decapoda and Stomatopoda of Ela. Distribution of species according to depth range, expressed in percentage of total number of species (188). *Shallow-water*: species collected in a depth range of few meters to 100 m (39%). *Deep*: benthic species collected deeper than 100 m (31%). *Bathypelagic*: shrimps collected by trawl between 100-2000 m (24%). *Seashore*: grapsid and plagusiid crabs of the littoral (4%).

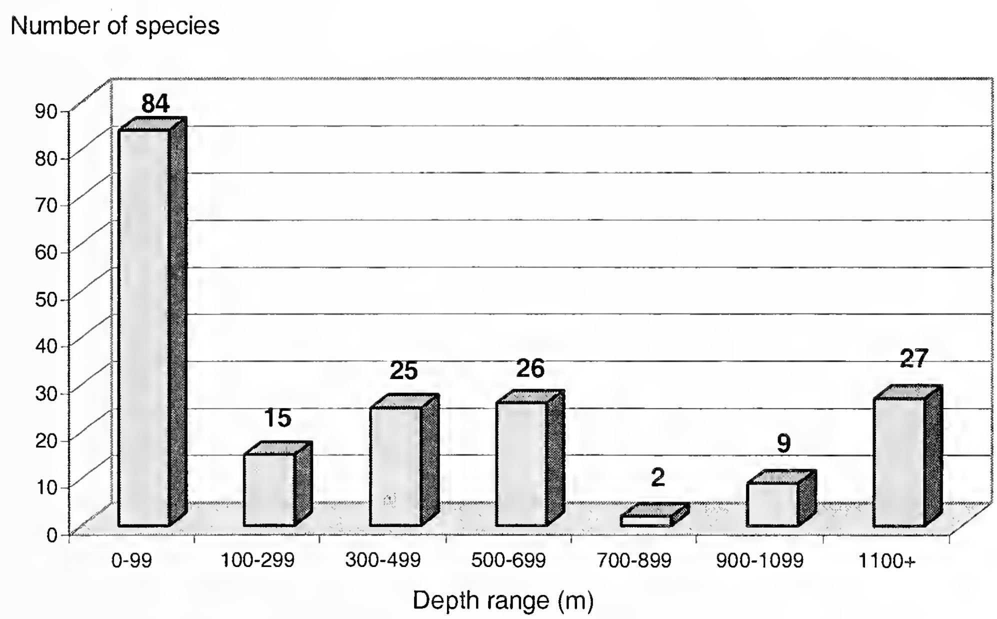


Figure 5. Decapoda and Stomatopoda of Ela. Number of species by depth range (*1100+* = 1100 m and deeper).

Biogeographic Study

In an attempt to identify the origin of EIa fauna, each species of this inventory has been assigned to one of the following groups, according to its geographic distribution: a) *Widely Distributed* for species distributed worldwide or occurring in Pacific and Atlantic Oceans or distributed from Indian Ocean to west American coasts; b) *Indo-West Pacific* for species distributed in the Indian Ocean and/or West and Central Pacific, but not reaching the American coasts; c) *East Pacific* for species known only on the west American coasts excluding those that occur in the East Pacific but have a wide geographic distribution (these are included in the *Widely Distributed* group); and d) *EIa local*, for species that are still known only from the area of study. Abundance of species within each group is given on Table 2 for 165 taxa determined to species level and the list of species for each group is given in Appendices B1-B4.

Table 2. Decapoda and Stomatopoda of EIa classified according to their geographic distribution (n is the number of the species)

	n	%
Widely Distributed	52	31.5%
Indo-West Pacific	65	39.4%
East Pacific	14	8.5%
EIa Local	34	20.6%
Total	165	100%

Widely Distributed Species (Appendix B1). Out of the 52 species that have a wide distribution, 27 belong to bathypelagic taxa of the Aristaeidae, Oplophoridae, and Sergestidae, 14 are marine shallow-water species (0-100 m), mainly shrimps of the Alpheidae, Gnathophyllidae, Hippolytidae, Palaemonidae, and Stenopodidae, seven are deep species (200-1050 m) of the Pandalidae, Parapaguridae, and Polychelidae, and four are crabs that live along the coastline (*Leptograpsus variegatus*, *Pachygrapsus transversus*, *Plagusia chabrus*, and *Plagusia dentipes*).

Indo-West Pacific Species (Appendix B2). The majority of the species, 39.4% or 65 species, are from the Indo-West Pacific, which confirms the basic IWP nature of EIa fauna. Among these 65 species, 19 are deep species, mainly of the Pandalidae and Parapaguridae, 35 are shallow-water species, mainly Alpheidae, Diogenidae, Palaemonidae, Porcellanidae, Trapeziidae, and Xanthidae, eight are bathypelagic shrimps (e.g. Sergestidae, Pasiphaeidae), and three are grapsids crabs with terrestrial affinities, *Ptychognathus* *easteranus*, *Cyclograpsus longipes*, and *Geograpsus crinipes*. The Polynesian origin of this IWP group is attested by 74% of the species that are also recorded in French Polynesia (37 species) and/or Hawaii (33 species).

East Pacific Species (Appendix B3). Twenty seven EIa species that occur on the American coasts are included in the *Widely Distributed Species* (see Appendix B1). They are species such as *Alpheus lottini*, *Carpilius convexus*, and *Trapezia ferruginea* that cannot be used to establish a true link between EIa and the eastern Pacific because of their wide distribution. On the contrary, the 14 species (8.5%) listed in Appendix B3 occur only in EIa and the Americas and are not known in any other places in the world. Therefore, they are more interesting for biogeographic consideration. Among them, seven are bathypelagic shrimps of the genera *Pasiphea* and *Sergestes* that reach as far as 110° W to the west. Because of their pelagic mode of life they are not a satisfactory proof of faunal affinities between EIa and the Americas. The six remaining species are benthic and more interesting in that respect. They are *Ageitomaia baeckstroemi*, *Chaceon chilensis*, *Galathea lenzi*, *Paromola rathbunae*, *Platymera gaudichaudii*, and *Projasus bahamondei*. *Ageitomaia baeckstroemi* and *Paromola rathbunae* are not true eastern Pacific taxa because they do not reach the Chilean coasts. In the east, their geographic distribution is limited to the Chilean oceanic islands of Desventuradas and/or Juan Fernández (see Fig. 1). *Chaceon chilensis*, *Platymera gaudichaudii*, and *Projasus bahamondei* reach the Chilean coasts and can be considered as a part of the deep benthic continental fauna that extends to the west as far as the Sala y Gómez and Nazca submarine ridges. *Galathea lenzi* appears to be the single shallow-water species that occurs both on Sala y Gómez Island and on the Chilean coast (Concepción and Valdivia in Retamal, 1981), therefore indicating a weak link between EIa and Chile.

As far as a boundary can be set up between IWP and EP provinces, it can be positioned around 83-84° W on the Sala y Gómez and Nazca seamounts according to the observation of Parin *et al.* (1997: 176) on two east Pacific species, the lobster *Projasus bahamondei* and the crab *Chaceon chilensis*. Obviously this limit is not strict, as *Chaceon chilensis*, for example, is reported as far as 89°11 W in the west by Zarenkov (1990; R/V Professor Shtokman stn CT 1976). However, if *Widely Distributed Species* are excluded, it clearly appears that most of the taxa recorded east of 84° W are EP (eight out of 12; see appendix B3) while only one is IWP (*Nematocarcinus gracilis*) and three are still only known from these seamounts. On the other hand, out of the 43 species captured on the seamounts at 84° W or westward (*Widely distributed Species* excluded) the majority are IWP (22), only three are EP (*Paromola rathbunae*, *Pasiphaea americana*, and *Sergestes extensus*), and 18 still are reported only from this area.

EIa Local Species (Appendix B4). Thirty-four species are still known only from EIa, which is a rate of endemism of 20.6%. However, as the IWP inventory is still far from being complete, especially for deep taxa, it is difficult to assess which of these 34 local species are true endemic species. In a rough approach, species collected at depth ranges difficult to sample can be excluded: four species collected at Easter Island between 40-100 m (La Pérouse Bay); and 21 species collected between 150-800 m on the seamounts of Sala y Gómez and Nazca. The nine remaining species, *Calcinus pascuensis*, *Discias pascuensis*, *Palaemonella disalvoi*, *Parribacus perlatus*, *Percnon pascuensis*, *Periclimenes rapanui*, *Plagusia integripes*, *Pylopaguropsis garciai*, and *Scyllarides roggeveeni* were collected between seashore to 40 m, i.e. a depth range that is rather well inventoried in the IWP. From that point of view, they represent potentially true endemic species to Easter and Sala y Gómez Islands, which makes a rate of endemism of 18% (nine species out of 50 determined to species level between 0-40 m).

Mironov (in Parin *et al.*, 1997: 221) has proposed the "Sala-y-Gómezian faunistic complex" for the submarine ridge situated between 83° W to 101° W, excluding Easter and Sala y Gómez Islands. This is based mainly on the echinoids and molluscan faunas. The Decapoda inventoried in this work between 83°-101° W include 18 local species out of 56 determined to species level. This makes a rate of endemism of 32% for this submarine ridge alone.

Comparison with French Polynesian Islands. Westward of EIa, French Polynesia is the closest place where the Decapoda and Stomatopoda are already inventoried (Poupin, 1996, 1998, Internet). The comparison between the two areas is presented in Table 3. At species level there is a 4.5-fold decrease in species level from French Polynesia (842 species) to EIa (188 species). Although this difference can be partly explained because of more explorations in French Polynesia, especially during the last 20 years (*cf.* Poupin, 1998: 43, fig. 9), it nevertheless clearly demonstrates the depauperate nature of EIa fauna. Freshwater taxa of the Atyidae (*Atyoida*, *Caridina*) and Palaemonidae (*Macrobrachium*, *Palaemon*), and semi-terrestrial taxa of the Coenobitidae (*Birgus*, *Coenobita*) and Gecarcinidae (*Cardisoma*, *Discoplax*, *Epigrapus*), are totally absent from the place. The reduction is even more obvious for eight genera that can be considered as similarly inventoried in both areas with an average reduction factor of 5.7 (see Table 4).

Despite this decrease in biodiversity, the similarity between the two areas is nonetheless attested by a high number of shared taxa: 91% at family level; 65% at generic level; and 37% at species level (Table 3). Among the species in common between French Polynesia and EIa there are 33 shallow-water species, 18 deep species (100 m and below), seven bathypelagic species, and four semi-terrestrial species (crabs *Cyclograpsus longipes*, *Geograpsus crinipes*, *Leptograpsus variegatus*, and *Ptychognathus easteranus*). Eight species still are distributed only from French Polynesia to EIa: one freshwater crab

(*Ptychognathus easteranus*), one lobster (*Panulirus pascuensis*), two coral-associated crabs (*Trapezia areolata*, *Trapezia punctimanus*), and four deep species (*Paragiopagurus wallisi*, *Plesionika fenneri*, *Platepistoma balssii*, *Progeryon mararae*).

Table 3. Comparison of Decapoda and Stomatopoda fauna between French Polynesian Islands and EIa at family, generic and species levels. Data for French Polynesian Islands are from checklists by Poupin (1996, 1998) updated at http://decapoda.free.fr on January 2003. (*Only 165 EIa taxa determined to species level are considered for calculation of this percentage).

	Family	Genus	Species
French Polynesia	86	347	842
Easter Island	54	118	188
Difference	-32	-229	-654
Shared Taxa	49	77	62
% of Shared Taxa	91%	65%	38%*

Table 4. Decrease in species number from French Polynesia to EIa for eight genera than can be considered as similarly inventoried in the two places. FR = Factor of Reduction from French Polynesia to EIa.

Group	Genus	French Polynesia	EIa	FR
Lobsters	*Panulirus*	6	1	6
	Parribacus	3	1	3
Shrimps	*Alpheus*	39	6	6,5
	Plesionika	22	6	3,7
Anomura	*Calcinus*	21	3	7
	Petrolisthes	12	1	12
Crabs	*Percnon*	4	1	4
	Trapezia	14	4	3,5
			Mean FR	5,7

At least three species indicate the closest link between EIa and the south of French Polynesia between latitudes 20-30° S. They are the hermit crab *Calcinus imperialis*, the lobster *Panulirus pascuensis* and the crab *Leptograpsus variegatus* (Table 5). Two other species are potential indicators of such a link, the xanthid *Liomera laperousei*, possibly present at 28° S in French Polynesia (McDonald bank, in Laboute & Richer de Forges, 1986) and the grapsid *Pachygrapus transversus*, perhaps present in Rapa (Poupin, field observation, November 2002, in study). Other EIa species that occur along the southern edge of tropical Pacific are the shrimp *Rhynchocinetes balssi* and the grapsid *Plagusia chabrus*. Because of their wide distribution (see Table 5) it is most probable that they also occur in the south of French Polynesia although not yet recorded from that place.

Table 5. EIa Decapoda that occur along the southern edge of tropical Pacific. Latitude ranges derived from distributions given in Griffin (1973), Holthuis (1972, 1991), Poupin (1996), and Poupin *et al.* (2003).

	Distribution	Latitude range
Calcinus imperialis	Easter Is., Tuamotu (Fangataufa), Kermadec Is., Norfolk Is., New Caledonia, Vanuatu.	14° - 34 ° S
Leptograpsus variegatus	South America from Peru to Chile, Juan Fernández, Easter Island, Rapa, New Zealand, Tasmania, Australia.	5° - 46 ° S
Panulirus pascuensis	Easter Island, Sala y Gómez, Pitcairn, Rapa	26° - 30 ° S
Plagusia chabrus	Chile (Taltal to Los Vilos), Desventuradas, Juan Fernández, Easter Island, New Zealand, Tasmania, South Africa (Cape of Good Hope)	25° - 40 ° S
Rhynchocinetes balssi	Juan Fernández, Easter Island, New Zealand, Norfolk Is., Lord Howe Is.	29° - 35 ° S

CONCLUSION

In the present inventory, 188 taxa of the Decapoda and Stomatopoda have been recognized in EIa, 165 of which to species level. The local fauna still remains imperfectly known for several reasons. Firstly, a few old collections are still only partially identified (23 taxa remain undetermined at species level) and some contemporary collections, such as the Decapoda collected in 1998-1999 during the US National Park Service Expedition, are still unpublished. Secondly, the investigations in the depth range of 50-800 m appear very limited around Easter and Sala y Gómez Islands. They were made only during the 1958 SIO Downwind Expedition (La Pérouse Bay, dredge, 40-100 m) and the 1999 CIMAR-V Expedition (Sala y Gómez, trawl, around 100 m). The resulting gap in our knowledge can be perceived by comparison with the results obtained by the 1997 MUSORSTOM 9 Expedition to the Marquesas Islands in a depth range of 50-1000 m (Richer de Forges *et al.*, 1999). To date, partial results from this expedition indicate more than 100 records of Decapoda and Stomatopoda, of which 58 are new for the French Polynesian fauna (Poupin, unpublished data). Thirdly, imperfection in this inventory is due to potentially overlooked references as well as taxonomic status that remain unclear. In this work, for example, the opinion of Chan & Crosnier (1987) that *Plesionika alaini* (Burukovsky, 1992) is a junior synonym of *Plesionika williamsi* Forest, 1964 is adopted although R. Burukovsky (pers. com.) disagrees with that view.

However incomplete and imperfect as it may be, this inventory clearly confirmed the IWP nature of EIa. The majority of species (39.4%) are IWP, of which 74% are Polynesian. Some species indicate a link between EIa and the islands that lie along the southern edge of the tropical Pacific (e.g. Rapa, Kermadec, and Norfolk), an observation that is in agreement with the results obtained for the mollusks by Rehder (1980: 14, Fig. 6-9). The decrease in species diversity from west to east can be measured between French Polynesia and EIa. Overall, the number of species decreases by a factor of 4.6 and for eight genera that are well inventoried in both places there is a mean reduction factor of 5.7.

The boundary between IWP and EP regions is positioned around 83-84° W in agreement with the analysis of Parin *et al.* (1997) on the fauna of the Sala y Gómez and Nazca seamounts. Although this limit is not clear-cut, for example for species such as *Chaceon chilensis* or *Nematocarcinus gracilis*, it is clear that most of the Decapoda are EP east of this limit while they are IWP west of it.

The rate of endemism of EIa still remains difficult to assess because of vagaries of collections and disparities observed within the area. Overall there are 34 EIa local species, i.e. a rate of endemism of 20.6%. If the depth range of 0-40 m is considered alone, because it is of easy access and therefore supposed to be better inventoried, then only 18% of the species are endemic. As this figure applies only for the species collected around Easter Island, it can be compared with some groups already studied there. The rate of endemism is 14% for the algae (Santelices & Abbott, 1987), 22% for the fishes (Randall, 1998), and up to 42% for the mollusks (Rehder, 1980). If the "Sala-y-Gómezian" area identified by Mironov & Detinova (1990) is considered alone (seamounts at 150-800 m, between 83°-101° W), the rate of endemism is 32%. In comparison, the rate of endemism for all the invertebrates collected on these seamounts (west of 83° W) is 51% (Parin *et al.*, 1997).

As the data presented in this inventory are stored in a database, a convenient means to correct and update this checklist in the future is to post it on the Internet. Similar Internet projects are already available for Australia (ABIF, Internet), French Polynesia (Poupin, Internet), Hawaii (Eldredge & DeFelice, Internet), Japan (Sakai, Internet), and Taiwan (Shih, Internet). Although unequal in their formats and contents, these websites appear as useful and promising tools for a better knowledge of the crustacean fauna in the Pacific area.

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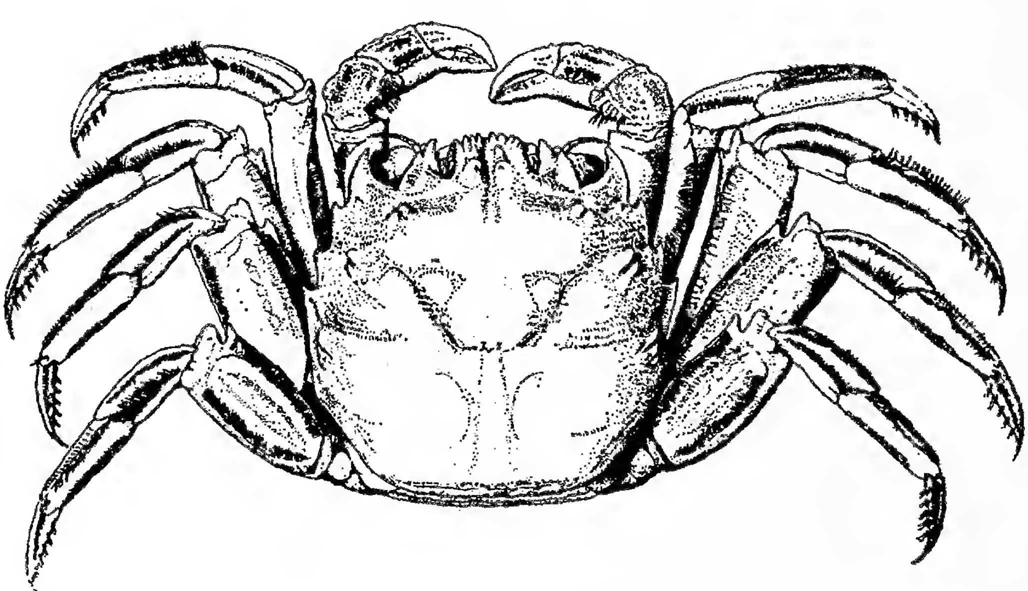

Plagusia integripes Garth, 1973. Easter Island, shallow-water off Hanga Roa, female holotype (AHF 6511) (After Garth, 1973: 327, Fig. 1)

LIST OF THE SPECIES

CLASS MALACOSTRACA

SUBCLASS HOPLOCARIDA

ORDER STOMATOPODA

FAMILY ODONTODACTYLIDAE

***Odontodactylus hawaiiensis* Manning, 1967**. - *Odontodactylus hawaiiensis*. - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. unknown; with this comment: "Fragments of a prey item, which was probably *Odontodactylus hawaiiensis*, were common in stomachs of the black jack *Caranx lugubris*"). - Retamal, 2002: 73, fig. 1 (Sala y Gómez, 117 m; det. S. Ahyong).

FAMILY PSEUDOSQUILLIDAE

***Pseudosquillisma oculata* (Brullé, 1837)**. - *Pseudosquilla oculata*. - DiSalvo *et al.*, 1988: 458 (Easter Island; scuba dives 15-60 m; det. unknown). - *Pseudosquillisma oculata* - Manning, 1995: 110 (new comb.).

***Raoulserenea oxyrhyncha* (Borradaile, 1898)**. - *Pseudosquilla oxyrhyncha* - Gravier, 1936: 254 (Easter Island; with this comment: "Deux exemplaires ont été récoltés : l'un mâle, de 47 mm, environ de longueur, l'autre femelle, de 31 mm"). - *Raoulserenea oxyrhyncha* - Manning, 1995: 116 (new comb.). - REMARKS - Comment from Ahyong (email, 02 Feb. 2001) "It (*Raoulserenea oxyrhyncha*) is very similar to *Pseudosquillisma oculata*, so the records of these species from Easter Island require verification. They could be either or even referable to two other species."

SUBCLASS EUMALACOSTRACA

ORDER DECAPODA

SUBORDER DENDROBRANCHIATA

Mostly cosmopolitan bathypelagic or pelagic shrimps collected by trawl during cruises of R/V Professor Shtokman (Burukovsky, 1990; Parin *et al.*, 1997; Vereshchaka, 1990). Two species are still unrecorded outside EIa, *Metapenaeopsis stokmani* Burukovsky, 1990 and *Sicyonia nasica* Burukovsky, 1990.

FAMILY ARISTAEIDAE

***Aristaeomorpha foliacea* (Risso, 1827)**. - *Aristaeomorpha foliacea* - Burukovsky, 1990: 189 (Sala y Gómez and Nazca seamounts, 25°04' S / 97°26' W, 300-500 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Bentheogennema pasithea* (De Man, 1907)**. - *Bentheogennema pasithea* - Vereshchaka, 1990: 130 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Gennadas barbari* Vereshchaka, 1990**. - *Gennadas barbari* Vereshchaka, 1990: 131 (Sala y Gómez and Nazca seamounts, 22°06'-25°58' S / 81°19'-100°41' W, ?160-2280 m).

***Gennadas incertus* (Balss, 1927)**. - *Gennadas incertus* - Vereshchaka, 1990: 130 (Sala y Gómez and Nazca seamounts, 21°41'-22°06' S / 81°19'-81°46' W, ?230-2000 m).

***Gennadas propinquus* Rathbun, 1906**. - *Gennadas propinquus* - Vereshchaka, 1990: 131 (Sala y Gómez and Nazca seamounts, 21°41'-22°06' S / 81°19'-81°46' W, ?230-2000 m).

***Gennadas scutatus* Bouvier, 1906**. - *Gennadas scutatus* - Vereshchaka, 1990: 131 (Sala y Gómez and Nazca seamounts, 21°41'-22°06' S / 81°19'-81°46' W, ?230-2000 m).

***Gennadas tinayrei* Bouvier, 1906**. - *Gennadas tinayrei* - Vereshchaka, 1990: 130 (Sala y Gómez and Nazca seamounts, 21°41'-25°40' S / 81°46'-88°31' W, 160-2100 m).

FAMILY BENTHESICYMIDAE

***Benthesicymus investigatoris* Alcock & Anderson, 1899**. - *Benthesicymus investigatoris* - Burukovsky, 1990: 189 (Sala y Gómez and Nazca seamounts, 24°58'-25°33' S / 88°31'-99°35' W, ? 330-1500 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

FAMILY PENAEIDAE

***Metapenaeopsis stokmani* Burukovsky, 1990**. - *Metapenaeopsis stokmani* Burukovsky, 1990: 189 (Sala y Gómez and Nazca seamounts, 25°39' S / 85°24' W, 162-190 / 150-300 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

FAMILY SICYONIIDAE

***Sicyonia nasica* Burukovsky, 1990**. - *Sicyonia nasica* Burukovsky, 1990: 191 (Sala y Gómez and Nazca seamounts, 25°04'-25°54' S / 84°22'-86°17' W, 200-500 m, mainly 200/300 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - Crosnier (in press).

FAMILY SOLENOCERIDAE

***Hadropenaeus lucasii* (Bate, 1881)**. - *Hadropenaeus lucasii* - Burukovsky, 1990: 188 (Sala y Gómez and Nazca seamounts, 25°04'-25°58' S / 85°07'-100°41' W, 162-590 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Hymenopenaeus halli* Bruce, 1966**. - *Hymenopenaeus halli* - Burukovsky, 1990: 188 (Sala y Gómez and Nazca seamounts, 25°07' S / 99°35' W, 330-800 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

FAMILY SERGESTIDAE

***Sergestes atlanticus* H. Milne Edwards, 1830**. - *Sergestes atlanticus* - Vereshchaka, 1990: 137 (Sala y Gómez and Nazca seamounts, 21°41'-25°40' S / 81°46'-99°35' W, 200-2500 m).

***Sergestes brevispinatus* Judkins, 1978**. - *Sergestes brevispinatus* - Vereshchaka, 1990: 138 (Sala y Gómez and Nazca seamounts, 22°06'-25°58' S / 81°19'-100°41' W, 218-2280 m).

***Sergestes consobrinus* Milne, 1968** – *Sergestes consobrinus* - Guzmán, 2003: 1036 (Easter Island, CIMAR-5, stn 35, 27°11'S, 109°15'W, Isaac-Kids midwater trawl, 450 m)

***Sergestes corniculum* Krøyer, 1855**. - *Sergestes corniculum* - Vereshchaka, 1990: 137 (Sala y Gómez and Nazca seamounts, 25°40' S / 85°27' W, ?160-2000 m).

***Sergestes cornutus* Krøyer, 1855**. - *Sergestes cornutus* - Vereshchaka, 1990: 137 (Sala y Gómez and Nazca seamounts, 25°04'-25°33' S / 89°12'-99°35' W, 218-1120 m).

***Sergestes extensus* Hanamura, 1983**. - *Sergestes extensus* - Guzmán, 2003: 1036 (Sala y Gómez ridge to Easter Island, CIMAR-5, stn 11 to stn 27, 27°00'S - 79°08'W / 27°11'S - 103°15'W, Isaac-Kids midwater trawl, 450-500 m).

***Sergestes geminus* Judkins, 1978**. - *Sergestes geminus* Judkins, 1978: 25 (eastern tropical Pacific, up to 10° S/110° W). -REMARK - Planktonic species included here although it is slightly out of the area studied. *Sergestes geminus* is a twin species of *S. orientalis*. *Sergestes orientalis* is widely distributed in the Indo-West Pacific but is not yet recorded from EIa.

***Sergestes gibbilobatus* Judkins, 1978**. - *Sergestes gibbilobatus* Judkins, 1978: 25 (eastern tropical Pacific, up to 20° S/110° W, 780 km in the north of Easter Island). - Vereshchaka, 1990: 138 (Sala y Gómez and Nazca seamounts, 21°41'-24°58' S / 81°19'-88°31' W, 230-2000 m).

***Sergestes halia* Faxon, 1893**. - *Sergestes halia* - Vereshchaka, 1990: 137 (Sala y Gómez and Nazca seamounts, 21°41'-25°58' S / 81°19'-100°41' W, 230-2280 m).

***Sergestes pectinatus* Sund, 1920**. - *Sergestes pectinatus* - Guzmán, 2003: 1036 (Sala y Gómez ridge, CIMAR-5, stn 16 to 21, 27°00'S - 86°33'W / 26°09'S - 93°97'W, Isaac-Kids midwater trawl, 450-500 m).

***Sergestes pestafer* Burkenroad, 1937**. - *Sergestes pestafer* - Vereshchaka, 1990: 137 (Sala y Gómez and Nazca seamounts, 21°41'-25°58' S / 81°19'-100°41' W, 230-2280 m). - Guzmán, 2003: 1037 (Sala y Gómez ridge, CIMAR-5, stn 11 to 27, 27°00'S - 79°08'W / 27°04'S - 103°07'W, Isaac-Kids midwater trawl, 475-500 m).

Sergestes vigilax **Stimpson, 1860**. - *Sergestes vigilax* - Vereshchaka, 1990: 137 (Sala y Gómez and Nazca seamounts, 24°58'-25°58' S / 85°27'-100°41' W, 160-2280 m).

Sergia bigemmea **(Burkenroad, 1940)**. - *Sergia bigemmea* - Guzmán, 2003: 1038 (Sala y Gómez ridge, CIMAR-5, stn 18, 27°01'S, 89°34'W, Isaac-Kids midwater trawl, 500 m).

Sergia gardineri **(Kemp, 1913)**. – *Sergia gardineri* - Vereshchaka, 2000: 102 (Geographic distribution and synonymy). - REMARKS - Presence of this species probable in EIa although it is not certain that specimens very actually captured in the area.

Sergia laminata **(Burkenroad, 1940)**. - *Sergestes laminatus* - Vereshchaka, 1990: 138 (Sala y Gómez and Nazca seamounts, 21°41'-25°40' S / 81°19'-89°12' W, 160-2280 m). - *Sergia laminata*. - Vereshchaka, 2000: 95 (Geographic distribution and synonymy).

Sergia potens **(Burkenroad, 1940)**. – '*Sergestes*? *potens*' - Vereshchaka, 1990: 138 (Sala y Gómez and Nazca seamounts, 21°41'-25°58' S / 81°19'-100°41' W, 230-2000 m). - *Sergestes robustus* Smith, 1882 - Vereshchaka, 1990: 138 (Sala y Gómez and Nazca seamounts, 22°06' S / 81°19' W, 230-2000 m) [Not *Sergia robusta* (Smith, 1882)]. - *Sergia potens* - Vereshchaka, 2000: 139 (Geographic distribution and synonymy). - REMARKS – Vereshchaka (2000: 157) has this comment under *Sergia robusta*: "The record - of *S. robustus* - by Vereshchaka, (1990) from the area of the Nazca and Sala-y-Gómez ridges is an error, as this species now appears to be one of those briefly described by Burkenroad (1940), being juveniles of *S. maxima* and *S. potens*."

Sergia regalis **(Gordon, 1939)**. - *Sergia regalis* - Vereshchaka, 2000: 149 (Geographic distribution and synonymy). - REMARKS - No specimens of this species were actually captured in EIa but, according to the distribution figured by Vereshchaka (2000: 153, fig. 54), its occurrence in the area is probable.

Sergia scintillans **(Burkenroad, 1940)**. - *Sergia scintillans* - Vereshchaka, 1990: 138 (Sala y Gómez and Nazca seamounts, 25°07'-25°58' S / 85°27'-99°35' W, 160-2000 m). - Vereshchaka, 2000: 164 (Geographic distribution and synonymy).

SUBORDER PLEOCYEMATA

INFRAORDER STENOPODIDEA

FAMILY SPONGICOLIDAE

Spongicola parvispina **Zarenkov, 1990**. - *Spongicola parvispina* Zarenkov, 1990: 218 (25°04' S - 97°26' W, 470-485 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

FAMILY STENOPODIDAE

Stenopus hispidus **(Olivier, 1811)**. - *Stenopus hispidus* - DiSalvo *et al.*, 1988: 458, 468, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

INFRAORDER CARIDEA

Sixty two shrimps, often common in the IWP. Only six species are still unrecorded outside EIa: three shallow-water species described by Fransen (1987) (*Discias pascuensis*, *Palaemonella disalvoi*, *Periclimenes rapanui*); and six deep species described by Burukovsky (1990) (*Alpheus romenskyi*, *Glyphocrangon wagini*, *Nematocarcinus pseudocursor*, *Pandalina nana*, *Pontophilus nikiforovi*, *Processa pygmaea*).

FAMILY PASIPHAEIDAE

Pasiphaea americana **Faxon, 1893**. - *Pasiphaea americana* - Burukovsky, 1990: 195 (Sala y Gómez and Nazca seamounts, 24°58' S / 88°31' W, 500-700 m). - Vereshchaka, 1990: 141 (Sala y Gómez and Nazca seamounts, 24°58'-25°33' S / 88°31'-89°12' W, 510-1500 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

Pasiphaea chacei **Yaldwyn, 1962**. - *Pasiphaea chacei* - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Pasiphaea cristata* Bate, 1888**. - *Pasiphaea cristata* - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 24°58'-25°58' S / 88°31'-100°41' W, 330-1800 m).

***Pasiphaea flagellata* Rathbun, 1906**. - *Pasiphaea flagellata* - Burukovsky, 1990: 195 (Sala y Gómez and Nazca seamounts, 25°47' S - 86°17' W, 200-300 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Pasiphaea kaiwiensis* Rathbun, 1906**. - *Pasiphaea kaiwiensis* - Vereshchaka, 1990: 141 (Sala y Gómez and Nazca seamounts, 24°40' S / 85°28' W, 320-2000 m).

FAMILY OPLOPHORIDAE

***Acanthephyra cucullata* Faxon, 1893**. - *Acanthephyra cucullata* - Vereshchaka, 1990: 139 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Acanthephyra curtirostris* Wood Mason, 1891**. - *Acanthephyra curtirostris* - Vereshchaka, 1990: 139 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Acanthephyra eximia* Smith, 1884**. - *Acanthephyra eximia* - Burukovsky, 1990: 194 (Sala y Gómez and Nazca seamounts, 24°58'-25°54' S / 84°22'-89°12' W, 500-800 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Acanthephyra trispinosa* Kemp, 1939**. - *Acanthephyra trispinosa* - Vereshchaka, 1990: 139 (Sala y Gómez and Nazca seamounts, 21°41'-25°40' S / 81°19'-86°34' W, 160-2280 m).

***Ephyrina ombango* Crosnier & Forest, 1973**. - *Ephyrina ombango* - Vereshchaka, 1990: 139 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Meningodora mollis* Smith, 1882**. - *Meningodora mollis* - Vereshchaka, 1990: 139 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Notostomus elegans* A. Milne Edwards, 1881**. - *Notostomus elegans* - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Oplophorus gracilirostris* A. Milne Edwards, 1881**. - *Oplophorus gracilirostris* - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 25°33'-25°58' S / 89°12'-100°41' W, 330-1800 m).

***Oplophorus spinosus* (Brullé, 1839)**. - *Oplophorus spinosus* - Burukovsky, 1990: 194 (Sala y Gómez and Nazca seamounts, 24°58' S / 88°31' W, 500-700 m). - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 21°41'-25°58' S / 81°19'-100°41' W, 160-2280 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Systellaspis cristata* (Faxon, 1893)**. - *Systellaspis cristata* - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 21°41' S / 81°46' W, 960-2000 m).

***Systellaspis debilis* A. Milne Edwards, 1881**. - *Systellaspis debilis* - Vereshchaka, 1990: 140 (Sala y Gómez and Nazca seamounts, 25°58' S / 100°41' W, 330-1800 m).

FAMILY DISCIADIDAE

***Discias pascuensis* Fransen, 1987**. - *Discias pascuensis* Fransen, 1987: 501, fig. 1-3 (Tahai, west coast of Easter Island, 39 m, in dead coral, February 1986, cl. 1.06 mm). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

FAMILY NEMATOCARCINIDAE

***Nematocarcinus gracilis* Bate, 1888**. - *Nematocarcinus gracilis* - Burukovsky, 2000b: 1165 (Nazca ridge, 23.04.1987, 23°25' S, 83°19' W, 600-650 m; synonymy). - Burukovsky, 2001: 1305 (Distribution). - *Nematocarcinus undulatipes* - Burukovsky, 1990: 195 (Sala y Gómez and Nazca ridges). - Parin *et al.*, 1997: 162, tab. 3 (List) [Not *N. undulatipes* Bate, 1888, *in* part *cf.* Burukovsky, 2000b: 1165]. - REMARKS - The *Nematocarcinus* sp. recorded by Vereshchaka (1990: 141) from Sala y Gómez and Nazca seamounts are larvae almost impossible to identify to species level (A.L. Vereshchaka, pers. com.).

***Nematocarcinus pseudocursor* Burukovsky, 1990**. - *Nematocarcinus pseudocursor* Burukovsky, 1990: 194 (Sala y Gómez and Nazca seamounts). - Parin *et al.*, 1997: 162, tab. 3 (List). - Burukovsky, 2000a: 901 (Nazca and Sala y Gómez, R/V Professor Shtokman 25°07' S – 99°27' W / 25°33' S – 89°11' W, 563-790 m; synonymy). - *Nematocarcinus undulatipes* - Burukovsky, 1990: 195 (Nazca and Sala y Gómez ridges). - Parin *et al.*, 1997: 162, tab. 3 (List) [Not *N. undulatipes* Bate, 1888, *in* part *cf.* Burukovsky, 2000a].

FAMILY RHYNCHOCINETIDAE

***Rhynchocinetes balssi* Gordon, 1936**. - *Rhynchocinetes balssi* - Holthuis, 1972: 35 (Easter Island, Hanga Roa; bottom rock, coral and sand, 12 m). - DiSalvo *et al.*, 1988: 468, 469 (scuba dives, 15-60 m; with this comment: "Crevices at various depths between 10 and 50 m contained *Rhincocinetes balssi*").

FAMILY STYLODACTYLIDAE

***Stylodactylus pubescens* Burukovsky, 1990**. - *Stylodactylus pubescens* Burukovsky, 1990: 198 (Sala y Gómez and Nazca seamounts, 25°04'-25°09' S - 96°18'-97°26' W, 545-800 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - Cleva, 1997: 395 (Nazca and Sala y Gómez, 1 male cl. 9.5 mm, 1 ovigerous female, cl. 8.5 mm, leg. Burukovsky).

FAMILY GNATHOPHYLLIDAE

***Gnathophyllum americanum* Guérin, 1857**. - *Gnathophyllum americanum* - Fransen, 1987: 508, fig. 4 (Easter Island, Hanga Piku, in dead coral, in tide pool, 1987, 2 females cl. 3.3 mm). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

FAMILY PALAEMONIDAE

***Brachycarpus biunguiculatus* (Lucas, 1846)**. - *Brachycarpus biunguiculatus* - Holthuis, 1972: 33 (Easter Island, Hanga Roa; bottom rock, coral and sand, 12 m). - Fransen, 1987: 509, fig. 5 (Tahai, west coast of Easter Island, 39 m, in dead coral, February 1986, 1 female cl. 4.65 mm). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen). - Udekem d'Acoz, 1999: 94 (Ecology, distribution).

***Harpiliopsis beaupresii* (Audouin, 1826)**. - *Harpiliopsis beaupresii* - Holthuis, 1972: 32 (Easter Island, Hanga-piko). - Fransen, 1987: 510, fig. 6 (Easter Island, in front of Hanga Piko, living in *Pocillopora damicornis*, 43 m, February 1986, 1 female cl. 2.0 mm). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen). - Bruce, 1998: 38 (Key and distribution with mention of coral hosts genera: *Pocillopora*, *Seriatopora*, *Stylophora*, rarely *Acropora*).

***Leander sp.* in Vereshchaka (1990)**. - *Leander sp.* - Vereshchaka,, 1990: 141 (Sala y Gómez and Nazca seamounts, 25°40' S / 85°27' W, 160-2000 m).

***Palaemonella disalvoi* Fransen, 1987**. - *Palaemonella disalvoi* Fransen, 1987: 511, fig. 7-12 (Easter Island, Tahai, west coast, off Hanga Rao, Motu Tautara; dead coral, 33-60 m). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

***Palaemonella spinulata* Yokoya, 1936**. - *Palaemonella spinulata* - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

***Periclimenes alcocki* Kemp, 1922**. - *Periclimenes alcocki* - Burukovsky, 1990: 197 (Sala y Gómez and Nazca seamounts, 25°04' S - 97°26' W, 200-500 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Periclimenes rapanui* Fransen, 1987**. - *Periclimenes rapanui* Fransen, 1987: 519, fig. 13-15 (Easter Island, Tahai, west coast, off Hanga Roa; dead coral, 30-39 m). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

***Periclimenes sp.* in Vereshchaka 1990**. - *Periclimenes sp.* - Vereshchaka, 1990: 141 (Sala y Gómez and Nazca seamounts, 25°04'-25°58' S / 97°26'-100°41' W, 218-1800 m).

FAMILY ALPHEIDAE

***Alpheopsis equalis* Coutière, 1896**. - *Alpheopsis equalis* - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Alpheus collumianus* Stimpson, 1860**. - *Alpheus collumianus* - DiSalvo *et al.*, 1988: 458 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Alpheus crockeri* (Amstrong, 1941)**. - *Alpheus crockeri* - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Alpheus lanceostylus* Banner, 1959**. - '*Alpheus lanceolatus* (Banner)' (sic) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner). - REMARKS - As *A.* '*lanceolatus*' is not a valid species, this record must be *Alpheus lanceostylus* Banner, 1959 (A. Anker, pers. com.).

***Alpheus lottini* Guérin-Méneville, 1829**. - *Alpheus lottini* - Fransen, 1987: 525 (Vaihu, Easter Island, 16 m, in dead coral, February 1986, 1 juvenile 1.90 mm). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner). - Retamal & Navarro, 2001: 215 (Easter Island, off Anakena Bay, in branches of coral *Pocillopora*; coll. M. Retamal, 1995 Chilean Navy POI Expedition).

***Alpheus pacificus* Dana, 1852**. - *Alpheus pacificus* - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Alpheus romenskyi* Burukovsky, 1990**. - *Alpheus romenskyi* Burukovsky, 1990: 197 (Sala y Gómez and Nazca seamounts, 25°34' S / 89°04' W, 540-560 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Athanas* ? *marshallensis* Chace, 1955**. - '*Athanas* nr. *marshallensis*' (sic) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Metabateaeus minutus* (Witelegge, 1897)**. - *Metabateaeus minutus* - Saavedra *et al.*, 1996: 117 (Easter Island, Hanga Tee, 0.7 m).

***Metalpheus paragracilis* (Coutière, 1897)**. - *Metalpheus paragracilis* - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Metalpheus rostratipes* (Pocock, 1890)**. - *Alpheus rostratipes* - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner). - Banner & Banner, 1967: 268 (Synonymy and distribution). - *Metalpheus rostratipes* - Crosnier & Forest, 1966: 246 (Synonymy). - Wicksten & Hendrick, 1992: 5 (Distribution).

***Synalpheus* ? *paraneomeris* Coutière, 1905**. - '*Synalpheus* nr. *paraneomeris*' (sic) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner).

***Synalpheus* ? *tumidomanus* (Paulson, 1875)**. - '*Synalpheus* nr. *tumidomanus*' (sic) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. D. Banner). - REMARKS - This species includes three distinct sub-species among which *S. tumidomanus* sensu strico is restricted to the Indo-Pacific (*cf.* Udekem d'Acoz, 1999: 106).

FAMILY HIPPOLYTIDAE

***Hippolyte sp.* (in Fransen, 1987: 525)**. - *Hippolyte sp.* - Fransen, 1987: 525, fig. 16f (Vaihu, Easter Island, 16 m, in coral). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

***Lysmata trisetacea* (Heller, 1861)**. - *Lysmata trisetacea* - Holthuis, 1972: 33 (Easter Island, Rano Raraku, Vaihu, Vinapu, Hanga Roa, bottom rock, coral and sand, 12 m).

***Thor amboinensis* (De Man, 1888)**. - *Thor amboinensis* - Fransen, 1987: 526, fig. 16a, b (Easter Island, off Hanga Roa, Motu Tautara, Tahai west coast, Motu Nui, 5-60 m, dead coral, February 1986). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

***Thor spinosus* Boone, 1935**. - *Thor spinosus* - Fransen, 1987: 528, fig. 16c, e (Easter Island, Tahai west coast, Motu Tautara, dead coral, 33-39 m). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

FAMILY PROCESSIDAE

***Processa pygmaea* Burukovsky, 1990**. - *Processa pygmaea* Burukovsky, 1990: 191 (Sala y Gómez and Nazca seamounts, 25°04' S / 97°29' W, 267-280 / 200-500 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

FAMILY PANDALIDAE

***Heterocarpus laevigatus* Bate, 1888**. - *Heterocarpus laevigatus* - Burukovsky, 1986: 62 (Sala y Gómez). - Crosnier, 1988: 75 (from Burukovsky record; Sala y Gómez at 26° S - 105° W). - Burukovsky, 1990: 199 (Sala y Gómez and Nazca seamounts, 23°26'-25°33' S - 83°20'-98°14' W, 300-800 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Heterocarpus sibogae* De Man, 1917**. - *Heterocarpus sibogae* - Burukovsky, 1990: 200 (Sala y Gómez and Nazca seamounts, 24°58'-25°58' S - 85°07'-100°41' W, 200-800 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Pandalina nana* Burukovsky, 1990**. - *Pandalina nana* Burukovsky, 1990: 201 (Sala y Gómez and Nazca seamounts, 23°26'-25°19' S - 83°20'-97°27' W, 200-700 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Plesionika edwardsii* (Brandt, 1851)**. - *Plesionika (Plesionika) edwardsii* - DiSalvo *et al.*, 1988: 458, 469, tab. 4 (Easter Island, from traps baited and left at 100 m; det. M. Wicksten). - Burukovsky, 1990: 203 (Sala y Gómez and Nazca seamounts, 25°07'-25°58' S - 85°07'-99°35' W, 200-500 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Plesionika ensis* A. Milne Edwards, 1881**. - *Plesionika (Plesionika) ensis* - Burukovsky, 1990: 204 (Sala y Gómez and Nazca seamounts, 24°58'-25°33' S - 86°34'-97°26' W, 300-800 m). - Parin *et al.*, 1997: 162, tab. 3 (List). - REMARKS - *Plesionika ensis* and *P. reflexa* Chace, 1985 are twin species still not confidently separated; both species are known from the Polynesian Islands (*cf.* Chan & Crosnier, 1997: 194).

***Plesionika fenneri* Crosnier, 1986**. - *Heterocarpus fenneri* - Burukovsky, 1990: 199 (Sala y Gómez and Nazca seamounts, 25°04'-25°33' S - 89°12'-97°26' W, 500-700 m). - Parin *et al.*, 1997: 162, tab. 3 (List). – *Plesionika fenneri* – Chan & Crosnier, 1997: 196 (Synonymy and distribution).

***Plesionika martia* (A. Milne Edwards, 1883)**. - *Plesionika (Plesionika) martia* - Burukovsky, 1990: 205 (Sala y Gómez and Nazca seamounts, 24°58'-25°07' S - 88°31'-99°35' W, 300-800 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Plesionika ocellus* (Bate, 1888)**. - *Plesionika (Nothocaris) ocellus* - Burukovsky, 1990: 206 (Sala y Gómez and Nazca seamounts, 25°04' S - 97°26' W, 300-500 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

***Plesionika williamsi* Forest, 1964**. - *Plesionika (Plesionika)* aff. *willamsi* - Burukovsky, 1990: 206 (Sala y Gómez and Nazca seamounts, stn CT 1951, 25°38' S - 86°34' W, 400 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - *Plesionika crosnieri* Burukovsky, 1992: 145 (same station than in Burukovsky, 1990, plus CPTM 8099 'Torok', 26-27 March 1990, 25°39' S - 86°51' W, 583-600 m; and 14-15 October 1989, 35°56' S - 100°41' W, 517-520 m). - *Plesionika alaini* Burukovsky, 1993: 18 (nom. nov. for *P. crosnieri* Burukovsky, 1992). - *Plesionika williamsi* - Chan & Crosnier, 1987: 209 (Synonymy and distribution). - REMARKS – The synonymy between *P. alaini* (Burukovsky, 1992) and *P. williamsi* Forest, 1964, proposed by Chan & Crosnier (1987), is adopted in this work. However, R. Burukovky does not agree with that opinion and considers that the two species are distinct (pers. com., January 23, 2003).

FAMILY CRANGONIDAE

***Pontocaris rathbuni* (De Man, 1918)**. - *Pontocaris rathbuni* - Burukovsky, 1990: 209 (Sala y Gómez and Nazca seamounts, 25°04' S - 97°26' W, 300-500 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Pontophilus gracilis junceus* Bate, 1888**. - *Pontophilus gracilis junceus* - Burukovsky, 1990: 209 (Sala y Gómez and Nazca seamounts, 24°58'-25°07' S - 88°31'-99°35' W, 500-800 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Pontophilus nikiforovi* Burukovsky, 1990**. - *Pontophilus nikiforovi* Burukovsky, 1990: 209 (Sala y Gómez and Nazca seamounts, 25°03' S - 97°27' W, 150-300 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Pontophilus*? *sp.* in Vereshchaka (1990)**. - ? *Pontophilus* sp. - Vereshchaka, 1990: 141 (Sala y Gómez and Nazca seamounts, 25°04' S / 97°26' W, 218-800 m).

FAMILY GLYPHOCRANGONIDAE

***Glyphocrangon wagini* Burukovsky, 1990**. - *Glyphocrangon wagini* Burukovsky, 1990: 206 (Sala y Gómez and Nazca seamounts, 24°56'-25°33' S - 88°31'-99°35' W, 500-700 m). - Parin *et al.*, 1997: 162, tab. 3 (List).

INFRAORDER THALASSINIDEA

FAMILY CALLIANASSIDAE

***Callianassa amboinensis* De Man, 1888**. - '*Callinanssa amboinensis* (DeMan)' (sic). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. Holthuis & Fransen).

***Callianassa sp.* in Vereshchaka (1990)**. - *Callianassa sp.* - Vereshchaka, 1990: 143 (Sala y Gómez and Nazca seamounts, 25°04' S / 97°26' W, 220-360 m).

INFRAORDER PALINURA

Seven lobsters recorded in EIa: one WD (*Pentacheles laevis*); three IWP (*Arctides regalis*, *Panulirus pascuensis*, *Polycheles surdus*); one EP (*Projasus bahamondei*); and two still unrecorded outside EIa (*Parribacus perlatus* and *Scyllarides roggeveeni*);

FAMILY POLYCHELIDAE

***Pentacheles laevis* Bate, 1878**. - *Pentacheles laevis* - Galil, 2000: 301 (Nazca ridge, R/V Professor Mesyatsev, 1050 m).

***Polycheles surdus* Galil, 2000**. - *Polycheles surdus* Galil, 2000: 347 (Nazca and Sala y Gómez, R/V Professor Mesyatsev and Professor Shtokman, 545-800 m). - ? Polychelidae *sp*. - Vereshchaka, 1990: 143 (Sala y Gómez and Nazca seamounts, coll. R/V Professor Shtokman).

FAMILY PALINURIDAE

***Panulirus pascuensis* Reed, 1954**. - *Panulirus pascuensis* Reed, 1954 (Easter Island). - Holthuis, 1972: 36 (Easter Island, Hanga Roa, 5 m). - Báez & Ruiz, 1985: 98 (Easter Island and Sala y Gómez; specimens in MNHNS Santiago, coll. 1960-1972). - DiSalvo *et al.*, 1988: 457 (Easter Island). - Holthuis, 1991: 150 (Distribution, including Pitcairn Island). - Poupin, 1996a: 5, 9, 81 (French Polynesia, Rapa Island).

***Projasus bahamondei* George, 1976**. - *Projasus bahamondei* - Rudjakov *et al.*, 1990: 156 (Sala y Gómez and Nazca seamounts, 20°47'-21°25' S / 80°53'- 81°37' W, probably around 320 m). - Parin *et al.*, 1997: 146, 163 (List; with this comment p. 176: "East of 84° W the traps caught many spiny lobsters *Projasus bahamondei* and crabs *Chaceon chilensis*").

FAMILY SCYLLARIDAE

***Arctides regalis* Holthuis, 1963**. - *Arctides regalis* - DiSalvo *et al.*, 1988: 455, 458, tab. 4 (Easter Island; det. Holthuis). - Holthuis, 1991: 177 (Distribution, including Easter Island). - Retamal, 2000: 45 (Easter Island, CIMAR-5, Hotu Marotiri, 12 m).

***Parribacus perlatus* Holthuis, 1967**. - *Parribacus perlatus* Holthuis, 1967: 305 (Easter Island, Anakena, La Pérouse bay; in sand among rock). - Holthuis, 1972: 44, pl. 1 (same specimens). - Báez & Ruiz, 1985: 99 (Easter Island; specimens in MNHNS Santiago, coll. 1976-1978). - DiSalvo *et al.*, 1988: 457 (Easter Island). - Holthuis, 1991: 214 (Distribution "So far only known from Easter Island").

***Scyllarides roggeveeni* Holthuis, 1967**. - *Scyllarides roggeveeni* Holthuis, 1967: 306 (Easter Island, Hanga Pico, fish trap; with this comment: "The species is the closest to *Scyllarides astori* Holthuis from the Galapagos Island"). - Holthuis, 1972: 47, pl. 2 (same specimen). - Báez & Ruiz, 1985: 100 (Easter Island; specimens in MNHNS Santiago, coll. 1968). - Holthuis, 1991: 193 (Distribution with: "Only known from Easter Island"). - DiSalvo *et al.*, 1988: 457 (Easter Island).

INFRAORDER ANOMURA

Most of the 23 anomura of this list are IWP. *Galathea lenzi* is the only EP species and possibly also *Oncopagurus* cf. *haigae* if this specimen is finally attributed to *haigae*. Five species are still unrecorded outside EIa (*Calcinus pascuensis*, *Oncopagurus mironovi*, *Oncopagurus stockmani*, *Porcellanopagurus foresti*, and *Pylopaguropsis garciai*).

FAMILY GALATHEIDAE

***Galathea lenzi* Rathbun, 1907**. - *Galathea lenzi* - Retamal, 1981: 22 (Distribution in Chili). - Retamal, in press (Sala y Gómez, CIMAR-5, stn 71, Agassiz trawl, 80 m, stn 71, 26°28'14 S, 105°20'39 W, small sp. 0.5 cm in length).

***Munida sp.* in Vereshchaka (1990)**. - *Munida* sp. - Vereshchaka, 1990: 148 (Sala y Gómez and Nazca seamounts, 24°40'-25°58' S / 85°28'-100°41' W, 220-360 m).

***Phylladiorhynchus integrirostris* (Dana, 1853)**. - *Phylladiorhynchus serrirostris*. - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Haig). - *Phylladiorhynchus integrirostris*. - Baba, 1991: 485 (Synonymy, distribution and references, and this remark under *Phylladiorhynchus pusillus*, p. 487: "At the request of J. Haig I have examined 11 specimens from Easter Island in 40 m; they are referable to *P. integrirostris*"). - Synonym: *Phylladiorhynchus serrirostris* (Melin, 1939).

FAMILY PORCELLANIDAE

***Petrolisthes coccineus* (Owen, 1839)**. - *Petrolisthes coccineus* - Báez & Ruiz, 1985: 101 (Easter Island; specimens in MNHNS Santiago, coll. 1953).

***Petrolisthes extremus* Kropp & Haig, 1994**. - *Petrolisthes sp. nov* (?). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; see Remarks). - *Petrolisthes extremus* Kropp & Haig, 1994: 313 (Easter Island: from starfish stomach, January 1965, coll. I. Efford & J. Mathias, LACM; Anakena 7-8 m, coll. I. Efford & J. Mathias, LACM/AHF, Motu Iti, rock 8 August 1972, coll. H.I. Moyano LACM/AHF). - REMARKS - *Petrolisthes sp. nov* in DiSalvo *et al* (1988) was pre-identified by J. Haig. It can reasonably belong to *P. extremus*, although Kropp & Haig (1994) do not mention DiSalvo *et al.* collections

FAMILY ALBUNEIDAE

***Albuneidae sp.* det. N. Bahamonde**. - Albuneidae *sp.* (1) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. N. Bahamonde; with this comment: "N. Bahamonde of the University of Chile, Santiago, is currently describing a new albuneid crab obtained at Anakena Beach"). - REMARKS - This species is still undescribed. Dr. N. Bahamonde (pers. com., April 2001) has this comment: "The Albuneidae from Easter Island is now in the Hydrobiological section, Chilean National History Museum, Santiago". According to Boyko (2002: 260) it could be *Albunea bulla* Boyko, 2002.

FAMILY DIOGENIDAE

***Calcinus imperialis* Whitelegge, 1901**. - *Calcinus imperialis* - DiSalvo *et al.*, 1988: 458 (Easter Island, scuba dives, 15-60 m; det. J. Haig). -Poupin *et al.*, 2003: 94 (Easter Island).

***Calcinus pascuensis* Haig, 1974**. - *Calcinus pascuensis* Haig, 1974: 27 (Easter Island; Hanga Roa, 1 male missing big left chela). - Báez & Ruiz, 1985: 100 (Easter Island; specimens in MNHNS Santiago, coll. 1978). - DiSalvo *et al.*, 1988: 458, 463 (Easter Island, inshore flats; det. J. Haig). - Poupin *et al.*, 2003: 92 (Easter Island; littoral to 23 m deep).

***Calcinus vachoni* Forest, 1958**. - *Calcinus vachoni* - Poupin *et al.*, 2003: 95 (Easter Island).

FAMILY PAGURIDAE

Paguridae *spp.* in Vereshchaka (1990). - Paguridae larvae I-IV - Vereshchaka, 1990: 143-145 (Sala y Gómez and Nazca seamounts, 22°06'-25°04' S / 81°19'-97°26' W, 220-360 m).

***Porcellanopagurus foresti* Zarenkov, 1990**. - *Porcellanopagurus foresti* Zarenkov, 1990: 239 (Sala y Gómez and Nazca seamounts, 25°40' S / 85°27' W, 240-245 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - Saint Laurent & McLaughlin, 2000: 117 (mention of Zarenkov species, but no specimen examined).

***Pylopaguropsis garciai* McLaughlin & Haig, 1989**. - *Pylopagurospis sp. nov*. - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; det. J. Haig). - *Pylopaguropsis garciai* McLaughlin & Haig, 1989: 162, fig. 4c, 6c, 8d, 10c, 12c, 13k (Easter Island, off Hanga Roa, 1 male 4.9 mm, AHF, National Geographic Expedition, February 1985, 40 m, coll. H. Garcia.).

FAMILY PARAPAGURIDAE

Almost of the Parapaguridae of list are from Zhadan (1997) the only exception being *Tylapsis anomala* in Lemaitre (1998). *Bivalvopagurus sinensis* (de Saint Laurent, 1972) is not included although it is mentioned by Parin *et al.* (163, 216 tab. 3) from a personal communication by Zhadan. However, as this species is not included in Zhadan (1997) it is probably a preliminary determination.

***Oncopagurus* cf. *haigae* (De Saint Laurent, 1972)**. - *Oncopagurus* cf. *haigae* - Zhadan, 1997: 59 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, stn 1957, 29/04/87, 24°56.5' S, 88°31.6' W, 570-575 m; with this comment: "If the assignment of our specimen *to O. haigae* proves to be correct, this would be the only eastern Pacific species of Parapaguridae found so far at the Nazka and Sala-y-Gomez ridges").

***Oncopagurus mironovi* Zhadan, 1997**. - *Oncopagurus mironovi* Zhadan, 1997: 59 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, stn 1957, 29/04/87, 24°56.5' S, 88°31.6' W, 570-575 m; stn 1965(I) 30/04/87, 24°58.5' S, 88°29.3' W, 542-565 m; stn 1965(II), 30/04/87, 24°56.3' S, 88°32.6' W, 562-580 m; with this comment: "Lemaitre's 1996 specimens which he identified as *O. indicus* do differ from what we believe to be the true *O. indicus*. At the same time, his description is very similar to that of *O. mironovi*").

***Oncopagurus sp.* A in Zhadan, 1997**. - *Oncopagurus sp.* A. - Zhadan, 1997: 67 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, 25°05.7'-25°59.8' S, 99°27.7'-100°40.0' W, 330-750 m; with this comment: "This species closely resembles *O. tuamotu* (Lemaitre, 1994) and *O. cidaris* Lemaitre, 1996 and is in fact something intermediate between these species").

***Oncopagurus stockmani* Zhadan, 1997**. - *Parapagurus dimorphus* - Zarenkov, 1990: 238 (Sala y Gómez and Nazca seamounts, 22°06' S / 81°19' W, 240-245 m) [Not *Sympagurus dimorphus* (Studer, 1883), *cf.* Zhadan, 1997]. - *Sympagurus africanus subsp. nov.* - Parin *et al.*, 1997: 163 (List) [Not *Oncopagurus africanus* (De Saint Laurent, 1972), *cf.* Zhadan, 1997]. - *Oncopagurus stockmani* Zhadan, 1997: 65 (Sala y Gómez and Nazca seamounts, 20°46.8'-25°53.0' S, 80°52.2'-85°07.0' W, 227-350 m; synonymy).

***Paragiopagurus boletifer* (de Saint Laurent, 1972)**. - *Parapagurus sculptochela* Zarenkov, 1990: 237 (Sala y Gómez and Nazca seamounts, 25°04'-25°40' S / 85°27'-97°26' W, 218-400 m). - *Paragiopagurus boletifer* - Zhadan, 1997: 69 (Sala y Gómez and Nazca seamounts, R/V Professor Mesyatzev (sp. ZMUM), and R/V Professor Shtokman, 25°02.6'-25°34.0' S, 85°27.0'-99°24.8' W, 230-410 m; synonymy and this comment: "Comparison of type material of *Parapagurus sculptochela* Zarenkov, 1990 with Lemaitre's 1994 definition of *P. boletifer* shows that *P. sculptochela* is a junior synonym of *P. boletifer*"). - *Sympagurus boletifer* - Parin *et al.*, 1997: 163, tab. 3 (List).

***Paragiopagurus ruticheles* (A. Milne Edwards, 1891)**. - *Paragiopagurus ruticheles*. - Zhadan, 1997: 67 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, 25°01.1'-25°59.8' S, 97°28.5'-100°40.0' W, 290-400 m). - *Sympagurus ruticheles* - Parin *et al.*, 1997: 163, tab. 3 (List).

***Paragiopagurus wallisi* (Lemaitre, 1994)**. - *Paragiopagurus wallisi*. - Zhadan, 1997: 69 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, 25°05.1' S, 97°27.9' W, 260-265 m). - *Sympagurus wallisi* - Parin *et al.*, 1997: 163, tab. 3 (List).

***Strobopagurus aff. gracilipes* (A. Milne Edwards, 1891)**. - *Strobopagurus aff. gracilipes*. - Zhadan, 1997: 77 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, 24°56.5'-25°33.6' S, 88°29.3'-99°27.7' W, 570-790 m).

***Sympagurus affinis* (Henderson, 1888)**. - *Sympagurus affinis*. - Zhadan, 1997: 70 (Sala y Gómez and Nazca seamounts, R/V Professor Shtokman, 24°58.5'-25°33.6' S, 88°29.3'-90°19.0' W, 542-600 m, and R/V Professor Ikhtiandr). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Sympagurus dofleini* (Balss, 1912)**. - *Parapagurus rectichela* Zarenkov, 1990: 235 (Sala y Gómez and Nazca seamounts, 24°58'-25°40' S / 86°34'-99°35' W, 330-565 m). - *Sympagurus rectichela* - Zhadan, 1997: 71 (R/V Professor Shtokman, and R/V Ikhtiandr, Sala y Gómez and Nazca seamounts, 25°02.2'-27°07.2' S, 86°34.0'-99°46.7' W, 330-600 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - Lemaitre, 2000: 211 (New Zealand). - *Sympagurus dofleini* - Lemaitre, 2003: in press (Synonymy).

***Tylaspis anomala* Henderson, 1885**. - *Tylaspis anomala* - Lemaitre, 1998: 294, fig. 1, 2a, 3a, 4-7 (NE of Easter Island, R/V Albatross, stn 4701, 19°11' S, 102°24' W, 2265 fm - 4143 m - 26.XII.1904 with this comment: "the specimen from New Caledonia were each found carrying an unidentified anemone").

INFRAORDER BRACHYURA

Fifty-nine crabs listed from EIa including: seven WD species; 23 IWP species; four EP species (*Ageitomaia baeckstroemi*, *Chaceon chilensis*, *Paromola rathbunae*, *Platymera gaudichaudii*); 13 EIa local species (*Actaea allisoni*, *Cyrtomaia danieli*, *Ebalia sculpta*, *Forestia pascua*, *Garthambrus allisoni*, *Garthambrus mironovi*, *Heterocrypta epibranchialis*, *Homologenus orientalis*, *Liomera laperousei*, *Monodaeus pettersoni*, *Percnon pascuensis*, *Plagusia integripes*, *Randallia nana*); and 12 taxa still undetermined to species level.[3]

FAMILY DROMIIDAE

***Lauridromia dehaani* (Rathbun, 1923)**. - *Dromia dehaani* - Zarenkov, 1990: 224 (stn 1923, Sala y Gómez and Nazca seamounts, 25°40' S - 85°27' W, 162 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - *Lauridromia dehaani* - McLay, 1993: 145 (new comb. and distribution of the genus, "Indian and Pacific Ocean").

***Lewindromia unidentata* (Rüppel, 1830)**. - *Dromidia unidentata unidentata* - Garth, 1973: 316 (Anakena, METEI, stn F85, 6-8 m; covered by a sponge *Hymeniacidon*). - *Cryptodromiopsis unidentata* - McLay, 1993: 192, fig. 7a-k, 18a (new comb., synonymy and distribution). - *Lewindromia unidentata* - Guinot & Tavares, 2003: 74 (new genus). - Synonym - *Dromidia unidentata hawaiiensis* Edmonson, 1922.

FAMILY DYNOMENIDAE

Dynomenidae sp. det. J.S. Garth. - Dynomenidae sp. (1) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island, scuba dives, 15-60 m; det. J. Garth).

FAMILY HOMOLIDAE

***Homologenus orientalis* Zarenkov, 1990**. - *Homologenus orientalis* Zarenkov, 1990: 225 (stn 1996, 2018; Sala y Gómez and Nazca seamounts, 25°07.9' S - 99°26.8' W, 730-800 m). - Guinot & Richer de Forges, 1995: 447 (examination of Zarenkov specimens). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Paromola rathbunae* Porter, 1908**. - *Paromola japonica* - Zarenkov, 1990: 225 (stn 1904; Sala y Gómez and Nazca seamounts, 25°19.9' S - 85°06.7' W, 280 m) [Not *P. japonica* Parisi, 1915, *cf.* Guinot & Richer de Forges, 1995]. - Parin *et al.*, 1997: 163, tab. 3 (List). - *Paromola rathbunae* - Guinot & Richer de Forges, 1995: 362 (re-determination of Zarenkov specimens, 1 ov. female 75.6x72 mm, ZMUM Ma 4042). – REMARKS - Guinot & Richer de Forges (1995: 364) have this comment: "L'appartenance de la *Paromola* présente dans cette zone (Nazca and Sala y Gómez) à l'espèce habitant Juan Fernandez plutôt qu'à l'espèce indo-ouest-pacifique *P. japonica*, constitue un cas supplémentaire de l'endémisme constaté pour de nombreux organismes de la faune de l'ensemble île de Pâques et îles Sala y Gómez".

FAMILY LATREILLIIDAE

***Latreillia metanesa* Williams, 1982**. - *Latreillia phalangium* - Zarenkov, 1990: 224 (Sala y Gómez and Nazca seamounts, 25°04'-25°40' S / 85°27'-97°26' W, 162-260 m). - Parin *et al.*, 1997: 163, tab. 3 (List) [Not *Eplumula phalangium* (de Haan, 1839), *cf.* Castro *et al.*, in press]. - *Latreillia metanesa* – Castro *et al.*, in press (Sala y Gómez, R/V Professor Shtokman, stn 1924, Great Mounain, 25°34'-25°35' S / 85°27'-85°30' W, 24-245 m, 26.04.1987, 1 ov. female, ZMUM; Nazca ridge, Shoal Guyot, 25°44' S / 88°25' W, DW HO 73, 26.01.1958, 1 male USNM).

Latreillidae sp. det. J.S. Garth. - Latreillidae *sp.* (1) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Garth).

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[3] One deep crab, not included in this list, has been collected near EIa, at the hydrothermal vent of the Easter Microplate (31°09' S, 111°56' W, 2335 m, *Alvin* dives 3337-3338, January 1999): *Allograea tomentosa* Guinot, Hurtado & Vrijenhoek, 2002.

FAMILY CALAPPIDAE

Calappidae sp. det. J.S. Garth. - Calappidae *sp.* (1) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Garth).

***Mursia aspera* Alcock, 1899 ?** - *Mursia aspera* - Zarenkov, 1990: 220 (Sala y Gómez and Nazca seamounts, 22°06'-25°07' S / 81°19'-99°35' W, 162-350 m). - Parin *et al.*, 1997: 163, tab. 3 (List). – REMARKS – Galil (1993: 355) indicates: "Zarenkov's (1990) specimens differ from *M. aspera* in lacking prominent conii on carapace, external surface of chela and on upper margins of pereiopoda meri". As this observation is based on Zarenkov's drawing only (B.S. Galil, pers. com.) the exact identity of Zarenkov's material remains an open question.

***Mursia hawaiiensis* Rathbun, 1893**. - *Mursia hawaiiensis* - Galil, 1993: 364 (R/V Professor Shtokman, cruise 18, stn 1920, 25°44.04' S, 85°24.93' W, 97-1252 m, coll. Zarenkov, with this indication "information possibly inaccurate").

***Platymera gaudichaudii* H. Milne Edwards, 1837**. - *Mursia gaudichaudii* - Zarenkov, 1990: 220 (Sala y Gómez and Nazca seamounts, 22°06' S / 81°19' W, 162-350 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - *Platymera gaudichaudii* - Galil, 1993: 373 (Synonymy and distribution but without Zarenkov reference).

FAMILY LEUCOSIIDAE

***Ebalia sculpta* Zarenkov, 1990**. - *Ebalia sculpta* Zarenkov, 1990: 223 (stn 1923, 1983, Sala y Gómez and Nazca seamounts, 25°04'-25°58' S / 97°26'-100°41' W, 162-350 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Randallia nana* Zarenkov, 1990**. - *Randallia nana* Zarenkov, 1990: 220 (Sala y Gómez and Nazca seamounts, stn 1986, 1987, 2027, 2029, 25°04' S-97°26' W, 218-485 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

FAMILY MAJIDAE

***Ageitomaia baeckstroemi* (Balss, 1924)**. - *Ageitomaia baeckstroemi* - Retamal, in press (Sala y Gómez, CIMAR-5, stn 75, Agassiz trawl, 85 m, 26°27'12 S, 105°22'01 W). - Griffin & Tranter, 1986: 201 (Systematic and distribution).

***Cyrtomaia danieli* Zarenkov, 1990**. - *Cyrtomaia danieli* Zarenkov, 1990: 230 (Sala y Gómez and Nazca seamounts, 24°58'-25°40' S / 86°34'-99°35' W, 350-800 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Cyrtomaia platypes* Yokoya, 1933**. - *Cyrtomaia platypes* - Zarenkov, 1990: 232 (Sala y Gómez and Nazca seamounts, 25°04'-25°58' S / 97°26'-100°41' W, 350 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

***Huenia pacifica* Miers, 1979**. - *Huenia pacifica* - Retamal, 2001: 211 (Sala y Gómez, CIMAR-5 cruise, stn 65, 105 m, stn 71, 80 m; det. M. Wicksten). - Retamal, in press (M. Retamal pers. com, February 2002: Decapods of CIMAR-5 cruise, that will be published in Ciencia y Tecnología del Mar). - Griffin & Tranter, 1986: 80 (Distribution).

Majidae *spp.* (2) det. J.S. Garth. - Majidae *spp.* (2). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Garth).

FAMILY HYMENOSOMATIDAE

Hymenosomatidae *sp.* det. J.S. Garth. - Hymenosomatidae *sp.* (1). - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Garth).

FAMILY PARTHENOPIDAE

***Daldorfia horrida* (Linné, 1758)**. - *Daldorfia horrida* - Garth, 1985: 2 (Easter Island, La Pérouse Bay, 40-100 m). - DiSalvo *et al.*, 1988: 458, 469 (Easter Island, 55 m).

***Garthambrus allisoni* (Garth, 1993)**. - *Parthenope (Platylambrus) allisoni* Garth, 1993: 790, fig. 5 (Sala y Gómez seamont, fracture zone, 25°03' S, 97°29' W, 591 m, Carrousel Expedition, dredge 5, stn 19, 591 m, SIO Scripps Institution of Oceanography, 64-527, August 1, 1964). - *Garthambrus allisoni* - Ng, 1996: 157 (new comb.).

***Garthambrus mironovi* (Zarenkov, 1990)**. - *Asterolambrus mironovi* Zarenkov, 1990: 233, fig. 11 (Sala y Gómez and Nazca seamounts, stn 1921, 1924, 1992, 1996, 2038, 2029, 25°04'-25°40'S / 85°27'-99°35'W, 162-800 m). - *Parthenope (Platylambrus) mironovi* - Garth, 1993: 792 (Shoal Guyot, rock dregde, SIO Downwind Expedition, 25°44' S, 85°25' W, 228 m; R/V P. Shtokman, lchtyologists' seamount, 240-400 m, 25°03.1' S, 97°29.1' W). - Parin *et al.*, 1997: 163, tab. 3 (List). - *Garthambrus mironovi*. - Ng 1996: 158 (new comb.").

***Heterocrypta epibranchialis* Zarenkov, 1990**. - *Heterocrypta epibranchialis* Zarenkov, 1990: 232 (Sala y Gómez and Nazca seamounts, 25°11'-25°58' S / 100°39'-100°41' W, 290-350 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

FAMILY ATELICYCLIDAE

Atelicyclidae *sp.* det. J.S. Garth. - Atelicyclidae *sp.* (1) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Garth).

FAMILY GERYONIDAE

***Chaceon chilensis* Chirino-Gálvez & Manning, 1989**. - *Chaceon chilensis* - Zarenkov, 1990: 228 (Sala y Gómez and Nazca seamounts, stn 1847, 1867, 1904, 1976, 21°25-25°33' S / 81°19'-89°12' W, 280-440 m). - Parin *et al.*, 1997: 163, tab. 3 (List; with this comment, p. 176: "East of 84° W the traps caught many spiny lobsters *Projasus bahamondei* and crabs *Chaceon chilensis*").

FAMILY PORTUNIDAE

***Ovalipes trimaculatus* (De Haan, 1833)**. - *Ovalipes trimaculatus* - DiSalvo *et al.*, 1988: 466, tab. 4 (Easter lsland; scuba dives, 15-60 m; det. J. Garth).

Portunidae *spp.* (7) det. J.S. Garth. - Portunidae *spp.* (7) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives, 15-60 m; det. J. Garth).

***Thalamita* aff. *dakini* Montgomery, 1931**. - *Thalamita sp.* - Retamal, 1999: 7 (Sala y Gómez; coll. M. Retamal, 1995 Chilean Navy POI Expedition). - REMARKS - This pers. com. from M.A. Retamal (email, February 2002): "ln 1995, I collected one specimen in Sala y Gómez, identified as *Thalamita sp.* [*cf.* Retamal, 1999] but in 2000, another 5 were identified and I assume are *T. medipacifica* Edmonson". As *Thalamita medipacifica* Edmonson is a junior synonym of *T. dakini* Montgomery (see Crosnier, 2002: 419, 444), the *Thalamita* sp. of Retamal (1999) is placed her under *T.* aff. *dakini*.

***Portunus pubescens* (Dana, 1852)**. - *Portunus pubescens* - Garth, 1973: 316 (Easter lsland, Hanga-Roa, 1 female). - Báez & Ruiz, 1985: 102 (Easter Island; specimens in MNHNS Santiago, coll. 1960-1978).

FAMILY CARPILIIDAE

***Carpilius convexus* (Forskål, 1775)**. - *Carpilius convexus* - Garth, 1973: 317 (Anakena, 1 m). - Báez & Ruiz, 1985: 103 (Easter Island; specimens in MNHNS Santiago, coll. 1953-1976). - DiSalvo *et al.*, 1988: 457, 467, 470 (Easter Island).

FAMILY GONEPLACIDAE

***Progeryon mararae* Guinot & Richer de Forges, 1981**. - *Progeryon mararae* - Zarenkov, 1990: 228 (Sala y Gómez and Nazca seamounts, stn 1990, 25°04' S / 97°26' W, 390 m). - Parin *et al.*, 1997: 163, tab. 3 (List).

FAMILY TRAPEZIIDAE

***Trapezia areolata* Dana, 1852**. - *Trapezia areolata* - Garth, 1973: 320 (Easter Island, Hanga Piko, scuba diving, coral reef, 8-10 m). - Castro, 1997: 116 (Easter Island, Anakena Bay, 9.09.1995, coll. M. Retamal, 1995 Chilean Navy POI Expedition).

***Trapezia ferruginea* Latreille, 1828 ?** - *Trapezia ferruginea* - ?Garth, 1985: 11 (Easter Island, La Pérouse Bay, 40-100 m, 1 male lacking right cheliped and all legs but one). - Báez & Ruiz, 1985: 103 (Easter lsland, one specimen deposited in MNHNS Santiago, coll. 1984). – REMARKS - Specimen from La Pérouse Bay, in Garth (1985), probably lost (pers. com. P. Castro). Other specimens attributed to *T. ferruginea* by Garth (1973: 322) belong in fact to *T. punctimanus* Odinetz (*cf.* Castro, 1997: 127).

***Trapezia punctimanus* Odinetz, 1984**. - *Trapezia cymodoce ferruginea* - Rathbun, 1907: 58 (Easter Island) [Not *T. cymodoce* (Herbst) or *T. ferruginea* Latreille; *cf.* Castro, 1997]. - *Trapezia cymodoce* - Garth, 1973: 320 (Hanga Piko) [Not *T. cymodoce* (Herbst, 1801); *cf.* Castro, 1997]. - *Trapezia ferruginea* - Garth, 1973: 322 (Easter Island, specimen from stomach of large starfish) [Not *T. ferruginea* Latreille, 1828; *cf.* Castro, 1997]. - *Trapezia punctimanus* - Castro, 1997: 126 (Easter Island, Anakena Bay, 9.09.1995, coll. M. Retamal, 1995 Chilean Navy POI Expedition; plus specimens attributed to *T. cymodoce ferruginea*, by Rathbun, 1907, and to *T. cymodoce* and *T. ferruginea*, by Garth, 1973).

***Trapezia tigrina* Eydoux & Souleyet, 1842**. - *Trapezia danai* Ward (sic) - Garth, 1973: 321 (Easter Island, scuba diving, 8-10 m). - Castro, 1997: 130 (Synonymy: *Trapezia danae* Ward, 1939 = *Trapezia tigrina* Eydoux & Souleyet, 1842).

FAMILY XANTHIDAE

***Actaea allisoni* Garth, 1985**. - *Actaea allisoni* Garth, 1985: 4 (Easter Island, La Pérouse Bay, 40-100 m).

***Banareia parvula* (Krauss, 1843)**. - *Actaea parvula* - Garth, 1973: 318 (Anakena Bay). - *Banareia parvula* - Serène, 1984: 42 (Distribution).

***Chlorodiella cytherea* (Dana, 1852)**. - *Chlorodiella cytherea* - Garth, 1973: 320 (Easter Island, Hanga Piko, Anakena Bay).

***Etisus electra* (Herbst, 1801)**. - *Etisus electra* - Garth, 1973: 320 (Easter Island, Anakena Bay).

***Forestia pascua* Garth, 1985**. - *Forestia pascua* Garth, 1985: 3, fig. 1-5 (Easter Island, La Pérouse Bay, 40-100 m).

***Liomera laperousei* Garth, 1985**. - *Liomera laperousei* Garth, 1985: 7, fig. 11-16 (Easter Island, La Pérouse Bay, 40-100 m).

***Liomera monticulosa* (A. Milne Edwards, 1873)**. - *Liomera monticulosa* - Garth, 1985: 6 (Easter Island, La Pérouse Bay, 40-100 m).

***Liomera rugata* (A. Milne Edwards, 1834)**. - *Liomera rugata* - Garth, 1973: 318 (Hotu Iti). - Báez & Ruiz, 1985: 103 (Easter Island, specimens in MNHNS Santiago, coll. 1953-1960).

***Lophozozymus dodone* (Herbst, 1801)**. - *Lophozozymus dodone* - Garth, 1973: 319 (Easter Island, Anakena Bay).

***Monodaeus pettersoni* Garth, 1985**. - *Monodaeus pettersoni* Garth, 1985: 9, fig. 17-22 (Easter Island, La Pérouse Bay, 40-100 m).

***Platepistoma balssii* (Zarenkov, 1990)**. - *Cancer balssii* Zarenkov, 1990: 228 (Sala y Gómez and Nazca seamounts, 25°04' S / 97°26' W, 295-350 m). - Parin *et al.*, 1997: 163, tab. 3 (List). - *Platepistoma balssii* - Davie, 1991: 503 (new comb.).

***Pseudoliomera remota* (Rathbun, 1907)**. - *Actaea remota* Rathbun, 1907: 43, pl. 1 fig. 9, pl. 7 fig. 1 (Easter Island, shore). - *Pseudoliomera remota* - Garth, 1973: 318 (Rathbun' specimens). - Serène, 1984: 102 (Synonymy).

Xanthidae *spp.* (8) det. J.S. Garth. - Xanthidae *spp.* (8) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives 15-60 m; det. J. Garth).

FAMILY CRYPTOCHIRIDAE

Cryptochiridae *spp.* (2) det. J.S. Garth. - Hapalocarcinidae *spp.* (2) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island, scuba dives, 15-60 m; det. J. Garth). - REMARKS - Cryptochiridae is a replacement name for Hapalocarcinidae (see Martin & Davis, 2001: 55).

FAMILY PINNOTHERIDAE

Pinnotheridae *sp. nov.* det. J.S. Garth. - Pinnotheridae *sp. nov.* (1) - DiSalvo *et al.*, 1988: 458, tab. 4 (Easter Island; scuba dives, 15-60 m; det. J. Garth).

FAMILY GRAPSIDAE

***Cyclograpsus longipes* Stimpson, 1858**. - *Cyclograpsus longipes* - Garth, 1973: 325 (Easter Island, Vaihu). - Báez & Ruiz, 1985: 106 (Easter Island, specimens in MNHNS Santiago).

Geograpsus crinipes **(Dana, 1851)**. - *Geograpsus crinipes* - Garth, 1973: 323 (Easter Island, Poike in an altitude of 250 m; Tahai).

Leptograpsus variegatus **(Fabricius, 1793)**. - *Leptograpsus variegatus* - Rathbun, 1907: 29 (Easter Island, La Pérouse Bay). - Garth, 1973: 323 (Easter Island, Hanga Roa, and sp. examined by Rathbun). - Báez & Ruiz, 1985: 104 (Easter Island, specimens in MNHNS Santiago, coll. 1953-1983). - Retamal & Navarro, 1996: 53 (Sala y Gómez, littoral, coll. M. Retamal, 1995 Chilean Navy POI Expedition).

Pachygrapsus transversus **(Gibbes, 1850)**. - *Pachygrapus transversus* - Rathbun, 1907: 29 (Easter Island, shore). - Garth, 1973: 324 (same sp. than Rathbun, and new spp. from Hanga Piko; with this comment: "Since Indo-West Pacific species of *Pachygrapsus, P. planifrons* De Man and *P. minutus* A. Milne Edwards, were encountered by the Scripps International Geophysical Year, IGY Expedition at Clipperton Island (Garth, 1965), it is with interest that the writer verified from freshly collected METEI material the Easter Island record (Rathbun, 1907)"). - Báez & Ruiz, 1985: 105 (Easter Island; specimens in MNHNS Santiago, coll. 1953-1968).

Ptychognathus easteranus **Rathbun, 1907**. - *Ptychognathus easteranus* Rathbun, 1907: 31 (Easter Island, shore). - Garth, 1973: 325 (Rathbun's specimens, plus new sp. at Hanga Piko).

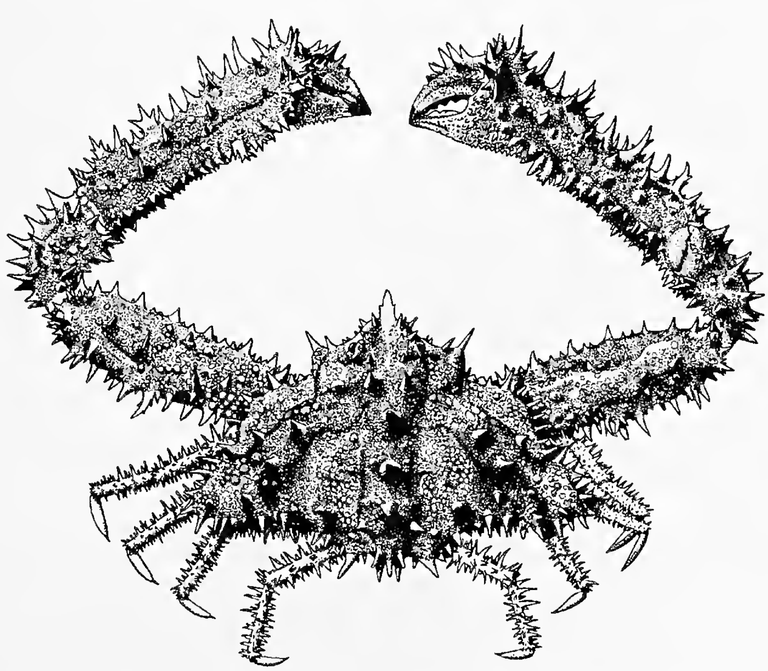
FAMILY PLAGUSIIDAE

Percnon pascuensis **Retamal, 2002**. - *Percnon pascuensis* Retamal, 2002: 63, fig. 1 (Vinapu and Anakena, Easter Island, littoral, 1999 CIMAR-5 Expedition).

Plagusia chabrus **(Linnaeus, 1758)**. - *Plagusia chabrus* - Báez & Ruiz, 1985: 106 (Easter Island, specimens in MNHNS Santiago, coll. 1953-1978). - REMARKS - This species is very similar to *P. dentipes*; see Griffin (1973: 436, fig. 14, tab. 3-4) for a detailed comparison of the two species.

Plagusia dentipes **De Haan, 1835**. - *Plagusia dentipes* - Rathbun, 1907: 36 (Easter Island, shore). - Garth, 1973: 326 (Rathbun sp. and 2 new spp., Easter Island). - Griffin, 1973: 435, fig. 14b (Easter Island, with discussion on affinities with *P. chabrus* and this conclusion: "*P. dentipes* thus appears quite definitely to be a valid species")

Plagusia integripes **Garth, 1973**. - *Plagusia integripes* Garth, 1973: 326 (Easter Island, Hanga Roa).



Garthambrus mironovi (Zarenkov, 1990). Shoal Guyot, 25°44' S, 85°25' W, rock dredge 228 m, SIO Downwind Expedition, 26 January 1958 (After Garth, 1993: 792, Fig. 6, drawing by M. Gaillard)

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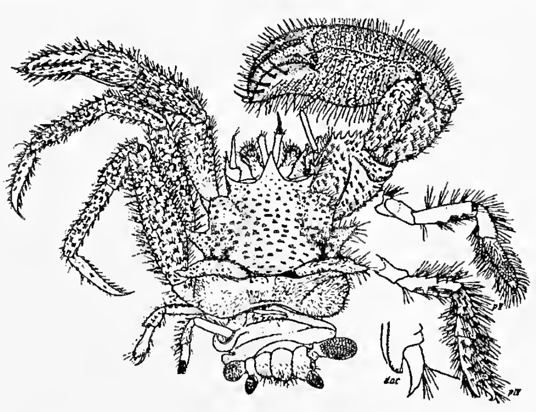

Porcellanopagurus foresti Zarenkov, 1990
Seamounts of Sala y Gómez and Nazca, 240-245 m, After Zarenkov (1990: 240, Fig. 14)

APPENDICES

A - TAXA UNDETERMINED TO SPECIES LEVEL

1. Albuneidae sp. det. N. Bahamonde
2. Atelicyclidae sp. det. J.S. Garth
3. Calappidae sp. det. J.S. Garth
4. *Callianassa* sp. in Vereshchaka (1990)
5. Dynomenidae sp. det. J.S. Garth
6. Hapalocarcinidae spp.(2) det. J.S. Garth
7. *Hippolyte* sp. (in Fransen, 1987: 525)
8. Hymenosomatidae sp. det. J.S. Garth
9. Latreillidae sp. det. J.S. Garth
10. *Leander* sp. in Vereshchaka (1990)
11. Majidae spp. (2) det. J.S. Garth
12. *Munida* sp. in Vereshchaka (1990)
13. *Mursia* aff. *aspera* Alcock, 1899
14. *Oncopagurus* cf. *haigae* (De Saint Laurent, 1972)
15. *Oncopagurus* sp. A in Zhadan, 1997
16. Paguridae spp. in Vereshchaka (1990)
17. *Periclimenes* sp. in Vereshchaka 1990)
18. Pinnotheridae sp. nov. det. J.S. Garth
19. *Pontophilus*? sp. in Vereshchaka (1990)
20. Portunidae spp. (7) det. J.S. Garth
21. *Strobopagurus* aff. *gracilipes* (A. Milne Edwards, 1891)
22. *Thalamita* sp. aff. *dakini*, M.A. Retamal pers. com.
23. Xanthidae spp. (8) det. J.S. Garth

B - SPECIES LISTED BY GEOGRAPHIC CATEGORIES

B1 Widely Distributed Species. EIa species distributed worldwide, or occurring in Pacific and Atlantic Oceans, or distributed from Indian Ocean to west American coasts. The '*' indicates the 27 species that occur in the eastern Pacific.

1. *Acanthephyra cucullata* Faxon, 1893 *
2. *Acanthephyra curtirostris* Wood Mason, 1891 *
3. *Acanthephyra eximia* Smith, 1884
4. *Alpheus crockeri* (Amstrong, 1941)
5. *Alpheus lottini* Guérin-Méneville, 1829 *
6. *Alpheus pacificus* Dana, 1852 *
7. *Aristaeomorpha foliacea* (Risso, 1827)
8. *Bentheogennema pasithea* (De Man, 1907) *

9. *Brachycarpus biunguiculatus* (Lucas, 1846) *
10. *Carpilius convexus* (Forskal, 1775) *
11. *Ephyrina ombango* Crosnier & Forest, 1973
12. *Gennadas incertus* (Balss, 1927) *
13. *Gennadas propinquus* Rathbun, 1906 *
14. *Gennadas scutatus* Bouvier, 1906 *
15. *Gennadas tinayrei* Bouvier, 1906 *
16. *Gnathophyllum americanum* Guérin, 1857
17. *Heterocarpus laevigatus* Bate, 1888
18. *Leptograpsus variegatus* (Fabricius, 1793) *
19. *Meningodora mollis* Smith, 1882 *
20. *Metalpheus paragracilis* (Coutière, 1897)
21. *Metalpheus rostratipes* (Pocock, 1890)
22. *Notostomus elegans* A. Milne Edwards, 1881 *
23. *Oplophorus gracilirostris* A. Milne Edwards, 1881
24. *Oplophorus spinosus* (Brullé, 1839) *
25. *Ovalipes trimaculatus* (De Haan, 1833) *
26. *Pachygrapsus transversus* (Gibbes, 1850) *
27. *Paragiopagurus ruticheles* (A. Milne Edwards, 1891)
28. *Pentacheles laevis* Bate, 1878
29. *Plagusia chabrus* (Linnaeus, 1758) *
30. *Plagusia dentipes* De Haan, 1835 *
31. *Plesionika edwardsii* (Brandt, 1851)
32. *Plesionika ensis* A. Milne Edwards, 1881
33. *Plesionika martia* (A. Milne Edwards, 1883)
34. *Plesionika williamsi* Forest, 1964
35. *Pseudosquillisma oculata* (Brullé, 1837)
36. *Sergestes atlanticus* H. Milne Edwards, 1830
37. *Sergestes consobrinus* Milne, 1968 *
38. *Sergestes corniculum* Krøyer, 1855
39. *Sergestes cornutus* Krøyer, 1855
40. *Sergestes gibbilobatus* Judkins, 1978
41. *Sergestes pectinatus* Sund, 1920 *
42. *Sergestes vigilax* Stimpson, 1860
43. *Sergia bigemmea* (Burkenroak, 1940) *
44. *Sergia laminata* (Burkenroad, 1940) *
45. *Sergia potens* (Burkenroad, 1940)
46. *Sergia scintillans* (Burkenroad, 1940) *
47. *Stenopus hispidus* (Olivier, 1811)
48. *Systellaspis cristata* (Faxon, 1893) *
49. *Systellaspis debilis* A. Milne Edwards, 1881
50. *Thor amboinensis* (De Man, 1888)
51. *Thor spinosus* Boone, 1935 *
52. *Trapezia ferruginea* Latreille, 1828 *

B2 Indo-West Pacific Species. EIa species distributed in the Indian Ocean and/or West and Central Pacific, but not reaching eastern Pacific. [H] and [P] identify the species known from Hawaii and French Polynesian Islands, respectively. Note that *Synalpheus tumidomanus* s.l. is included here although it is also known from the Mediterranea (see Udekem d'Acoz, 1999, p. 106 on the *tumidomanus* complex).

1. *Alpheopsis equalis* Coutière, 1896 [H]
2. *Alpheus collumianus* Stimpson, 1860 [H/P]
3. *Alpheus lanceostylus* Banner, 1959 [H]
4. *Arctides regalis* Holthuis, 1963 [H/P]
5. *Athanas marshallensis* Chace, 1955
6. *Banareia parvula* (Krauss, 1843) [H/P]
7. *Benthesicymus investigatoris* Alcock & Anderson, 1899 [H/P]
8. *Calcinus imperialis* Whitelegge, 1901 [P]
9. *Calcinus vachoni* Forest, 1958 [P]
10. *Callianassa amboinensis* De Man, 1888
11. *Chlorodiella cytherea* (Dana, 1852) [H/P]
12. *Cryptodromiopsis unidentata* (Rüppel, 1830) [H/P]
13. *Cyclograpsus longipes* Stimpson, 1858 [P]
14. *Cyrtomaia platypes* Yokoya, 1933
15. *Daldorfia horrida* (Linné, 1758) [H/P]
16. *Etisus electra* (Herbst, 1801) [P]
17. *Geograpsus crinipes* (Dana, 1851) [H/P]
18. *Hadropenaeus lucasii* (Bate, 1881) [H/P]
19. *Harpiliopsis beaupresii* (Audouin, 1826) [H/P]
20. *Heterocarpus sibogae* De Man, 1917 [P]
21. *Huenia pacifica* Miers, 1979
22. *Hymenopenaeus halli* Bruce, 1966 [P]
23. *Latreillia metanesa* Williams, 1982 [H/P]
24. *Lauridromia dehaani* (Rathbun, 1923)
25. *Liomera monticulosa* (A. Milne Edwards, 1873) [P]
26. *Liomera rugata* (A. Milne Edwards, 1834) [H/P]
27. *Lophozozymus dodone* (Herbst, 1801) [H/P]
28. *Lysmata trisetacea* (Heller, 1861) [H]
29. *Metabateaeus minutus* (Witelegge, 1897)
30. *Mursia hawaiiensis* Rathbun, 1893 [H/P]
31. *Nematocarcinus gracilis* Bate, 1888 [H]
32. *Odontodactylus hawaiiensis* Manning, 1967 [H]
33. *Palaemonella spinulata* Yokoya, 1936
34. *Panulirus pascuensis* Reed, 1954 [P]
35. *Paragiopagurus boletifer* (de Saint Laurent, 1972) [H/P]
36. *Paragiopagurus wallisi* (Lemaitre, 1994) [P]
37. *Pasiphaea cristata* Bate, 1888

38. *Pasiphaea flagellata* Rathbun, 1906 [H]
39. *Pasiphaea kaiwiensis* Rathbun, 1906 [H]
40. *Periclimenes alcocki* Kemp, 1922
41. *Petrolisthes coccineus* (Owen, 1839) [H/P]
42. *Petrolisthes extremus* Kropp & Haig, 1994
43. *Phylladiorhynchus integrirostris* (Dana, 1853) [H/P]
44. *Platepistoma balssii* (Zarenkov, 1990) [P]
45. *Plesionika fenneri* Crosnier, 1986 [P]
46. *Plesionika ocellus* (Bate, 1888) [H]
47. *Polycheles surdus* Galil, 2000 [H/P]
48. *Pontocaris rathbuni* (De Man, 1918) [H]
49. *Pontophilus gracilis junceus* Bate, 1888
50. *Portunus pubescens* (Dana, 1852) [H]
51. *Progeryon mararae* Guinot & Richer de Forges, 1981 [P]
52. *Pseudoliomera remota* (Rathbun, 1907) [H]
53. *Ptychognathus easteranus* Rathbun, 1907 [P]
54. *Raoulserenea oxyrhyncha* (Borradaile, 1898)
55. *Rhynchocinetes balssi* Gordon, 1936
56. *Sergia gardineri* (Kemp, 1913)
57. *Sergia regalis* (Gordon, 1939)
58. *Sympagurus affinis* (Henderson, 1888) [H/P]
59. *Sympagurus dofleini* (Balss, 1912) [H/P]
60. *Synalpheus paraneomeris* Coutière, 1905 [H/P]
61. *Synalpheus tumidomanus* (Paulson, 1875)
62. *Trapezia areolata* Dana, 1852 [P]
63. *Trapezia punctimanus* Odinetz, 1984 [P]
64. *Trapezia tigrina* Eydoux & Souleyet, 1842 [H/P]
65. *Tylaspis anomala* Henderson, 1885

B3 East Pacific Species. Species distributed in EIa and eastern Pacific only. Other EIa species that occur in eastern Pacific are included with *Widely Distributed Species* (27 species identified by a * in Appendix B1).

1. *Ageitomaia baeckstroemi* (Balss, 1924)
2. *Chaceon chilensis* Chirino-Gálvez & Manning, 1989
3. *Galathea lenzi* Rathbun, 1907
4. *Paromola rathbunae* Porter, 1908
5. *Pasiphaea Americana* Faxon, 1893
6. *Pasiphaea chacei* Yaldwyn, 1962
7. *Platymera gaudichaudii* H. Milne Edwards, 1837
8. *Projasus bahamondei* George, 1976
9. *Sergestes brevispinatus* Judkins, 1978
10. *Sergestes geminus* Judkins, 1978

11. *Sergestes gibbilobatus* Judkins, 1978
12. *Sergestes halia* Faxon, 1893
13. *Sergestes pestafer* Burkenroad, 1937
14. *Sergestes extensus* Hanamura, 1983

EIa species collected East of 84° W on the Sala y Gómez and Nazca seamounts. *Widely Distributed Species* of appendix B1 are excluded. [IWP] Indo-West Pacific species; [EP] East Pacific species; [EIa] species still recorded only on the seamounts.

1. *Acanthephyra trispinosa* Kemp, 1939 [EP]
2. *Chaceon chilensis* Chirino-Gálvez & Manning, 1989 [EP]
3. *Gennadas barbari* Vereshchaka, 1990 [EIa]
4. *Nematocarcinus gracilis* Bate, 1888 [IWP]
5. *Oncopagurus stockmani* Zhadan, 1997 [EIa]
6. *Pandalina nana* Burukovsky, 1990 [EIa]
7. *Pasiphaea chacei* Yaldwyn, 1962 [EP]
8. *Platymera gaudichaudii* H. Milne Edwards, 1837 [EP]
9. *Projasus bahamondei* George, 1976 [EP]
10. *Sergestes brevispinatus* Judkins, 1978 [EP]
11. *Sergestes halia* Faxon, 1893 [EP]
12. *Sergestes pestafer* Burkenroad, 1937 [EP]

B4 EIa Local Species. Species still reported only from EIa. The '*' indicates species that have been collected in a deep range of 0-40 m around Easter Island. The other species have been collected on the seamounts, in a depth range of 150-800 m.

1. *Actaea allisoni* Garth, 1985
2. *Alpheus romenskyi* Burukovsky, 1990
3. *Calcinus pascuensis* Haig, 1974 *
4. *Cyrtomaia danieli* Zarenkov, 1990
5. *Discias pascuensis* Fransen, 1987 *
6. *Ebalia sculpta* Zarenkov, 1990
7. *Forestia pascua* Garth, 1985
8. *Garthambrus allisoni* (Garth, 1993)
9. *Garthambrus mironovi* (Zarenkov, 1990)
10. *Gennadas barbari* Vereshchaka, 1990
11. *Glyphocrangon wagini* Burukovsky, 1990
12. *Heterocrypta epibranchialis* Zarenkov, 1990
13. *Homologenus orientalis* Zarenkov, 1990
14. *Liomera laperousei* Garth, 1985
15. *Metapenaeopsis stokmani* Burukovsky, 1990
16. *Monodaeus pettersoni* Garth, 1985

17. *Nematocarcinus pseudocursor* Burukovsky, 1990
18. *Oncopagurus mironovi* Zhadan, 1997
19. *Oncopagurus stockmani* Zhadan, 1997
20. *Palaemonella disalvoi* Fransen, 1987 *
21. *Pandalina nana* Burukovsky, 1990
22. *Parribacus perlatus* Holthuis, 1967 *
23. *Percnon pascuensis* Retamal, 2002 *
24. *Periclimenes rapanui* Fransen, 1987 *
25. *Plagusia integripes* Garth, 1973 *
26. *Pontophilus nikiforovi* Burukovsky, 1990
27. *Porcellanopagurus foresti* Zarenkov, 1990
28. *Processa pygmaea* Burukovsky, 1990
29. *Pylopaguropsis garciai* McLaughlin & Haig, 1989 *
30. *Randallia nana* Zarenkov, 1990
31. *Scyllarides roggeveeni* Holthuis, 1967 *
32. *Sicyonia nasica* Burukovsky, 1990
33. *Spongicola parvispina* Zarenkov, 1990
34. *Stylodactylus pubescens* Burukovsky, 1990

INDEX

ADDENDUM

This reference was found while this work was in press: Galil, B. S., and V. A. Spiridonov, 1998. *Mursia zarenkovi* new species (Decapoda, Calappidae) from the southeastern Pacific. Crustaceana, 71(8): 904-908. In that study, the crabs *Mursia aspera* Alcock, 1899 and *Mursia hawaiensis* Rathbun, 1893, from the Sala y Gómez and Nazca seamounts, are attributed to a single species, *Mursia zarenkovi* Galil & Spiridonov, 1998.

The slipper lobster *Parribacus perlatus* Holthuis, 1967, considered as endemic to Easter Island in this work, is now reported from French Polynesia: coll. BENTHAUS Expedition, November 2002, Rapa Island, 5-18 m, det. J. Poupin and T.Y. Chan, specimens deposited in MNHN, Paris collections.

ATOLL RESEARCH BULLETIN

NO. 501

KIRIBATI: "SOME ASPECTS OF HUMAN ECOLOGY," FORTY YEARS LATER

BY

FRANK R. THOMAS

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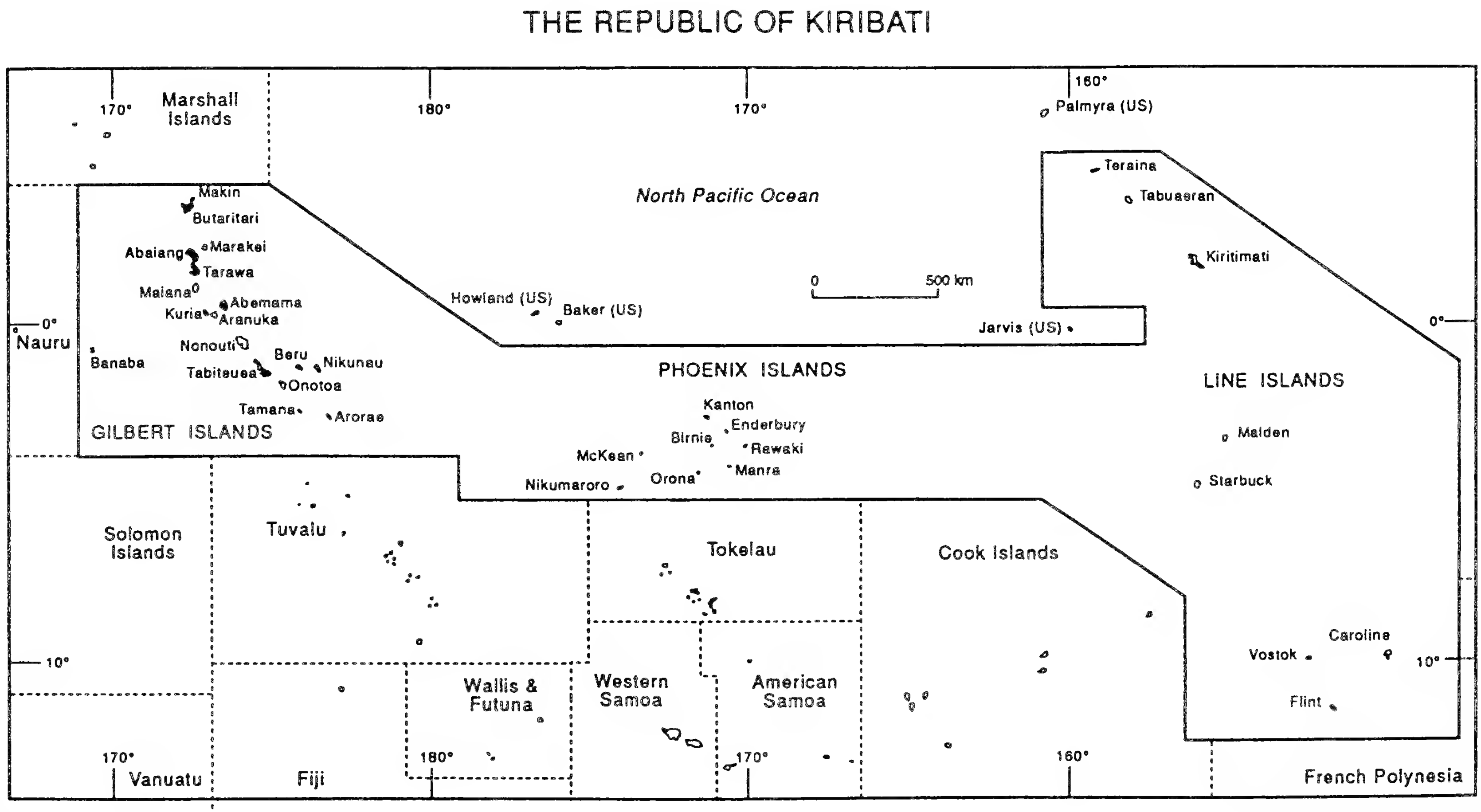

Figure 1. Index map of the Republic of Kiribati (courtesy of Macmillan Brown Centre for Pacific Studies, University of Canterbury, Christchurch, and Institute of Pacific Studies, University of the South Pacific, Suva).

KIRIBATI: "SOME ASPECTS OF HUMAN ECOLOGY," FORTY YEARS LATER

BY

FRANK R. THOMAS[1]

ABSTRACT

The Republic of Kiribati, comprising 33 atolls and reef islands, is unique in having the largest Pacific atoll population and the largest concentration of urban dwellers in the Pacific atoll groups. Because of uneven distribution, this population is severely taxing the environment, particularly on Tarawa Atoll. The island nation is attempting to strike a balance between modern aspirations and the need to develop limited resources in a sustainable way. The challenges of small size, remoteness, geographical dispersion, vulnerability to drought, and a highly limited internal market are of significance to the human ecology. While Kiribati benefits from aid and remittances and from other rent opportunities, including fishing licenses and income derived from the Revenue Equalization Fund (a legacy of phosphate mining on Banaba), it is also aiming to further develop its fisheries and, to a lesser degree, diversify local agricultural production in the hope of achieving greater economic independence and improve local nutrition. Future development of the primary sector cannot be divorced from wider concerns such as improvements in transport and storage infrastructure, resource management, pollution, coastal erosion, water quality control, renewable energy production, family planning, and global warming.

INTRODUCTION

It has been more than 40 years since R. L. A. Catala published his seminal work on the human ecology of the Gilbert Islands (now Kiribati) (Catala, 1957). A number of reports on these atolls and reef islands have subsequently appeared in *Atoll Research Bulletin* mainly focusing on physical geography and natural history but also including important human/environment studies such as Thaman's (1990) description of agroforestry and several reports on the state of marine resources (Beets, 2001; Johannes and Yeeting, 2001; Paulay, 2001; Tebano and Paulay, 2001). The Tarawa Lagoon Project, a major interdisciplinary environmental assessment survey (Abbott and Garcia, 1995)

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has contributed to our understanding of human/environment relationships on the main atoll. There are also case studies on social change of individual communities (Geddes, 1983; Geddes et al., 1982; Lawrence, 1983; Lundsgaarde, 1966; Sewell, 1983; Watters and Banibati, 1984) and an analysis and synthesis of socio-economic issues (Van Trease, 1993).

Although still regarded by some observers as one of the most traditional areas of Micronesia, the Republic of Kiribati has witnessed accelerated environmental and social change during the last decade. These changes would probably have gone unnoticed to the rest of the world were it not for media attention on the effects of climate and sea-level variability and the publicity surrounding the millennium celebrations on remote Caroline Island, renamed Millennium Island.

Fieldwork conducted by the author between 1993 and 2001 on several atolls focused primarily on marine resources exploitation but also covered issues on tenure systems and, more recently, agricultural production. It was realized, however, that new data needed to be integrated to wider themes, perhaps because on small, resource-poor islands with a burgeoning population the human ecological linkages are more narrowly defined than in other settings. Thus, this report attempts to cover a range of interrelated topics on past and more recent human experiences on these far-flung coral islands of the central Pacific.

PHYSICAL SETTING

Geography and Geology

Kiribati consists of 33 atolls and reef islands spread over an area exceeding 5 million km² of ocean straddling the equator between 04°43' N and 11°25' S latitude and between 169°32' E and 150°14' W longitude. The total land area, however, only slightly exceeds 800 km² (Fig. 1).

The Gilbert Islands are a group of 16 atolls and slightly raised limestone islands without lagoons. Banaba (Ocean Island), which lies some 400 km west and attains a maximum elevation of 81 m, is often considered to be part of the archipelago as a result of intensive social and political interaction with the Gilberts in recent history. The Gilbert Islands are spread over 640 km on both sides of the equator at the southeastern edge of Micronesia between 03°30' N and 02°45' S latitude and between 172°30' E and 177°00' E longitude. The total land area for the group is 279 km². Three subgroups within the Gilberts can be distinguished on the basis of rainfall: (i) north (Makin and Butaritari); (ii) center (from Marakei to Aranuka); and (iii) south (from Nonouti to Arorae) (Catala, 1957). Tarawa is the seat of government and main commercial center; the southern portion of the atoll includes a mixture of rural and urbanized sections. About 1,480 km east of the Gilberts lies the Phoenix Group, a cluster of eight largely uninhabited atolls and reef islands. Further east are the Line Islands including Kiritimati (Christmas Island) situated some 3,330 km from Tarawa and 2,100km southeast of Honolulu. Kiritimati is the world's largest atoll in terms of contiguous landmass (388 km²) accounting for almost half of Kiribati's dry surface but only about 4% of the population, which is concentrated in the Gilbert Group and especially on South Tarawa.

Lagoons range from almost total enclosure, as at Marakei, to the wide-open atolls of Nonouti and Tabiteuea. In comparison to the Marshalls and Tuvalu, lagoons in the Gilberts are relatively shallow (Richmond, 1993).

Climate

Most of the Gilbert Islands and several of the Line and Phoenix Islands are located in the dry belt of the equatorial oceanic climatic zone. Islands located within 5° of the equator normally experience two wet seasons as the Intertropical Convergence Zone (ITCZ) crosses the region twice a year (Sturman and McGowan, 1999). However, rainfall is extremely variable, both annually and between islands being strongly influenced by El Niño Southern Oscillation (ENSO) events. Precipitation ranges from about 3,000 mm in the north (Butaritari) to 1,110 mm in the south (Tamana) in the Gilbert Group and from about 4,000 mm (Teraina) in the Line Islands to less than 800 mm in Kanton (Phoenix Group) (Burgess, 1987; Hoare, 1996-98). Prolonged droughts are common, notably in the central and southern Gilberts, many of the Phoenix Islands, and Kiritimati. Hurricanes are rare. Temperatures show little seasonal differences. Daytime maxima are high, averaging between 31° and 33° C., although humidity is more variable among the various islands.

Soils and Hydrology

The highly alkaline and coarse-textured, coral-derived soils of Kiribati are among the poorest in the world. They are typically shallow with very low water-holding capacity, little organic matter, and low available macro- and micronutrients apart from calcium, sodium, and magnesium (Thaman, 1992). Because the soils are alkaline, fertility is dependent on organic matter for the concentration and recycling of plant nutrients and for soil water retention in excessively well drained soils. Organic carbon values for subsoils are always low (< 0.5%) unless there has been considerable disturbance such as that associated with the digging of *babai* or swamp taro (*Cyrtosperma chamissonis*) pits. Phosphate soils, which were once extensive on Banaba, are found in scattered locations throughout Kiribati. These brown-red soils are also slightly more acidic than the surrounding areas and originated from guano deposits accumulated over long periods of time under groves of *buka* (*Pisonia grandis*), a favored seabird rookery tree.

Because of their small size, low elevation, and the porosity of the coral bedrock, there are no surface streams. Instead, rainfall soaks through the porous surface soil creating a lens (Ghyben-Herzberg lens) of often slightly brackish freshwater floating on higher density saltwater beneath it and accessible by digging wells. Apart from small amounts of water that may be collected from coconut palm fronds and trunks during precipitation, the lens is the only source of freshwater. More recently, concrete cisterns have ensured the storage of rainwater. Generally, salinity decreases from both lagoon and ocean beaches towards the center of islets. The location and degree of groundwater development influences the nature of the vegetation, as well as the location of the village wells and cultivation pits. Unchecked urbanization and population growth on South Tarawa have resulted in sewage seeping into the groundwater at several locations.

Of concern for the future of human settlement, including access to drinking water and agricultural production, is the threat of global warming and associated rise in sea level (Nunn, 1993). Sea-level rise leads to contamination of soil and water tables with salt, severely limiting yields of sensitive crops, as evidenced by abandoned *babai* pits (Sullivan and Gibson, 1991: 26-27).

ARCHAEOLOGY

Compared to research carried out elsewhere on the Pacific, prehistoric archaeology in Kiribati with an emphasis on excavations and the use of radiometric dating techniques is a recent endeavor. Much of this work has focused on culture history and the typological approach, expanding on earlier surveys in the 1930s (Carson, 1998; Di Piazza, 1999; Emory, 1934; Lampert, 1968; Sinoto, 1973; Takayama, 1988; Takayama and Takasugi, 1987, 1988; Takayama et al., 1989, 1990; Throssell and Specht, 1989), suggesting an initial settlement of the Gilbert group from eastern Melanesia early in the first millennium AD (see also Irwin, 1992: 121-123; Pawley and Ross, 1993). This time frame appears consistent with dates obtained from the neighboring Marshall Islands (Weisler, 1999b). While earlier presence of human occupation is plausible, it might have been constrained prior to about 2,000 years ago by the absence of stable islets as suggested by dated beach rock in the Marshalls although McLean (1989: 16) argues for a period of reef- islet formation beginning around 3,500 years ago.

Data for mid- to late-Holocene higher sea level stands have been presented for a number of Pacific islands (for a review see Nunn, 1998: 243). For the Gilberts, Schofield (1977) proposed a high sea-level stand of +2.3 m as late as 1040 BP. However, most of the dated material appears to derive from cemented storm deposits having an uncertain exact relationship to a mean sea-level position (Marshall and Jacobson, 1985).

All of the Phoenix and Line Islands were uninhabited when first discovered by Europeans and have subsequently been referred to as “mystery” islands, joining other similar entities such as Pitcairn, Henderson, Nihoa and Necker, and Norfolk (Cleghorn, 1988; Diamond, 1985; Weisler, 1995). Several of these islands have yielded evidence of past human occupation. This has prompted researchers to investigate the reasons for abandonment by adopting a more ecologically oriented perspective to study the past (Di Piazza and Pearthree, 2001a; see also Thomas, 2002a for a behavioral ecological analysis of subsistence activities in the Gilberts).

Using a regional approach to understand island settlement and abandonment, Di Piazza and Pearthree (2001a) proposed the concepts of “mother communities”, “satellites”, and “isolates”, and concluded that resource scarcity and/or isolation resulting in abandonment were explanations limited to those islands that were relatively inaccessible, small, and/or dry. Some islands appeared never to have been inhabited, perhaps because they were too marginal in terms of water availability or because their fringing reefs prevented effective fishing. Mother communities with high rainfall, such as Tabuaeran, once supported relatively large resident populations supported by a rich agricultural base. These communities periodically exploited nearby satellites (e.g., Kiritimati) which, despite their drier appearance, were located within an overnight voyage of a richer land and offered attractive faunal resources, especially seabirds and turtles. While the demise of mother communities remains problematic, it is becoming increasingly obvious that settlement extinction need not be explained solely in terms of environmental crunches. The occurrence of exotic basalt, together with the abundance of timber on certain islands for canoe building, should serve as a reminder that populations were capable at any time of migrating to other archipelagos.

Evidence shows that present coastal sediments on Kiritimati were exposed by 3000 BP, and that the atoll might have been suitable for human settlement throughout the period of human colonization in Remote Oceania (Anderson et al., 2000). However, C14 dates from several sites cluster between AD 1200-1600 with most radiocarbon determinations centered in the early 15th century. Di Piazza and Pearthree (2001b; 2001c) have identified basalt on Manra (Sydney) in the Phoenix Islands and on Tabuaeran (Fanning) in the Line Group derived from the Tataga Matau quarry on Tutuila in American Samoa and from Eiao (Marquesas). These materials were transported over distances of 1,075 and 2,425 km, respectively.

DEMOGRAPHY

I-Kiribati (indigenous Gilbertese Micronesians) population numbers in the early period of Western contact are difficult to estimate. There is some evidence that people were aware of the problem of overpopulation and consequently devised various strategies to limit growth so as not to outstrip resources (Bedford and Macdonald, 1982).

As with all other Pacific countries, contact with the outside world brought about important demographic and social changes. In the first instance, local populations declined as a result of introduced diseases, blackbirding, and civil unrest spurred by political, economic, and religious rivalries (Bedford et al, 1980; Maude and Maude, 1981). Since the end of World War II, however, populations have increased dramatically (Table 1), while mortality has declined because of improvements in health care and access to food imports to counter the effects of drought, the most significant environmental hazard in Kiribati. However, dependency on these same imports, particularly in urban areas, has led to a rise in noncommunicable, nutritionally related diseases.

The population, having reached close to 84,500 in 2000, is unevenly distributed with about 93% living in the Gilbert Group. More than one-third of the total population lives on the islets of urbanized South Tarawa on some 16 km² of land. Averaged over the entire nation, the population density is 116 per km²; however, South Tarawa has a density of over 2,330 per km², with more than 6,000 per km² on Betio Islet. The average annual rate of natural population increase is 2.5%. At this rate, the population is expected to double in less than 30 years. The population is young, with 40% under 15 years and a median age of 20 years (CIA, 2001; Ministry of Finance 2001; South Pacific Commission, 2001).

Protestant groups tend to be smaller than Catholic families, the rate of growth poses a serious threat to living standards (Pollard, 1987). To partly alleviate population pressure,

Table 1. Population change in Kiribati and South Tarawa, 1841-2000. Courtesy Macmillan Brown Centre for Pacific Studies, University of Canterbury and Institute of Pacific Studies, University of the South Pacific, Suva; Ministry of Finance, Tarawa.

	Kiribati	**% Change**	**South Tarawa**	**% Change**	**% Population**
1841	40,000	-	na	-	-
1931	26,416	-34.0	na	-	-
1947	31,513	19.3	na	-	-
1963	43,336	37.5	6,101	-	14.1
1968	47,735	10.2	10,616	74.0	22.1
1973	51,931	8.8	14,861	40.0	28.6
1978	56,213	8.2	18,030	21.3	32.1
1985	63,883	13.6	21,393	18.7	33.5
1990	72,335	13.2	25,380	18.6	35.1
2000	84,494	16.8	36,717	44.7	43.5

Considerable internal migration occurs from the outer islands to South Tarawa. A large proportion of these migrants, together with many other *I-Kiribati*, are supported by remittances sent by family members who work in the phosphate mine on nearby Nauru and others who are engaged as merchant seamen. However, with the projected cessation of phosphate mining early in this century and advances in marine technology, it is expected that remittances will diminish with many workers returning home increasing pressure on local resources (Fleming and Hardaker, 1995: 89, 91; Macdonald, 1998: 62). Migration options are limited because Kiribati has severed all political ties with Great Britain and its citizens do not have the advantages that Cook Islanders, Niueans, and Tokelauans enjoy, namely New Zealand citizenship. This is somewhat tempered by Australian financial assistance, including student and training opportunities.

In recent years, overcrowding, notably on South Tarawa, has periodically resulted in serious health problems, particularly those related to contamination of freshwater supplies. Family-planning programs established in the 1960s proved unpopular. While in 1983 the government purchased the islands of Tabuaeran and Teraina in the Northern Line Islands from Burns Philp Fanning Islands Plantations for resettlement in 1983. The first transshipment of voluntary migrants from the Gilberts arrived in 1988, although settlers were already established to work on the coconut plantations since the late 19th century (Bailey, 1977). While these islands are attractive because of their high rainfall and thus the ability to support subsistence living, they remain relatively isolated from Tarawa and other important importing and exporting markets. Kiritimati has attracted wealthy sports fishermen for some years but unreliable flight schedules have lost Kiribati many valuable tourists (Langston, 1993). Unlike the resettlement scheme to the Phoenix Islands from 1938 to 1955, which failed because of drought conditions prevailing in the area (Lundsgaarde, 1966: 186-187; Maude, 1952), the Northern Line Islands have the potential to develop both agricultural and fisheries production, provided that foreign fishing boats curb their activities and that the number of settlers is kept within reasonable limits.

URBANIZATION

Kiribati has both the largest atoll population in the Pacific and the largest concentration of urban dwellers in the Pacific atoll groups (Rapaport, 1990). With 43% of *I-Kiribati* living on South Tarawa, and with an urban growth rate of 2.2%, there is currently no sign of abatement in rural-to-urban drift (South Pacific Commission, 2001). The health risks and social ills associated with urbanization in the developing world are well known, and Kiribati is certainly not immune to problems of unemployment and underemployment, squatter settlements, rising crime, groundwater and lagoon pollution from human and domestic animal waste, malnutrition, and general strain on existing infrastructure (Asian Development Bank, 2000; Bryant-Tokalau, 1993; Connell and Lea, 1998). As long as services remain concentrated, people will continue to flock to South Tarawa in the hopes of getting a better education, perhaps landing a job as a public servant, getting some casual work in the informal sector, or at least living close to relatives who are already employed. Thus, push factors, such as declining agricultural commodity prices, livelihood opportunities, and insufficient rural land to confer social standing, as well as pull factors, such as the prospect of cash employment, the availability of public services in town, and the intrinsic excitement of urban areas, are patterns that characterize the phenomenon of urban expansion throughout the Pacific (Connell, 1984; Rallu and Ahlburg, 1999).

Not only is urban growth putting pressure on inadequate facilities and access to land, it also weakens development of rural areas and jeopardizes the future of agricultural subsistence production. Although urban migrants maintain strong ties with outer island communities, they are constrained in their movements by unreliable transportation links. Kiribati's outer islands differ little from other remote islands in being marginalized in relative terms. The benefits of technological investments in transport such as the development of the container and cellular-container vessels, as well as air connections, clearly favor core areas to a much greater degree than the peripheries (Brookfield, 1980; Ward, 1999: 25-26).

Coastal erosion resulting from the construction of causeways and bacterial contamination of groundwater and lagoon shellfish beds linked to overcrowding are acutely felt in the fragile atoll environment (Connell, 2000; Connell and Lea, 1999; Doumenge, 1999; SOPAC, 2000). A large urban population also contributes to depletion of water reserves. Since the 1998 drought, desalinization units have been used to supplement the drinking water supply.

HEALTH

In a twist of irony, modernization, which has contributed to improving people's lives by fighting certain infectious diseases and increasing life expectancy, has also created new health hazards. Participation in the world economy has been accompanied by a rise in "lifestyle" diseases, particularly those associated with nutritionally inferior food imports, such as low-fiber bread and rice, refined sugar, tinned meats, and soft drinks. These food imports have decreased the healthy former diet, including the coconut sap-derived *kamaimai* drink rich in vitamins and nutrients, not many years ago a staple family drink. With more people living longer and birth rates remaining high, small island nations such as Kiribati must deal with overcrowding, particularly on South Tarawa. One direct consequence of this phenomenon is increasing groundwater contamination and a higher incidence of diarrheal diseases. Another hallmark of globalization is the spread of HIV/AIDS infection. According to statistics, acute respiratory infections, wounds and sores, and diarrheal diseases are the top three causes of morbidity in Kiribati. Cardiovascular conditions, originating in the perinatal period, and liver disease are the leading causes of death (WHO, 1999). Contamination of the freshwater lens and lagoon nearshore and seagrass areas by human and animal waste products led to the 1977 cholera outbreak on Tarawa (Danielson et al., 1995; Naidu et al., 1991: 77). To this day, diarrhea and related health issues continue to plague residents and certainly account for the high infant mortality rate (62/1,000 live births) – the second highest in the Pacific after Papua New Guinea (WHO, 1999; South Pacific Commission, 2001). Phillips (1995) noted that the consumption of raw or partially cooked shellfish contributes to illness and was of the opinion that, since people apparently find diarrhea so common, they do not associate it with sickness. Safe water and adequate sanitary facilities usage is a pressing problem with only about half of Kiribati's residents currently having access to both (WHO, 1999).

In addition to ciguatera poisoning (Tebano and MacCarthy, 1991), which directly affects the export of live reef-food fish as well as domestic sales, it was determined that the handling of fish after capture caused serious health risks. For example, the sale of ungutted fish is ubiquitous on Tarawa. There is a belief that ungutted fish are preferable for reasons of aesthetics and flavor, but there is little awareness of the relationship of gut and gill bacteria to spoilage. The problem is compounded by improper use of the extremely limited ice supplies. Novaczech and Chamberlain (2001) report that up to 1.5% of the population are sent to hospitals with fish poisoning every year and rates may be as high as 7% on individual islands although it is not clear how many cases can be attributed to ciguatera versus illness by spoilage.

Tobacco smoking is prevalent. Nearly three-quarters of adults are regular smokers, of which 95% are young males between 20 and 24 years old (Corrao et al., 2000). Thirty-three HIV positive cases have been confirmed so far (WHO, 1999).

Overview of Dietary Situation

As in many other Pacific Island nations, overall nutritional standards in Kiribati have been steadily declining. The root of the problem lies with changing lifestyles associated with urbanization and in food dependency fostered by foreign aid and private remittances, threatening local food-producing activities and general health standards in the region. (Dahl, 1996; Parkinson, 1982; Thaman, 1982). Food remains the prominent import item in Kiribati, totaling 17 million Australian dollars (Ministry of Finance, 1998).

Investment in a limited range of cash crops, together with urbanization, has contributed to a decline of traditional crops and thus a balanced diet. There is clear evidence that westernization and urbanization of Pacific Island populations have resulted in an increased incidence of several noncommunicable diseases, including diabetes, obesity, gout, hypertension, coronary heart disease, stroke, and certain cancers (Coyne, 2000: 14; Thaman, 1988). Dependence on nutritionally inferior food imports among growing segments of island populations is largely responsible for declining health standards. In Kiribati, between 1992 and 1998, there has been a steady increase in the number of reported hypertension and diabetes cases, which appear clearly related to rapid urbanization (Ministry of Health and Family Planning, 1998; Pargeter et al., 1984: 18). For a number of years, there has been a trend towards vitamin and mineral deficiency, especially on South Tarawa. Iron-deficiency anemia, vitamin A-deficiency-induced eye problems, and deficiencies in B-group vitamins are now regarded as serious in both urban and rural areas (Christensen, 1995; Schaumberg et al., 1996).

Inshore fishing provides the bulk of protein for the vast majority of *I-Kiribati*, even on South Tarawa. The proportion of fresh fisheries resources caught and locally consumed ranks among the highest in the Pacific region. Coastal fish catch/capita is close to 160 kg annually, surpassed only by New Zealand (Adams et al., 1999: 367). Although most households go out fishing and some sell part of their catch, they occasionally buy fresh fish as well. Tinned fish and tinned meat are readily available but most *I-Kiribati* prefer the taste of fresh fish, which are relatively cheap. Despite the wide availability of local marine products, undernutrition related to protein deficiency was found in 7% of preschool children and 69% of pregnant women (WHO, 1998).

South Tarawa faces the additional problem of land shortage which has discouraged local food production resulting in poor diets due to a switch from generally more nutritious local foods to imports high in fat, sodium, and sugar (Kienene, 1993; Lewis, 1988).

ECONOMY

The Asian Development Bank (ADB) (2000: 1) provides the following assessment of Kiribati's economic performance:

Except for a period of accelerating growth from 1994 to 1998, primarily due to expansionary government spending, economic growth in Kiribati has been relatively poor since independence. In 1999, real gross domestic product (GDP) is estimated to have increased only by 1.7 percent. The public sector continues to dominate the economy, accounting for about three-quarters of monetary GDP at factor cost. The combination of sluggish economic growth with an inability to provide adequate services to a growing population concentrated in South Tarawa has left Kiribati eighth amongst ADB's 12 Pacific developing member countries in terms of the Human Development Index.

As a "micro state", Kiribati presents unique challenges to development planners. The country is not only constrained by limited size but also by a host of other environmental and geographical factors including remoteness, geographical dispersion, vulnerability to natural disasters, and a highly limited internal market (Baaro, 1993; Briguglio, 1995; Liew, 1990; Shand, 1980).

With few opportunities for economic expansion in view of their restricted size and natural resource availability, small labor force, and low GDP, and thus restricted market size, small island nations have had the option to look outward by embracing the *MIRAB* approach to economic development by relying on Migration (of factors of production), Remittances/Aid (financial transfers), and Bureaucracy (non-tradable production) (Bertram and Watters, 1985). The *MIRAB* model of economic development highlights the importance and, some would argue, the necessity of such an approach to ensure the levels of expenditure are sustained. As Bertram (1999: 345) succinctly put it: "In a MIRAB economy, the indigenous population maximize their material well-being by means of globalization".

Despite current indications that the *MIRAB* model runs consistently, and apparently sustainably, ahead of local productive activity as measured by GDP, there is cause for concern regarding an over-reliance on such a model in light of fluctuations in the global economy, the reduced strategic importance of the Pacific Islands with the end of the Cold War, and the options that are available to "micro states" having different political status (Brown, 1992; Cameron, 1997; Gibson, 1993; Laplagne et al., 2001; Schoeffel, 1996: 23; Wartho and Overton, 1999).

Kiribati was granted independence in 1979 shortly after the British exhausted phosphate mining deposits on Banaba. This industry contributed about 85% of export earnings, 45% of GDP, and 50% of government revenue (Thistlethwait and Votaw, 1992: 30). Since then, copra and fish remained the main source of foreign exchange earnings but earnings from the former have fluctuated widely in recent years (Lawrence, 1985). Since independence, however, Kiribati has moved towards the *MIRAB* model of economic development by relying heavily on foreign aid and remittances by migrant workers, accounting for more than US$7 million (Bertram, 1999: 341). As mentioned earlier, remittances will likely diminish while migration options remain limited. Foreign aid is likely to continue, albeit with diminishing resources, as donors seek greater accountability. The public sector remains a significant employer but is unable to absorb a growing number of young people, many of whom lack the appropriate training, education, or experience. The agriculture, and especially the fisheries sectors, could provide alternative sources of livelihood for migrants. However, to cater for an increased population, new forms of sustainable land- and marine-use systems need to be worked out for production of both traditional and exotic crops as well as fisheries products.

Although Kiribati falls squarely within the *MIRAB* approach, some 80% of the people are engaged in subsistence production and the sale of primary products (AusAid, 2001). This apparent contradiction can be explained by the position of households along a continuum ranging from those that are almost exclusively cash-based to those where there is only minimal cash to alleviate subsistence. Moreover, households are not consistently located at the same point in the spectrum as a result of changes in their composition and individual circumstances. Even on South Tarawa, the traditional domain remains strong among households with one or more wage earners. These households often include several extended family members who share domestic duties and subsistence cropping or fishing but also make a cash contribution through commercial fishing or the manufacture of handicrafts (Macdonald, 1998).

While recognizing the challenges posed by “smallness” to further economic expansion, successive governments have perceived marine resources development, particularly living resources, as a means of attaining greater economic independence or self-reliance. With its vast exclusive economic zone (EEZ), Kiribati has thus relied heavily on rent derived from fishing royalties, notably from East Asian countries, because of inadequate local infrastructure to exploit the fisheries sector efficiently. Consequently, the *MIRAB* economy is being perpetuated although fishing royalties, together with income from the Revenue Equalization Reserve Fund (RERF), a legacy of phosphate mining, and payments made by the Japanese Space Agency on Kiritimati, illustrate the positive side of a strategy which seeks to diversify rent opportunities. Assets from the RERF amount to US$370 million, equal to 33% of GDP. The RERF, together with fishing license revenue and remittances, make up almost half of Kiribati’s national income (Asian Development Bank, 2000).

The two sectors of primary production – agriculture and fisheries – differ in their outputs with fisheries exceeding local agriculture, with the exception of copra for export, because of environmental constraints affecting the latter. However, there are good prospects to increase and improve agricultural production. Together with the development of nearshore fisheries exports and mariculture, agriculture could provide more opportunities for employment while reducing dependency on food imports.

AGRICULTURE

As a result of restricted landmass, distance from continents, the relatively young geological age of the atolls and reef islands, and harsh environmental conditions, there are estimated to be only 83 indigenous plant species in Kiribati (Gilbert group), none of which are endemic. Eight plants are presumably aboriginally introduced and the total sum of vascular plants ever reported is believed to be approximately 306 species including exotics and weeds (Fosberg and Sachet, 1987; Thaman, 1987).

Aboriginal introductions include the giant swamp taro (*Cyrtosperma chamissonis*), taro (*Colocasia esculenta*), giant taro (*Alocasia macrorrhiza*), yam (*Dioscorea* spp.) two breadfruit species (*Artocarpus altilis* and *A. mariannensis)* in addition to a hybrid of the two) and Polynesian arrowroot (*Tacca leontopetaloides*) (Thaman, 1990). Screw pine (*Pandanus tectorius*) is considered both indigenous and of aboriginal introduction given the diversity of local cultivars. The coconut (*Cocos nucifera*) may also have a dual origin. Four of these cultivars (coconut, screw pine, breadfruit, and swamp taro) played a major role in the precontact diet and in many ways continue to do so (Fig. 2). The Pacific fig (*Ficus tinctoria*) was also relied upon as a staple, together with screw pine, on the drier islands in the south (Parkinson, 1955). Despite constraints to agriculture in an atoll environment (Small, 1972), traditional cultivation techniques in Kiribati (and other atoll locations) showed a high degree of sophistication (Baiteke, 1994; Tofiga, 1985). Thaman (1990; 1993a) stressed the importance of a tree-crop-based multistory farming system. Arboriculture – the culture of trees – is a distinguishing characteristic of the earliest agriculture in the Pacific Islands and is still a prominent feature of the Kiribati landscape, even in urbanized settings. Agroforestry is described as a sustainable system of food production by virtue of the relative permanence of land use providing a wide range of subsistence needs, with crops receiving little direct cultivation beyond occasional mulching and replanting (Vergara and Nair, 1985). However, since the end of World War II, the Pacific has witnessed accelerated removal of trees. This process began during the colonial period with the establishment of monoculture, resulting in a simplification of forest cover to make room for cash crops (e.g., coconut plantations). Other factors that have contributed to agrodeforestation include rapid population growth, increased demand for fuel, continued urbanization, and development projects affecting the environment in negative ways (Thaman, 1994). Some countries have reacted to these threats by planting and protecting trees and forests. Multi-species agroforestry development provides hope for the sustainable use of local resources while lessening dependency on expensive imports and reverses the trend leading to a further deterioration of nutritional health throughout the region. The preservation of agroforestry is in turn linked to biodiversity conservation, including ecosystem diversity, species and taxonomic diversity, genetic diversity, and ethnobiological diversity (Thaman, 1993b). In regard to the latter, there is a wide range of ecological and cultural functions and uses of trees besides food, such as provision of shade, soil improvement, construction material, fuelwood, and medicines, to name a few.

Figure 2. Toddy cutting, North Tarawa (photo F. Thomas).

Another important traditional food-crop system now generally in decline is the pit cultivation of the giant swamp taro (Luomala, 1974; Fig. 3). Like arboriculture, aroid pit agriculture has a long sequence in the history of atoll settlements (Weisler, 1999a). Up to 24 cultivars have been identified in Kiribati (Ali and Asghar, 1987). Swamp taro is capable of producing sustained yields of staple, starchy food. Some varieties, grown mainly for prestige and ceremonies, may be cultivated for 10 to 15 years. With the widespread use of rice and flour, together with salinization of the water table, consumption of swamp taro has decreased. On South Tarawa and parts of North Tarawa, the taro beetle (*Papuana huebneri*) has also contributed to the abandonment of the majority of pits.

Figure 3. Swamp taro pit, North Tarawa (photo F. Thomas).

Despite limited land and poor soils, agriculture has a significant role to play in the economy of Kiribati in the achievement of increased copra production. In 1998, 7,577 metric tons were exported worth A$4.5 million, compared to fish exports with a value of A$1 million (Ministry of Finance, 1998). With its restrictive environment, the possible avenues for development of commercial agriculture are few. However, the agricultural sector could place more emphasis on local food production as a strategy for reducing imports as well as search for specialist foods or products that might contribute as minor exports. Examples of the latter include coconut cream and the Indian mulberry fruit (*Morinda citrifolia)*. To help attain these goals, the Agricultural Division within the Ministry of Natural Resources Development (MNRD), in cooperation with the Foundation of the Peoples of the South Pacific (FSP), began to focus in the mid-1980s on exotic food plants capable of growing well under harsh atoll conditions. On South Tarawa, 'mixed gardens' (Peduzzi, 1999) have essentially taken root at Bonriki Village where about 40 smallholder farmers work. In addition to fruits and vegetables (Table 2), sampled households at Bonriki revealed that the following tree crops were being planted and/or maintained: coconut, screw pine, Indian mulberry - mainly for medicinal purposes -, breadfruit, papaya (*Carica papaya*), and Pacific fig (Thomas, 2002b).

Although mixed subsistence-cash cropping of exotic fruits and vegetables on South Tarawa is mainly confined to Bonriki (in large part because of the relatively extensive tract of land and low population density on the ocean side next to the airport runway), it shows that, with some effort and organization, atolls need not depend solely on food imports. In addition to contributing to the rise of noncommunicable diseases, food imports result in the loss of foreign exchange earnings which could be spent more wisely on improved health care, education, and other development projects (cf. Thaman, 1983: 3). It is obvious that local food production alone, including the intensification of

Table 2. Crops planted by 20 sampled farmers and frequency occurrence of the crops (from Thomas, 2002b).

Crops (English Name)	**Scientific Name**	**Frequency Occurrence (# of households)**
Chinese cabbage	*Brassica chinensis*	20
Pumpkin	*Cucurbita pepo*	20
Tomato	*Lycopersicon esculentum*	17
Watermelon	*Citrullus vulgaris*	15
Cucumber	*Cucumis sativus*	13
Rockmelon/cantaloupe	*Cucumis melo cantalupensis*	9
Chilli	*Capsicum frutescens*	8
Eggplant	*Solanum melongena*	4
Bell pepper	*Capsicum annuum*	4
English cabbage	*Brassica oleracea capitata*	3
Swamp taro	*Cyrtosperma chamissonis*	2
Chinese broccoli	*Brassica alboglabra*	1
Hibiscus spinach	*Hibiscus manihot*	1

traditional agroforestry, will never be capable of supporting current population numbers. Agricultural production could increase significantly if unemployed and underemployed individuals were encouraged to take up farming in their home gardens (Thaman, 1995), adding exotic fruits and vegetables to the existing agroforestry system as evidenced by a few existing gardens scattered throughout densely settled urban areas. However, there is little doubt that increasing salinization of the water table will severely curtail plans for agricultural development. There are also important cultural barriers to be aware of such as the widespread perception among *I-Kiribati* that green leaves, papayas, and other introduced foods rich in vitamin A should be reserved as pig or famine food while pumpkins and vegetables are commonly not valued as food (Schoeffel, 1992: 233-234). On the other hand, local-level mariculture and lagoon restocking with giant clams (Tridacnidae) may offer one possible solution to this type of problem. This is because of the presence of zooxanthellae in the clam's mantle, accounting for higher vitamin A content than that in other shellfish. As giant clams are widely esteemed in Kiribati, As several nonfarming respondents indicated, agriculture requires a degree of constant care and thus does not appear attractive to many people. Limited cash is therefore spent on rice, flour, and a few other commodities that can be easily prepared and stored. Pollard (1987) identified the maintenance of an exchange rate determined by the value of the Australian dollar as a factor undermining local food production, thus permitting high and increasing levels of food imports. Outer island food production destined to the South Tarawa market is faced with the additional problem of unreliable transportation links. Despite these challenges, the Agriculture Division remains committed to improving transport, disease/pest control, and marketing skills for those farmers intent on supplying the domestic market (National Development Strategies, 2000). It is also important to balance off the needs for maximizing and protecting groundwater resources and maximizing overlying crop production.

FISHERIES

Fishing continues to occupy a prominent place in the lives of most *I-Kiribati*. Lagoon fishing involves both net- and line-capturing methods. Ocean fishing commonly focuses on Scombridae, notably skipjack tuna (*Katosowonus pelamis*) and yellowfin tuna (*Thunnus albacares*) as well as flying fish (*Cypselurus spp.*). Spearing is also practiced on a number of species. Fish traps, made from coral blocks, are impressive architectural features at low tides, located on ocean-side reef flats and in passages. They may extend up to 100 m in length and stand about 1 m high. Some families and villages raise milkfish (*Chanos chanos*) in specially designed enclosures located near the lagoon or in small inland pits excavated down to the water table. A number of invertebrates can also be found. While there are still gaps in our knowledge of species diversity in Kiribati, the total number of shellfish is undoubtedly comparable to the approximately 1,000 species recorded in the Marshall islands (Kay and Johnson, 1987).

Exclusive Economic Zone

With an EEZ covering more than 3.5 million km² – the second largest in the world – it is not surprising that the fisheries sector in Kiribati is seen as both a source of essential livelihood at the subsistence level and as a means of generating revenue by promoting the country's seemingly vast store of marine resources (Thistlethwait and Votaw, 1992: 28-29).

The licensing of fishing vessels belonging to Distant Water Fishing Nations (DWFNs), through multilateral treaty arrangementS, contributes highly variable returns which are largely affected by weather conditions, notably El Niño and its reverse, La Niña. For example, license revenues fell from A $40.3 million in 1998, as the impact of El Niño was felt, to A$31.8 million in 1999 during La Niña to A$17.2 million in 2000 (National Development Strategies, 2000). The main species taken are the pelagic, migratory skipjack and yellowfin tuna. Up to 40% of the world's annual tuna harvest currently originates in the central and western Pacific region — in part due to the fact that other areas have been over-fished — (Kawaley, 1999:350). Kiribati also lacks adequate onshore facilities to attract higher levels of tuna transshipment by foreign vessels. The EEZ is believed to contain potentially significant resources of manganese nodules and cobalt crusts on the seabed but, for the moment, an economically viable operation has yet to emerge (Teiwaki, 1988: 119-140). Kiribati is also seeking to develop its local fishing industry. To achieve this goal, however, important obstacles need to be surmounted such as the cost and availability of fuel, distance to markets, and competition against efficient, capital intensive DWFNs (Kearney, 1980).

Inshore Exports and Mariculture

The exploitation of Kiribati's EEZ for accrued benefit to the people of this island nation highlights the need for improved technology skills, information, and financial resources. Dolman (1990) argued that for small-island developing countries, 12 nautical miles are generally preferable to 200 nautical miles of biologically unproductive waters and highly migratory species. He further stated that the goal should be in terms of saving foreign exchange rather than generating it and to reduce dependency rather than seeking a place in a highly competitive market. The Government of Kiribati has acknowledged that inshore and mariculture development and the promotion of artisanal fishing could bring about economic improvement while lessening dependency on foreign aid. The government has reported increases in marine product exports (Table 3). In addition to fish, the specialized aquarium-fish market fetched almost A$1 million in 1998. Other important fisheries products include seaweed (with earnings exceeding half a million dollars in 1998) and bêche-de-mer (close to A$500,000 during the same period) (Ministry of Finance, 1998).

Table 3. Fisheries export value by commodity: 1987-1998 (A$'000). Courtesy Ministry of Finance, Tarawa.

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Fish	823	1606	2600	964	277	363	513	263	266	211	110	1058
Aquarium fish	0	0	0	0	336	258	533	551	817	639	698	932
Shark fins	16	18	42	32	24	118	123	175	659	194	94	129
Seaweed	62	15	85	723	676	286	217	297	176	382	373	626
Bêche-de-mer	0	0	0	0	0	0	685	764	379	769	268	483

Plans are underway to produce and market black pearls by smallholders on some of the outer islands and to develop a sustainable baitfish industry based on milkfish on South Tarawa.

The trade in aquarium fish was initiated on South Tarawa during the 1980s but was subsequently moved to Kiritimati because of its proximity to market centers in Honolulu. There has been a growing interest by the private sector in this lucrative trade since its establishment on Kiritimati (Kiribati Fisheries Division, 1999).

Seaweed is another high-value niche product inevitably subjected to world price fluctuations and destruction due to weather. Seaweed farming provides the major raw material for carrageenan which has widespread applications such as in processed foods, textiles, air fresheners, and pharmaceuticals. As a mariculture project, seaweed farming has already proven its worth in the Pacific (South, 1993).

Two species of seaweed, *Eucheuma alcarezii* and *Eucheuma spinosium*, were introduced to Kiribati in 1977 from the Philippines. The former species was found to thrive better under local conditions (Kiribati Fisheries Division, 1999). Tabuaeran and Abaiang have emerged as the major producers subsequent to failures of pilot projects on Tarawa. These failures were attributed to competition from other uses of the lagoon, particularly shellfish collecting by a growing number of urban migrants (Schoeffel, 1996: 80). In the early 1990s, some 2,000 smallholders, or nearly half the population of Abaiang, were growing seaweed (Tikai, 1993: 171). Seaweed production for the Gilberts in general has declined significantly, however, from a high of 1,019 metric tons in 1991 to a mere 12.2 metric tons in 2001 (Atoll Seaweed Co., 2001). The increasing frequency of westerly winds associated with El Niño has in effect discouraged many households to further invest in an activity considered high risk in an essentially risk-averse subsistence environment (Neemia-Mackenzie, 1998). Additional research into more weather-resistant varieties of seaweed, together with better monitoring of suitable growing sites, are being considered.

Despite the above difficulties, seaweed farming can contribute substantially more income to smallholders than copra production. A farmer can produce several crops per year yielding close to 25 tons of dry seaweed per hectare with minimal capital. While seaweed is still regarded as an export crop, there is potential to include it in the local diet particularly in efforts at reversing the effects of vitamin A and other vitamin and micronutrient intake problems. However, as with green vegetables, marine plants are still generally avoided for cultural reasons.

Trade in bêches-de-mer (holothurians), which is one of the first export products from Kiribati after Western contact, reached a peak of 125 tons in 1996 dipping to less than 15 tons in 1997. This drop is due to over-exploitation (Kiribati Fisheries Division, 1999). Of the 13 species that have been identified, four are considered to be of high value for the Asian market.

The production of black pearls derived from the black-lipped pearl oyster (*Pinctada margaritifera*) is one of the most recent mariculture projects in Kiribati. Cultured black pearls have become the most important export commodity among marine products in French Polynesia and the Cook Islands. This has led to concerns over possible declining profitability, perturbation of lagoon ecosystems, and growing tenure disputes (Rapaport, 1995).

The feasibility of producing and marketing black pearls in Kiribati has been the focus of considerable research and development. Research trials and pilot operations have been successfully carried out. Within the next few years, MNRD is expected to complete a feasibility and business plan for privately operated enterprises and then begin implementing a strategy for transferring the technology and business approach to the private sector (National Development Strategies, 2000). Given the level of pearl-farming development in French Polynesia and the Northern Cook Islands, it is hoped that Kiribati will learn from these experiences (Macpherson, 2000).

The need for mariculture of baitfish based on milkfish has been recognized in view of low wild-bait stocks. Cultured baitfish are to be exported primarily to support the licensed foreign long-line tuna fleet. Part of the output would also be sold on the Tarawa market. One problem faced in this connection is the infestation of fishponds with a predator, the introduced Malayan mosquito fish or tilapia (*Oreochromis* spp.) (National Development Strategies, 2000). When a visiting consultant to assist the local population in its protein requirements introduced tilapia, it resulted in the destruction of the milkfish in most of the ponds. As tilapia is not eaten, nor appreciated, due to its nonsalty taste, it is considered a serious pest.

Artisanal Fishing

In the Pacific, it is difficult to separate artisanal fisheries into commercial and subsistence operations because most communities sell part of their catch (Adams et al, 1999). However, the FAO (1998) reports that the nearshore commercial fish catch in Kiribati is principally made up of reef- and deep-slope fish (54%), shellfish (25%), and pelagic species (21%).

In contrast to agricultural production, nearshore fisheries throughout Kiribati are vigorously pursued. The Outer Island Fisheries Project (OIFP) was initially established with the goal of developing commercial fisheries on the outer islands and to provide a steady supply of fish to Tarawa. With the integration of OIFP and te Mautari Ltd (TML) – the government-owned company set up in 1981 for pole-and-line tuna fishing – to more cost- effectively supply both the export and the South Tarawa markets, the project, now called the Foundation for Integration of Fisheries, is currently targeting reef fish together with tuna (Kiribati Fisheries Division, 1999; National Development Strategies, 2000). Storage facilities and transport between the outer islands and Tarawa need improvement to create incentives for artisanal fishers to sell greater volumes (Neemia and Thaman, 1993).

Shellfish harvesting

Increased fertilization by sewage-driven nutrients appears to be responsible for the expansion of seagrass beds which are good shellfish habitats. Filter feeders exposed to contaminated water are agents of gastrointestinal diseases. With expanding urbanization, there has been a growing demand for cheap, easily gathered resources such as shellfish. While bacterial pollution from overcrowding has ensured for a time the proliferation of filter feeders such as Anadara cockles (*Anadara uropigimelana*), yearly harvest of these bivalves has been estimated at close to 1,400 tons causing concerns about resource sustainability (Paulay, 2001). Between 1993 and 1994, the roadside sale of Anadara was putting pressure on Tarawa stocks that were once relatively well-protected. Divers possessing any floating device, from a small canoe to a rubber inner tube, and goggles could collect large quantities of bivalves on a daily basis and sell their catch in rice sacks holding up to 34 kg of shellfish. The move by shellfish gatherers from the intertidal sand flats and seagrass beds to deeper sections of the lagoon was itself triggered by declining abundance and size of existing stocks closer to shore (Thomas, 2001a).

The strombid gastropod, *Strombus luhuanus*, is fast becoming the dominant shellfish taxon in Tarawa Lagoon because of gathering pressure on the preferred Anadara. The annual harvest is estimated at 400 tons (Paulay, 2001). The high variability of population density may reflect increased gathering pressure but could also be attributed to patchy distribution, perhaps linked to the snail's high mobility.

Stocks of giant clams have been greatly affected throughout the Pacific as a result of commercial exploitation by foreign vessels (Dawson, 1988). In addition, heavy exploitation to satisfy domestic consumption has led to the virtual demise of the largest taxon (*Tridacna gigas*) around Tarawa while stocks on the outer islands are low (Munro, 1986). There had been plans to culture giant clams for seeding on the outer islands and for restocking some areas of Tarawa Lagoon adjacent to reefs and away from dense human settlements (Kiribati Fisheries Division, 1994) but these were discontinued because of lack of funding.

In Kiribati, as in various other Pacific localities, small specimens (< 40 cm) of *Tridacna gigas* and *Hippopus hippopus* are occasionally carried to shallow lagoon reef flats or deposited in passes adjacent to settlements. In place, they are allowed to grow until ready for consumption (Figure 4).

Figure 4. Giant clam "garden", Abemama (photo F. Thomas).

A smaller, and more abundant species, *Tridacna maxima*, is taken from some outer islands and is the target for supporting a domestic commercial fishery. Fisheries statistics are incomplete, as many of the exploited shellfish (preserved by salting) are carried as personal consignment by boat from Abaiang to be sold on Tarawa.

Fishing on South Tarawa

Concern over the condition of Tarawa Lagoon is not limited to slow-moving animals such as bêches-de-mer and shellfish. Some reef fish are also threatened. The government continues to worry about the lack of an effective management plan for inshore marine resources. Lagoon and reef areas are witnessing increasing levels of pollution, primarily from human and animal waste, as well as a decline of a host of organisms as a result of over-fishing. A steady growth in the population of South Tarawa and in the availability of outboard motor boats and gill nets has contributed significantly to increased effort and total catch. Catching efficiency has also increased substantially with the introduction of gill nets that are more than 1 km long. The splash-fishing method (*ororo*), whereby fishermen drive fish into long gill nets by splashing the surface of the water with iron bars, may be particularly efficient. During the past two decades, however, several lagoon fish, such as bonefish (*Albula glossodonta*) and spangled emperor (*Lethrinus nebulosus*), have been greatly reduced in number (Beets, 2001; Tikai, 1993: 170). Fish-stock declines can also be attributed to the obstruction of spawning migration routes by causeways, notably in the case of bonefish (Abbott and Yeeting, 1995). While many fishermen were keenly aware of the changes affecting inshore resources, though not necessarily the underlying causes, they were for the most part unwilling to take action -- an example of the 'tragedy of the commons' (Hardin, 1968) whereby fishers fear that if one were to reduce his/her catch others would take that catch instead (Phillips, 1995).

Fishing can be highly lucrative for families with sufficient capital and labor. Households equipped with boats, several nets and fishing lines, as well as insulated cooler boxes, can fetch anywhere between A$200 to A$700/week which is considerably more than what farmers can earn selling their produce, estimated between A$30 and A$100/week (Thomas, 2002b).

TENURE

Before Western contact, settlements were dispersed, although they were usually close to the lagoon. The basic residential unit (and main social group) was the hamlet (*kainga*) composed of clustered households (*mwenga*) occupied by members of related extended families. Each *kainga* in the central and southern Gilberts owned land and designated marine areas extending in narrow strips from the ocean reef to the lagoon shore or from one ocean reef to the next on raised limestone islands (Atanraoi, 1995; Ruddle, 1994: 90-94) and engaged in economic production and in social exchanges. In the wetter, more productive northern Gilberts, chiefs held the title for an entire island or most of an island but everyone was entitled to live on the land. Swamp taro pits were divided among several *kainga* community headmen. Fishponds belonged to all those who participated in stocking and cleaning them. Fish traps were the property of individual builders and kinsmen who cooperated. Leaders of descent groups had the right to distribute flotsam, stranded porpoises, large fish, and possibly turtles, and to prohibit access to the reef (Maude, 1963). The British colonial administration, established at the end of the nineteenth century, later abolished this type of control in line with the Western concept of public rights in the sea and its resources.

Up until the late 1940s, the colonial government allowed customary marine tenure to prevail for all resources taken from the lagoon and ocean sides. The native Lands Commission subsequently recognized only certain rights, including ownership of fish traps, seawalls, accretions, reclaimed lands, and fishponds (Teiwaki, 1988: 40; Fig. 5). The registration of these rights is usually made in the name of the male head of the

Figure 5. Fishpond, Abemama (photo F. Thomas).

kainga or descent group (*utu*) who has customary obligation towards other members. However, the law did not specify this social requirement. The negative consequences of unrestricted access, however, prompted some island councils to adopt bylaws to protect fish and invertebrates thus leading to community efforts to prohibit fishing practices in certain areas, at certain times, and in relation to types of fish and gear (Miria-Tairea, 1995: 15). For instance, island councils on Tamana and Arorae have imposed restrictions on the use of pressure lamps to catch flying fish (Onorio, 1985). On North Tarawa, some forms of customary marine tenure continue to be practiced (Johannes and Yeeting, 2001). The effectiveness of such measures remains in doubt, however, and may parallel land-court decisions (land custom has been codified in Kiribati) where judgments are often ignored because of the lack of administrative capacity to enforce decisions as a result of divided ownership, excessive fragmentation of land, and scattered rights (Crocombe, 1999; Namai, 1987).

As noted above, giant clams are sometimes brought from various sections of the leeward reef and ocean reef flat to sandy lagoon patches in proximity to residences. Both *T. gigas* and *H. hippopus* are amenable to live storage in designated "gardens" because they are sedentary, may grow large, and are generally able to survive (although not necessarily reproduce optimally) in an environment different from where they occur naturally (Hviding, 1993: 45; Johannes, 1982; Maclean, 1978). Extant giant clam "gardens" may be demarcated by the presence of a circular coral enclosure about 40 cm high, coral rubble, a fish trap, or no distinguishing feature at all (Thomas, 2001b). Concentrations range from one or two specimens to much larger aggregates, sometimes consisting of large individuals but more commonly of smaller ones. Like fish traps and areas set aside for seaweed farming, giant clam "gardens" are the property of individual households whereas the reef flats on both lagoon and ocean sides are now regarded as common property. Because of endemic pilferage in populated areas, traditional giant clam "mariculture" is currently confined to relatively isolated areas such as sparsely inhabited islets. The "gardens" are disappearing from the Kiribati seascape, however, in large part because of the erosion of customary marine tenure. Owners are now less inclined to continue to care for giant clams in designated lagoon sections or to invest in maintaining large fish traps (Fig. 6). Another factor for the neglect of fish traps (and some land plots) relates to owner absenteeism linked to internal migrations to South Tarawa (King, 1999; Latouche, 1999).

Figure 6. Fish trap, Maiana (photo F. Thomas).

The Tarawa Lagoon Project called for a remodeled form of marine tenure based on more detailed studies of traditional systems of fishing rights that can be ethnographically salvaged and the legal parameters. The contributors recognized that marine tenure would be more difficult to implement near urban centers because of the large proportion of residents who have no claims to local fishing rights. It will be interesting to see the impact of outer island black-pearl farming on claims to customary marine tenure.

BIODIVERSITY CONSERVATION

While the fauna and flora on atolls are relatively impoverished compared to other island types, a number of plant species were traditionally recognized for their utilitarian qualities, including medicinal uses, as well as for their symbolic value (Thaman, 1990). Preserving biodiversity is thus linked to the maintenance of cultural vitality.

The flora of the Gilberts has been estimated at just over 300 species (83 indigenous), while the Line and Phoenix Islands include only 283 species of which 67 are indigenous (Guinther et al., 1992). Of the indigenous species, 40 are severely restricted in their distribution, endangered, or possibly extinct due to human activities. The impact of humans on the flora, including protective mangroves, has been extensive, especially in the last 100 years, with the widespread development of coconut plantations as well as expanding populations exhibiting various degrees of changed lifestyle through the adoption of Western values (Wilson, 1994). The environmental “rape” of Banaba for phosphate beginning in the early twentieth century is a *cause célèbre* illustrating biodiversity reduction with resulting serious social consequences. Following the deportation of the indigenous population by the Japanese during World War II to Tarawa, Nauru, and the Carolines, Banabans were then resettled on Rabi in Fiji at war’s end to allow further mining (Sigrah and King, 2001).

There are no indigenous land mammals in Kiribati. The Polynesian rat (*Rattus exulans*) was apparently the only terrestrial mammal noted by the United States Exploring Expedition in the first half of the nineteenth century (Wilkes, 1845: 75). Dogs may have become extinct before being reintroduced in the post-contact era (Grimble, 1933-34: 28; Takayama and Takasugi, 1988). Cats and pigs are also historic introductions. The avian fauna consists of 75 birds species with only one endemic, the Line Island reed warbler

(*Acrocephalus aequinoctialis*) (Guinther et al., 1992). The Line and Phoenix Islands, along with the Northwest Hawaiian Islands, constitute the most extensive system of tropical seabird rookeries in the world. However, these have become greatly diminished in the last few decades due to feral cats, rats, and extensive poaching, particularly on Kiritimati (Jones, 2000). Despite efforts to establish closed wildlife sanctuaries on Malden and Starbuck (Line Islands), parts of Kiritimati and, more recently, on Millennium Island, enforcement of the law remains problematic (Kepler, 2000). Because the islands in the Line and Phoenix group are widely scattered and mostly uninhabited, it is difficult to monitor activities which could have detrimental effects on the environment including illegal fishing or even the disturbance created by a single careless yachtsman (Kepler et al., 1994).

Between 600 and 800 species of inshore and pelagic finfish are believed to exist together with approximately 200 coral species (Guinther et al., 1992). However, the scarcity of certain marine organisms, such as turtles, large reef cods, and giant clams, and smaller catches and decreasing average size of species individuals indicate that atolls are seriously over-fished now. As with disturbance of vegetation, marine biodiversity is also affected by a host of human activities, including foreshore reclamation, construction of causeways, dumping of rubbish on the lagoon shore, and sewage discharge (Spalding et al., 2001; Wells, 1988: 207).

The Tarawa Lagoon Project resulted in a series of reports and a proposal to put into place a Tarawa Management Council. To date, however, no significant progress has been achieved on the implementation of the full council proposal. The Environment Act, which came into effect in 1999, gave responsibility to the Environment and Conservation Division of the Ministry of Environment and Social Development (MESD) for carrying out a community awareness and education program "on both the manner in which the Act will apply to new developments and more broadly in terms of the importance of protecting Kiribati's water, land and associated ecosystems" (National Development Strategies, 2000: 66).

There is a feeling that marine biodiversity conservation will be better served by "bottom-up" approaches tied to customary marine tenure (Tebano, 2000), but village-based control of resources and lagoon space will need to consider the potential challenge from individual fishing entrepreneurs with efficient extractive technology and even government representatives. Also, the resurrection, even in remodeled form, of marine tenure may generate or reactivate disputes concerning who has what traditional rights within bounded areas (Hunt, 1996).

CONCLUSIONS: TOWARDS SUSTAINABLE DEVELOPMENT

Literally volumes have been written on the topic of sustainable development. Yet, the concept remains elusive. As Overton (1999) remarked, sustainable development means different things to different interest groups. Referring to the Pacific Islands, he identified two noteworthy perspectives that had previously been neglected, namely the *local* and *social* perspectives. The local perspective is often regarded as subordinate to the global, while the social perspective remains "a junior partner in the sustainable development coalition" (Overton, 1999: 1). Pacific Island "micro states" offer specific development challenges and, while they are not poor by the usual standards of world poverty, they are nonetheless vulnerable to policies largely dictated by external forces. More often than not, these policies tend to ignore social structures and needs, even though they may support ecological and economic sustainability.

It had been said that for generations traditional management of resources in Kiribati ensured a plentiful supply of marine life to the indigenous population (Zann, 1985). While the debate on the effectiveness of indigenous conservation will no doubt continue (e.g., Acheson and Wilson, 1996: 586; Anderson, 1996: 174; Burney, 1997; Grayson, 2001; Hunter-Anderson, 1991; Kirch 2000; Nunn, 1997; Thomas, 1999), the fact remains that the modern world has led to accelerated changes in the way people relate to their environment. Today, changes in Kiribati lifestyle brought about by high rates of population growth, imbalance of population distribution, and a move towards Western-oriented materialism, are placing increasing demands on the environment and natural resources.

The extent of food dependency can be related to the degree that a nation relies on a *MIRAB* economy. Kiribati, like other Pacific "micro states" will, in all probability, continue to rely on one or more aspects of *MIRAB* particularly since current agricultural production is limited in most cases. With high human population densities and high fertility rates, food imports will undoubtedly continue to play a vital role in feeding growing populations, notably in urban centers. Mobility (migration) and associated remittances will remain an option for those seeking a better future, although opportunities differ among small-island states and territories. While *MIRAB* should be viewed with some apprehension in Kiribati, it is also true that rent income can play an important *supportive* role in the economy of small-island states. Local governments should continue to explore ways to capture various rent opportunities and thus aim at diversifying their options.

Many Pacific Island nations face rapidly growing populations with changing needs, wants and aspirations, and an increasing rate of urbanization. The scope for greater reliance on the manufacturing and industrial sector is small because of the islands' remoteness from large trade and investment centers in Australasia and the limits imposed by the size of domestic markets. Most Pacific Islands have little choice but to rely on economic growth based on natural resources exploitation. Agriculture and fisheries have been, and will remain, the main economic activity in the Pacific and often the main source of export earning. Encouraging economic growth and development to meet the needs of the current generation without jeopardizing the ability of future generations to meet theirs is a major challenge facing island nations. Because *I-Kiribati* are not migrating to Western countries (except when they marry foreigners), there are few opportunities to lessen population pressure on the islands. Thus, birth control will also need to be encouraged to ensure sustainable livelihoods.

The desire to achieve a higher nutritional and health status can be translated into a policy of substituting, in part, locally produced food for imported foods. In the case of South Tarawa, it should be recognized that food imports, particularly staples, play a very important role in meeting the dietary needs of the people. However, raising local food production is desirable for improving nutritional conditions and perhaps in generating revenue based on the export of specialist produce (Ward and Proctor, 1980: 364). Recent statistics showed that, while 23% of *I-Kiribati* were employed in traditional agriculture, these statistics indicated that commercial agriculture employed 0% (Purdie, 1999: 73). However, it is suggested here that further agricultural expansion should be geared primarily to satisfy local demand rather than for export. The socioeconomic and environmental implications of overspecialization of commercial agriculture in the region are well known (Overton et al., 1999). While there is little quantitative data on productivity and the economic importance of urban food gardening throughout the Pacific, it nevertheless seems considerable in terms of encouraging import substitution, improving the balance of payments, and maximizing self-sufficiency in food, fodder, fuel, medicines, perfumes, or ornamentation, and a wide range of other subsistence and limited commercial products. Also, it must be remembered that access to food is not guaranteed by simply increasing production, and food security in a long-term view may be put at risk by overambitious short-term production increases, which also reduce soil fertility or freshwater availability (Neemia and Thaman, 1993).

"Micro states" clearly have fewer options as far as their agricultural sector is concerned compared to their fisheries, particularly regarding the range of export products. Fisheries in Kiribati highlight the opportunities and challenges facing this sector of the economy. Marine resources development, if properly managed, should lead to greater economic independence without necessarily eliminating the *MIRAB* component. In regard to its EEZ, Kiribati needs to go beyond the task of assessing the life cycles of commercially significant tuna stocks and move towards a better understanding of the ecological system where fisheries take place to protect and preserve the marine environment (Kawaley, 1999). On Tarawa, where the population density is greatest, the utilization of the reef flats and lagoonal areas will increase leading to greater pressure on existing stocks. It is hoped that with the expansion of mariculture projects on the outer islands, such as black pearl farming, Kiribati will not only benefit financially but also reverse or at least slow down the rate of in-migration to South Tarawa. For the Pacific Islands in general, and Kiribati specifically, fisheries development will remain central to attaining greater economic autonomy. According to Lawson (1980), the development of inshore resources may have greater impact on the economies of certain islands than the development of oceanic fisheries because of their accessibility, relatively low level of capital investment, technology, and organization which can be developed by local fishermen, and because they provide employment and could form the basis of development of other linkage industries as well, such as gear manufacture, boat building, and maintenance.

The uncertainty surrounding *MIRAB* economies calls for other forms of development to complement existing arrangements. Kiribati's focus on fisheries appears well-founded, but development along this line will also need to address broader environmental and social impacts with a long-term perspective (SPREP, 1998: 20). To maximize returns, Kiribati still relies on revenue by DWFNs utilizing the country's EEZ but realizes that it exercises little control over resources. For that reason, the nation has committed itself to developing its own fishing industry and to encouraging smallholder projects focusing on mariculture. Conflicts may arise, however, as the exploitation of inshore resources for export may put pressure on artisanal fishers who have already seen declines of existing stocks caused by overfishing. Solutions will not be easy to achieve but by highlighting the complex web of environmental and social concerns, including improvements in transport and storage facilities, management of resources, pollution, coastal erosion and water quality control, approaches to renewable energy production, family planning, and responses to global warming, to name a few, it is hoped that further development of the agricultural and fisheries sector will be based on increasingly informed choices.

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CHECKLIST OF THE SHORE AND EPIPEGAGIC FISHES OF TONGA

BY

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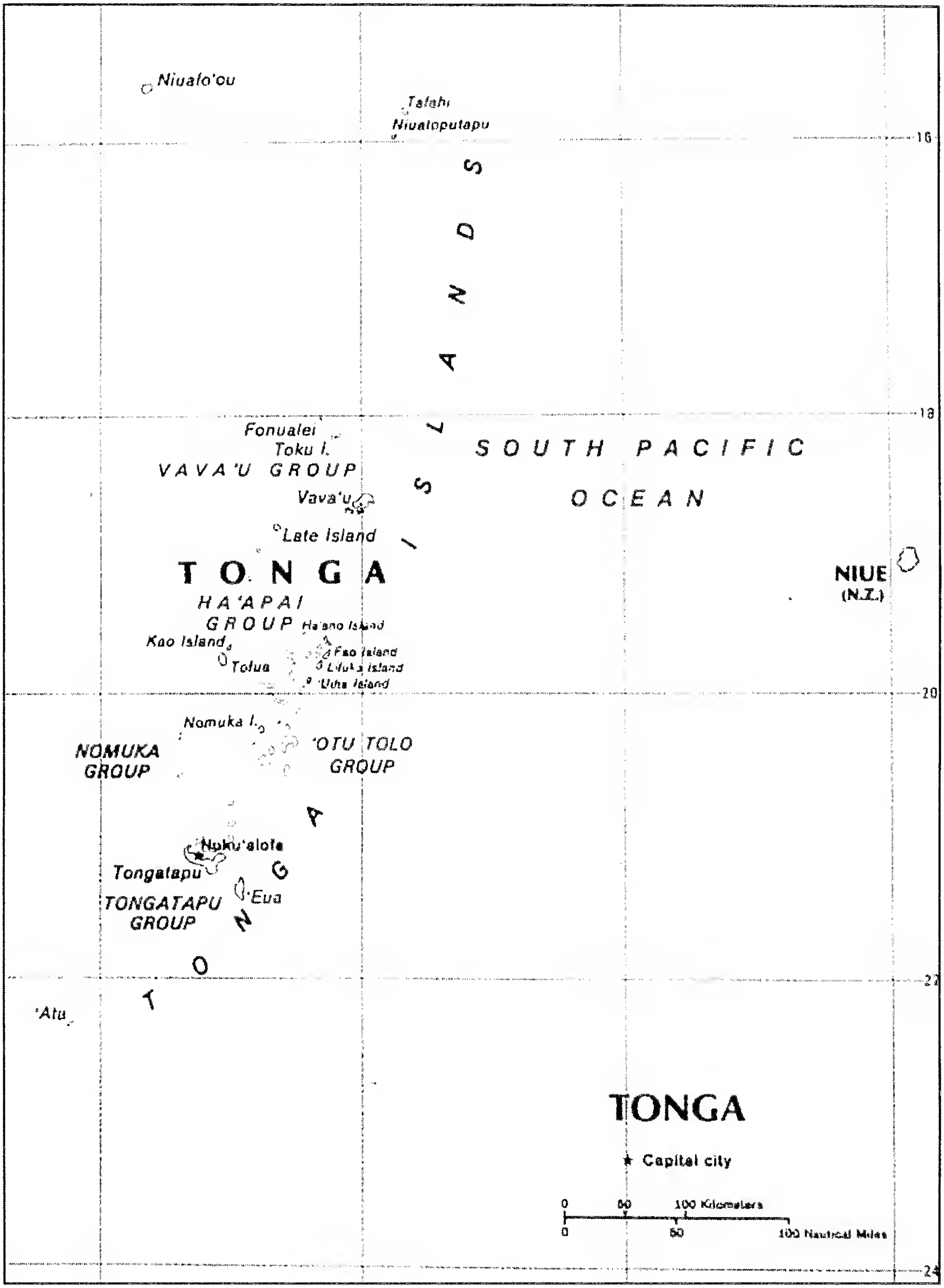

Figure 1. The Kingdom of Tonga.

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JOHN E. RANDALL[1], JEFFREY T. WILLIAMS[2], DAVID G. SMITH[2], MICHEL KULBICKI[3], GERALD MOU THAM[3], PIERRE LABROSSE[4], MECKI KRONEN[4], ERIC CLUA[4], and BRADLEY S. MANN[5]

ABSTRACT

A checklist is given below of 1162 species of shore and epipelagic fishes belonging to 111 families that occur in the islands of Tonga, South Pacific Ocean; 40 of these are epipelagic species. As might be expected, the fish fauna of Tonga is most similar to those of Samoa and Fiji; at least 658 species of the fishes found in Tonga are also known from Fiji and the islands of Samoa. Twelve species of shore fishes are presently known only from Tonga. Specimens of Tongan fishes are housed mainly in the fish collections of the National Museum of Natural History, Washington D.C.; Bernice P. Bishop Museum, Honolulu; Museum National d'Histoire Naturelle, Paris; and the Australian Museum, Sydney. Native Tongan names of fishes, when known, are presented after species names.

INTRODUCTION

The Polynesian kingdom of Tonga is unique among the archipelagoes of the Pacific in never coming under control of a western nation. It consists of 170 islands and islets in the South Pacific between latitudes 15°35'S and 22°20'S and longitudes 173°54'W and 175°38'W (Fig. 1). The islands are divisible into three major groups from south to north: Tongatapu; Ha'apai; and Vava'u. The largest island and seat of the government is Tongatapu; its maximum altitude is about 60 m. The Ha'apai Group consists of atolls and low islands. The islands of Vava'u are small, volcanic, and mountainous. Also included as part of Tonga are three small volcanic islands to the northwest called the Niuas: Niuafo'ou; Tafahi; and Niuatoputapu. Captain James Cook gave the name Friendly Island to the Tongan island of Lifuka in 1777 on his third voyage around the world. The name was applied by Europeans to the whole group and persisted in the literature for many years.

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Cook had visited Tonga on his second circumnavigation in "Resolution" with Johann Reinhold Forster and his son George as naturalists aboard. The unpublished four-volume compilation of the elder Forster's *Descriptiones Animalium* was used by J.G. Schneider, who incorporated many of the Forster names and descriptions in the *Systema Ichthyologiae* of Bloch and Schneider (1801) and attributed the authorship to Forster. Five of these fishes were collected in Tonga (Wheeler, 1981).

Five early French voyages of discovery resulted in stops at islands in the South Seas: De la Pérouse (1785-1788); d'Entrecasteaux (1791-1794); Duperrey (1822-1825); Dumont d'Urville (1826-1829); and a second voyage under Dumont d'Urville (1837-1840). Three visited Tonga, d'Entrecasteaux and both of Dumont d'Urville's voyages, but only the latter two obtained a few fishes at Tonga. Dumont d'Urville's first voyage was on the *Astrolabe* with the naturalists J.R.C. Quoy and J.P. Gaimard on board. His second voyage was on *Astrolabe* and *La Zélée*, with the naturalists J.B. Hombron and H. Jacquinot on the *Astrolabe* (not to be confused with C.H. Jacquinot who was the commander of *La Zélée*). As a result of these expeditions, Quoy and Gaimard (1834) described *Bodianus perditio* and Valenciennes in Cuvier and Valenciennes (1830, 1832, 1835, 1837) named *Epinephelus chlorocephalus* (still known from only one specimen), *Uranoscopus sulphureu*s, *Gobiodon histrio*, *G. quinquestrigatus*, and *Naso tonganu*s from Tonga.

The Muséum National d'Histoire Naturelle in Paris has 76 lots of fishes from Tonga including the species listed above. Included are two lots of the uranoscopid *Anema monopterygium* collected by Arnault at Tongatapu with no further data and no date. These were reidentified as *Genyagnus monopterygius* (Bloch and Schneider) by Hirokazu Kishimoto, the currently recognized authority of the family. Malcolm P. Francis (pers. comm.) has questioned the Tonga locality, but we have retained the species in this checklist.

Albert Günther (1880) listed nine fishes that were collected during the short stay of H.M.S. *Challenger* at Tongatapu on 20 July 1874, one of which, *Mugil tongae* (now known to be a synonym of *Mugil cephalus*), was described as new. Günther overlooked *Epinephelus fuscoguttatus* which was reported from Tongatapu by Boulenger (1895).

Günther included 871 species of fishes in his monumental *Andrew Garrett's Fische der Südsee* (1873-1910) of which 67 were specifically listed from Tonga. Some common wide-ranging species, such as the surgeonfish *Acanthurus triostegus*, were not mentioned as occurring in Tonga, but statements such as their being found throughout Polynesia would indicate their probable collection at Tonga.

Thirty-four species of fishes were reported from Tonga by Kendall and Goldsborough (1911) as a result of an expedition to the tropical Pacific from the U.S. Fish Commission steamer "Albatross" in 1899-1900 headed by Alexander Agassiz. Specimens were deposited in the Museum of Comparative Zoology of Harvard University and the National Museum of Natural History.

Henry W. Fowler (1930) reported on a collection of 36 species of fishes made by Lt. H.C. Kellers of the U.S. Naval Eclipse Expedition of 1930 at Niuafo'ou Island. He described three species as new, but these are regarded as synonyms today. Schultz (1950) described one of Keller's fishes as a new species of hawkfish, *Cirrhitus albopunctatus*; this is a valid species still known only from the two type specimens.

A Stanford University expedition on the schooner *Te Vega* headed by Rolf L. Bolin was in Tonga in May and June of 1965. Fishes were collected by night lighting, 3-m Tucker trawl, and rotenone; 131 lots of the *Te Vega* fishes have been entered in the database of the National Museum of Natural History, Washington, D.C.

Robert H. Snyder collected fishes for the Bishop Museum at South Seas localities in 1964; 53 lots of 30 species were obtained at Tongatapu.

The first author spent a month collecting fishes in Tongatapu and in Vava'u in 1983; he obtained 470 lots of 317 species with assistance of fisheries personnel.

In 1993 C.C. Baldwin, B.B. Collette, G.D. Johnson, D.G. Smith, and J.T. Williams of the Natural History Museum of the Smithsonian Institution, with E.A. Powers of the Peace Corps and E. O. Wiley of the University of Kansas, collected fishes at Tongatapu, Eua, islands of the Ha'apai Group, and Vava'u for six weeks. Their collections resulted in 3,904 lots comprising 789 species.

A team from the Institut de Recherche pour le Développement and the Secretariat of the Pacific Community, New Caledonia consisting of E. Clua, M. Kronen, M. Kulbicki, P. Labrosse, and G. Mou Tham made three visits to Tonga, each of about three weeks duration. The first was to the Ha'apai Group in November 2001, the second to Vava'u in March 2002, and the third to Tongatapu in August 2002. An average of 100 dives was made per visit. Fishes were collected at times to provide for identification, but few specimens were retained.

An anonymous 1983 report of a survey of the baitfish resources of Tonga was made available to us by the South Pacific Commission (now the Pacific Community). Included are the anchovy *Stolephorus indicus*, which from the known distribution should be expected in Tonga, and the cardinalfish *Rhabdamia gracilis*. In view of the distribution of the latter, we believe its occurrence in Tonga should be confirmed.

We present below the first checklist of the shore fishes of Tonga from our own collecting and photographic efforts and from what we conclude are valid records from the literature. We also include photographic and/or visual records for 30 species recorded by Larry Sharon. The most important reference has been the FAO volumes 3 to 6 on fishes edited by Carpenter and Niem (1999- 2001) entitled *The Living Marine Resources of the Western Central Pacific.*

The species in our checklist are listed alphabetically by genus and species within the families. They are not separated by subfamilies.

We include as shore fishes those that occur on the insular shelf at depths less than 200 m. We have refrained from adding species that we expect to be found in inshore waters at Tonga as their presence there cannot be confirmed. Examples are: *Carcharhinus albimarginatus*, *C. galapagensis*, *Hymantura fai*, *Brachysomophis sauropsis*, *Ophichthus altipennis*, *Trachinocephalus myops*, *Scorpaenopsis possi*, *Cephalopholis polleni*, *Apogon apogonides*, *Pseudamia zonata*, *Remora remora*, *Plectorhinchus gibbosus*, *P. vittatus*, *Centropyge aurantia*, *Chrysiptera caeruleolineata*, *Halichoeres hartzfeldii, Iniistius aneitensis, Pseudocheilinus ocellatus, Scarus festivus, Trichonotus elegans, T. setiger, Petroscirtes xestus, Exyrias belissimus, Oplopomus oplopomus, Acanthurus nubilus,* and *Melichthys niger*.

We have included the native Tongan names for the species when determined. These were obtained by the authors Dye (1983), Randy Thaman of the University of the

South Pacific, and Bradley S. Mann who was a Peace Corps volunteer in Tonga during the time of the first author's visit. Many families of fishes, especially those with species of little value as food fishes, have a general Tongan name that is applied to all species of the family such as haku for needlefishes (Belonidae), huli for the fusiliers (Caesionidae), sifisifi for the butterflyfishes (Chaetodontidae), and hohomo for parrotfishes (Scaridae). There is a general Tongan name for a few groups of families such as 'anga for sharks, fai for rays, toke for eels, and lokua for blennies and gobies. The general term for some of these families is given to all of the species. Some species of fishes of special value have different names for the growth stages. The mullet *Mugil cephalus*, for example, is named from small to large: te'epala, te'efo, 'unomoa, kanahe, and kanahetauau.

The islands of Tonga are positioned on the easternmost margin of the Australian continental lithospheric plate, with the Pacific lithospheric plate extending eastward and northward from the Tonga Islands (Springer, 1982). The marine fauna of Tonga is biogeographically important due to its location between these two plates. Several authors have noted the diminution in the number of species of shore fishes as one moves eastward in the Pacific from the rich Indo-Malayan region. Randall (1998) estimated that there are 2600 species of shore fishes in Indonesia. Allen and Adrim (2003) compiled a list of 2057 species of coral-reef fishes in Indonesia to a depth of 60 m which is comparable to the estimate of 2600 as the latter includes shore fishes to 200 m and those of other inshore habitats such as mangroves, sea-grass beds, and sand flats. Kulbicki and Rivaton (1997) recorded 1487 species of lagoon and reef fishes (to 80 m) for New Caledonia (1659, including the Loyalty Islands and Chesterfield Islands), Wass (1984) listed 946 for Samoa, and Randall (1998) recorded 633 for the Society Islands, 256 for Rapa (recent collecting efforts in 2002 by JTW, S. Planes, and R. Galzin have increased the number of known fish taxa to 358 at Rapa), and 126 for Easter Island (Rapa and Easter are more southern in Oceania as well as eastern).

Admittedly, the collecting has not been equal at all localities and proper comparisons cannot be made of island groups with small islands and atolls to high islands with more marine habitats from greater freshwater runoff. Also islands of higher latitude, in general, will have fewer species. Nevertheless, the trend is clear, particularly for Pacific plate archipelagoes which have fewer species than continental plate islands. Zug et al. (1989) prepared a list of fishes collected or observed at Rotuma, Kulbicki et al. (1994) for the Chesterfield Islands; Kulbicki and Williams (1997) for Ouvéa Atoll, Loyalty Islands; Randall (1999) for the Pitcairn Islands; and Randall and Earle (2000) for the Marquesas Islands. All of these are based on one to a few relatively brief, though intensive, periods of fish collecting, and they are not as complete as the other checklists.

We record below a total of 1162 species of fishes from Tonga (species in the list entered as "spp." are counted as representing two species; species living below 200 m excluded). Forty of these are epipelagic fishes, so this number should be deducted from the total to restrict the number to reef and shore fishes. We recognize that the number of species will increase with further collecting, especially in poorly sampled sand and soft-bottom habitats.

As would be expected from the proximity of Tonga to the islands of Fiji and Samoa, the fish fauna is most similar to those of these two archipelagoes. We note that at least 658 Tonga species of fishes are shared with Fiji and the Samoa Islands. Undoubtedly this number is much greater, but there is no checklist of Fiji fishes.

Twelve species of fishes from our list below are presently known only from Tonga. These are designated by an asterisk. Thirty-two species are listed only by genus. These represent sight records that could not be identified beyond genus with assurance (such as *Dasyatis* sp.), species waiting description, and species of which we have specimens that we cannot identify.

CHECKLIST

ECHINORHINIDAE (BRAMBLE SHARKS)
Echinorhinus cookei Pietschmann, 1928
SQUALIDAE (DOGFISH SHARKS)
Squalus megalops (Macleay, 1881)
STEGOSTOMATIDAE (ZEBRA SHARK FAMILY)
Stegostoma fasciatum (Seba, 1759) -- takaneva, ‘anga tavake
GINGLYMOSTOMATIDAE (NURSE SHARKS)
Nebrius ferrugineus (Lesson, 1830) -- ‘anga kopoa
RHINCODONTIDAE (WHALE SHARK FAMILY)
Rhincodon typus (Smith, 1828) -- fa’emi
ISURIDAE (MACKEREL SHARKS)
Isurus oxyrinchus Rafinesque, 1809
ALOPIIDAE (THRESHER SHARKS)
Alopias sp. -- ‘anga tavake
CARCHARHINIDAE (REQUIEM SHARKS)
Carcharhinus amblyrhynchos (Bleeker, 1856) -- ‘anga tu’a, ‘anga kelo
Carcharhinus falciformis (Bibron, 1839)
Carcharhinus longimanus (Poey, 1861)
Carcharhinus melanopterus (Quoy and Gaimard, 1824) --hahau, kapakau hingano
Carcharhinus plumbeus (Nardo, 1827) -- ‘anga tenifa
Prionace glauca (Linnaeus, 1758) -- ‘anga ‘aho
Galeocerdo cuvier (Péron and Lesueur, 1822) -- ‘anga neiufi
Triaenodon obesus (Rüppell, 1837) -- ‘anga lahahina
SPHYRNIDAE (HAMMERHEAD SHARKS)
Sphyrna lewini (Griffith and Smith, 1834) -- ‘anga matai
DASYATIDAE (STINGRAYS)
Dasyatis kuhlii (Müller and Henle, 1841) -- fai pala
Dasyatis sp.
MYLIOBATIDAE (EAGLE RAYS)
Aetobatis narinari (Euphrasen, 1790) -- fai manu
MOBULIDAE (MANTAS)
Manta birostris (Donndorff, 1790)
ELOPIDAE (TENPOUNDERS)
Elops hawaiiensis Regan, 1909 -- ‘ava tahi
MEGALOPIDAE (TARPONS)
Megalops cyprinoides (Broussonet, 1782)
ALBULIDAE (BONEFISHES)

Albula sp. -- kiokio

ANGUILLIDAE (FRESHWATER EELS)

Anguilla marmorata Quoy and Gaimard, 1824 -- tuna vai
Anguilla megastoma Kaup, 1856 -- tuna vai
Anguilla obscura Günther, 1872 -- tuna vai

CONGRIDAE (CONGER EELS AND GARDEN EELS)

Conger cinereus Rüppell, 1828 -- toke tuna
Heteroconger hassi (Klausewitz and Eibl-Eibesfeldt, 1959)

OPHICHTHIDAE (SNAKE EELS)

Apterichtus flavicauda (Snyder, 1904)
Brachysomophis crocodilinus (Bennett, 1833)
Callechelys catostoma (Forster, 1801)
Callechelys marmorata (Bleeker, 1853)
Ichthyapus vulturis (Weber and de Beaufort, 1916)
Leiuranus semicinctus (Lay and Bennett, 1839)
Muraenichthys laticaudatus (Ogilby, 1897)
Muraenichthys macropterus Bleeker, 1857)
Muraenichthys schultzei Bleeker, 1857
Myrichtys colubrinus (Boddaert, 1781)
Myrichtys maculosus (Cuvier, 1816) -- aki
Ophichthus cephalozona (Bleeker, 1864)
Schismorhynchus labialis (Seale, 1917)
Schultzidia johnstonensis (Schultz and Woods, 1949)
Scolecenchelys gymnota (Bleeker, 1857)

MORINGUIDAE (SPAGHETTI EELS)

Moringua sp.

CHLOPSIDAE (FALSE MORAYS)

Kaupichthys diodontus Schultz, 1943

MURAENIDAE (MORAY EELS) -- toke

Anarchias allardicei (Jordan and Starks, 1906)
Anarchias cantonensis (Schultz , 1943)
Anarchias seychellensis Smith, 1962
Anarchias spp.
Echidna delicatula (Kaup, 1856)
Echidna leucotaenia Schultz, 1943
Echidna nebulosa (Ahl, 1789) -- toke siale
Echidna polyzona (Richardson, 1845)
Echidna unicolor Schultz, 1953
Enchelycore bayeri (Schultz, 1953)
Enchelycore schismatorhynchus (Bleeker, 1853)
Enchelynassa canina (Quoy and Gaimard, 1824)
Gymnomuraena zebra (Shaw, 1797)
Gymnothorax buroensis (Bleeker, 1857)
Gymnothorax chilospilus Bleeker, 1865
Gymnothorax enigmaticus McCosker and Randall, 1982
Gymnothorax eurostus (Abbott, 1861)

Gymnothorax fimbriatus (Bennett, 1832)
Gymnothorax flavimarginatus (Rüppell, 1830) -- toke kula
Gymnothorax fuscomaculatus (Schultz, 1953)
Gymnothorax javanicus (Bleeker, 1859) -- toke ngatala
Gymnothorax margaritophorus Bleeker, 1865
Gymnothoras melatremus Schultz, 1953
Gymnothorax meleagris (Shaw, 1795) -- toke ‘akua
Gymnothorax monostigma (Regan, 1909)
Gymnothorax nudivomer (Günther, 1867)
Gymnothorax pictus (Ahl, 1789) -- toke tea
Gymnothorax pindae Smith, 1962
Gymnothorax richardsonii (Bleeker, 1852)
Gymnothorax rueppellii (McClelland, 1844)
Gymnothorax thyrsoideus (Richardson, 1845)
Gymnothorax undulatus (Lacepède, 1803) -- toke ngatala
Gymnothorax zonipectis Seale, 1906
Rhinomuraena quaesita Garman, 1888
Scuticaria tigrina Lesson,. 1828
Uropterygius alboguttatus Smith, 1962
Uropterygius concolor Rüppell, 1838
Uropterygius fuscoguttatus Schultz, 1953
Uropterygius inornatus Gosline, 1958
Uropterygius macrocephalus (Bleeker, 1865)
Uropterygius marmoratus (Lacepède, 1803)
Uropterygius nagoensis Hatooka, 1984
Uropterygius xanthopterus Bleeker, 1859

CLUPEIDAE (SARDINES AND HERRINGS) -- satini
Amblygaster clupeoides Bleeker, 1849
Amblygaster sirm (Walbaum, 1792)
Dussumieria elopsoides Bleeker, 1849
Herklotsichthys quadrimaculatus (Rüppell, 1837) -- ulukau
Sardinella melanura (Cuvier, 1829)
Spratelloides delicatulus (Bennett, 1832)
Spratelloides gracilis (Temminck and Schlegel, 1846)

ENGRAULIDAE (ANCHOVIES) -- heli
Encrasicholina devisi (Whitley, 1940)
Encrasicholina heteroloba (Rüppell, 1837)
Encrasicholina punctifer Fowler, 1938
Stolephorus indicus (van Hasselt, 1823)
Thryssa baelema (Forsskål, 1775)

CHIROCENTRIDAE (WOLF HERRINGS)
Chirocentrus dorab (Forsskål, 1775)

CHANIDAE (MILKFISH FAMILY)
Chanos chanos (Forsskål, 1775) -- ‘ava vai

PLOTOSIDAE (EEL CATFISHES)

Plotosus lineatus (Thunberg, 1787) -- kopoa

SYNODONTIDAE (LIZARDFISHES) -- mohe'aho

Saurida gracilis (Quoy and Gamard, 1824)
Saurida nebulosa Valenciennes, 1849
Saurida undosquamis (Richardson, 1848)
Synodus binotatus Schultz, 1953
Synodus capricornis Cressey and Randall, 1978
Synodus dermatogenys Fowler, 1912
Synodus variegatus (Lacepède, 1803)

LAMPRIDAE (OPAHS)

Lampris guttatus (Brünnich, 1758)

OPHIDIIDAE (BROTULAS AND CUSK EELS)

Brotula multibarbata Temminck and Schlegel, 1846
Brotula townsendi Fowler, 1900

BYTHITIDAE (VIVIPAROUS BROTULAS)

Brosmoyphysiops pautzkei Schultz, 1960
Dinematichthys randalli Machida, 1994
Dinematichthys five n. spp., being described by Schwarzhans, Nielsen, & Moller.

CARAPIDAE (PEARLFISHES)

Carapus homei (Richardson, 1844)

ANTENNARIIDAE (FROGFISHES) -- houhau maka

Antennarius analis (Gosline, 1957)
Antennarius coccineus (Cuvier, 1831)
Antennarius hispidus (Bloch and Schneider, 1801)
Antennarius pictus (Shaw and Nodder, 1794)
Antennatus tuberosus (Cuvier, 1817)
Histrio histrio (Linnaeus, 1758)

MUGILIDAE (MULLETS)

Crenimugil crenilabis (Forsskål, 1775) -- kanahe
Liza alata (Steindachner, 1892)
Liza macrolepis (Smith, 1846) -- fua
Liza melinoptera (Valenciennes, 1836)
Liza subviridis (Valenciennes, 1836)
Liza vaigiensis (Quoy and Gaimard, 1825) -- kafa kafa
Mugil broussonnetii (Valenciennes, 1836)
Mugil cephalus Linnaeus, 1758 -- kanahe
Valamugil engeli (Bleeker, 1859)
Valamugil seheli (Forsskål, 1775) -- kanahe

ATHERINIDAE (SILVERSIDES) -- heli

Atherinomorus lacunosus (Forster, 1801)
Hypoatherina ovalaua (Herre, 1935)
Hypoatherina temminckii (Bleeker, 1853)

ISONIDAE (SURF FISHES)

Iso sp.

BELONIDAE (NEEDLEFISHES) -- haku

Ablennes hians (Valenciennes, 1846)

Platybelone argalus platyura (Bennett, 1832)
Strongylura incisa (Valenciennes, 1846)
Tylosurus acus melanotus (Bleeker, 1850)
Tylosurus crocodilus crocodilus (Péron and Lesueur, 1821)

HEMIRAMPHIDAE (HALFBEAKS) -- ihe
Euleptorhamphus viridis (Van Hasselt, 1823)
Hemiramphus archipelagicus Collette and Parin, 1978
Hemiramphus far (Forsskål, 1775) - hu'ila
Hyporhamphus acutus acutus (Günther, 1872)
Hyporhamphus affinis (Günther, 1866)
Hyporhamphus dussumieri (Valenciennes, 1846)
Zenarchopterus dispar (Valenciennes, 1847)

EXOCOETIDAE (FLYINGFISHES) -- malolo
Cheilopogon atrisignis (Jenkins, 1904)
Cheilopogon pitcairnensis (Nichols and Breder, 1935)
Cheilopogon simus (Valenciennes, 1847)
Cheilopogon spilonopterus (Bleeker, 1866)
Cheilopogon spilopterus (Valenciennes, 1846)
Cheilopogon unicolor (Valenciennes, 1846)
Cypselurus poecilopterus (Valenciennes, 1846)
Exocoetus obtusirostris (Günther, 1866)
Exocoetus volitans Linnaeus, 1758
Hirundichthys albimaculatus (Fowler, 1934)
Parexocoetus brachypterus (Richardson, 1846)

ANOMALOPIDAE (FLASHLIGHT FISHES)
Anomalops katoptron (Bleeker, 1856)

HOLOCENTRIDAE (SQUIRRELFISHES AND SOLDIERFISHES)
Myripristis adusta Bleeker, 1853 -- malau
Myripristis berndti Jordan and Evermann, 1903 -- malau
Myripristis kuntee Valenciennes, 1831 -- malau
Myripristis hexagona (Lacepède, 1802) -- malau
Myripristis murdjan (Forsskål, 1775) -- malau
Myripristis pralinia Cuvier, 1829 -- malau
Myripristis randalli Greenfield, 1974 -- malau
Myripristis tiki Greenfield, 1974 -- malau
Myripristis violacea Bleeker, 1851 -- malau
Myripristis vittata Cuvier, 1831 -- malau
Neoniphon argenteus (Valenciennes, 1831) - telekihi
Neoniphon aurolineatus (Liénard, 1839) -- telekihi
Neoniphon opercularis (Valenciennes, 1831) --telehiki
Neoniphon sammara (Forsskål, 1775 -- telekihi
Plectrypops lima (Valenciennes, 1831)
Sargocentron caudimaculatum (Rüppell, 1835) -- ta'a
Sargocentron diadema (Lacepède, 1802)
Sargocentron iota Randall, 1998

Sargocentron ittodai (Jordan and Fowler, 1903)
Sargocentron melanospilos (Bleeker, 1858)
Sargocentron microstoma (Günther, 1859)
Sargocentron punctatissimum (Cuvier, 1829)
Sargocentron rubrum (Forsskål, 1775)
Sargocentron spiniferum (Forsskål, 1775) -- ta'a
Sargocentron tiere (Cuvier, 1829) -- ta'a
Sargocentron tiereoides (Bleeker, 1853) -- ta'a
Sargocentron violaceum (Bleeker, 1853)

AULOSTOMIDAE (TRUMPETFISHES)
Aulostomus chinensis (Linnaeus, 1766) --toutau

FISTULARIIDAE (CORNETFISHES)
Fistularia commersonii Rüppell, 1835 -- totau

SYNGNATHIDAE (SEAHORSES AND PIPEFISHES)
Choeroichthys brachysoma (Bleeker, 1855)
Choeroichthys cinctus Dawson, 1976
Choeroichthys sculptus (Günther, 1870)
Corythoichthys flavofasciatus (Rüppell, 1838)
Corythoichthys intestinalis (Ramsay, 1881)
Corythoichthys nigripectus (Herald, 1953)
Corythoichthys schultzi Herald, 1953
Cosmocampus banneri Herald and Randall, 1972
Cosmocampus maxweberi (Whitley, 1933)
Doryrhamphus excisus excisus Kaup, 1856
Dunckerocampus dactyliophorus (Bleeker, 1853)
Halicampus boothae (Whitley, 1964)
Halicampus mataafae (Jordan and Seale, 1906)
Hippichthys spicifer (Rüppell, 1838)
Hippocampus histrix Kaup, 1856 -- hoosi tahi
Hippocampus kuda Bleeker, 1852 -- hoosi tahi
Micrognathus andersonii (Bleeker, 1858)
Microphis brachyurus (Bleeker, 1853)
Phoxocampus belcheri (Kaup, 1856)
Phoxocampus diacanthus (Schultz, 1943)
Syngnathoides biaculeatus (Bloch, 1785)

SOLENOSTOMIDAE (GHOST PIPEFISHES)
Solenostomus paradoxus (Pallas, 1770)

SCORPAENIDAE (SCORPIONFISHES) -- hohau
Dendrochirus biocellatus (Fowler, 1938)
Dendrochirus brachypterus (Cuvier, 1829)
Dendrochirus zebra (Cuvier, 1829) -- houhau maka
Pontinus sp.
Pterois antennata (Bloch, 1787) -- hohau
Pterois radiata Cuvier, 1829 -- hohau
Pterois volitans (Linnaeus, 1758) -- hohau ta
Scorpaenodes albaiensis (Evermann and Seale, 1907)

Scorpaenodes guamensis (Quoy and Gaimard, 1824)
Scorpaenodes hirsutus (Smith, 1957)
Scorpaenodes minor (Smith, 1958)
Scorpaenodes parvipinnis (Garrett, 1864)
Scorpaenopsis diabolus (Cuvier, 1829)
Scorpaenopsis macrochir Ogilby, 1910
Sebastapistes cyanostigma (Bleeker, 1856)
Sebastapistes mauritiana (Cuvier, 1829)
Sebastapistes strongia (Cuvier, 1839)
Synanceia verrucosa (Bloch and Schneider, 1801) -- nofu
Taenianotus triacanthus Lacepède, 1802

CARACANTHIDAE (CORAL CROUCHERS)
Caracanthus maculatus (Gray, 1831)
Caracanthus unipinnis (Gray, 1831)

PLATYCEPHALIDAE (FLATHEADS)
Eurycephalus otaitensis (Cuvier, 1829)
Onigocia bimaculata Knapp, Imamura and Sakashita, 2000
Onigocia pedimacula (Regan, 1908)
Rogadius pristiger (Cuvier, 1829)
Thysanophrys chiltonae (Schultz, 1966)

DACTYLOPTERIDAE (HELMET GURNARDS)
Dactyloptena orientalis (Cuvier, 1829) -- lulutahi

SERRANIDAE (GROUPERS AND ALLIES) -- ngatala
Anyperodon leucogrammicus (Valenciennes, 1828)
Aporops bilinearis Schultz, 1943
Belonoperca chabanaudi Fowler and Bean, 1930
Cephalopholis argus Bloch and Schneider, 1801 -- ngatala uri
Cephalopholis aurantia (Valenciennes, 1828)
Cephalopholis leopardus (Lacepéde, 1801)
Cephalopholis miniata (Forsskål, 1775) -- ngatala kula
Cephalopholis sexmaculata (Rüppell, 1830) -- ngatala kula
Cephalopholis sonnerati (Valenciennes, 1828) -- ngatala kula
Cephalopholis spiloparaea (Valenciennes, 1828)
Cephalopholis urodeta (Forster, 1801)
Epinephelus areolatus (Forsskål, 1775)
Epinephelus caeruleopunctatus (Bloch, 1790)
**Epinephelus chlorocephalus* (Valenciennes, 1830)
Epinephelus chlorostigma (Valenciennes, 1828)
Epinephelus cyanopodus (Richardson, 1846) -- mohu'afi
Epinephelus fasciatus (Forsskål, 1775) -- ngatala kula
Epinephelus fuscoguttatus (Forsskål, 1775)
Epinephelus hexagonatus (Forster, 1801)
Epinephelus howlandi (Günther, 1873) -- ngatala pusi
Epinephelus lanceolatus (Bloch, 1790) -- ngatala 'usi
Epinephelus maculatus (Bloch, 1790)

Epinephelus magniscuttis Postel, Fourmanoir and Guézé, 1963
Epinephelus malabaricus (Bloch and Schneider, 1801)
Epinephelus merra Bloch, 1793 -- ngatala pusi
Epinephelus miliaris (Valenciennes, 1830)
Epinephelus morrhua (Valenciennes, 1833)
Epinephelus octofasciatus Griffin, 1926 -- mohuafi
Epinephelus ongus (Bloch, 1790)
Epinephelus polyphekadion (Bleeker, 1849)
Epinephelus retouti Bleeker, 1868
Epinephelus rivulatus (Valenciennes, 1830)
Epinephelus spilotoceps Schultz, 1953
Epinephelus tauvina (Forsskål, 1775) -- ngatala popua
Gracila albomarginata (Fowler and Bean, 1930)
Grammistes sexlineatus (Thunberg, 1792) -- pe'e 'uta
Grammistops ocellata Schultz, 1953
Liopropoma susumi (Jordan and Seale, 1906)
Plectranthias longimanus (Weber, 1913)
Plectranthias nanus Randall, 1980
Plectranthias winniensis (Tyler, 1966)
Plectropomus laevis (Lacepède, 1801) -- ngatala tonokuli
Plectropomus leopardus (Lacepède, 1802) -- ngatala kula
Plectropomus pessuliferus Fowler, 1904
Pogonoperca punctata (Valenciennes, 1830)
Pseudanthias bartlettorum (Randall and Lubbock, 1981)
Pseudanthias carlsoni Randall and Pyle, 2001
Pseudanthias cooperi (Regan, 1902)
Pseudanthias dispar (Herre, 1955)
Pseudanthias fasciatus (Kamohara, 1954)
Pseudanthias flavicauda Randall and Pyle, 2001
Pseudanthias hypselosoma Bleeker, 1878
Pseudanthias lori (Lubbock and Randall, 1976)
Pseudanthias pascalus (Jordan and Tanaka, 1927)
Pseudanthias pictilis Randall and Allen, 1978
Pseudanthias pleurotaenia (Bleeker, 1857)
Pseudanthias randalli (Lubbock and Allen, 1978)
Pseudanthias squamipinnis (Peters, 1855)
Pseudanthias ventralis (Randall, 1979)
Pseudogramma polyacanthum (Bleeker, 1856)
Pseudogramma xanthum Randall, Baldwin and Williams, 2002
Saloptia powelli Smith, 1963
Serranocirrhitus latus Watanabe, 1949
Suttonia lineata Gosline, 1960
Variola albomarginata Baissac, 1952 -- ngatala 'ull
Variola louti (Forsskål, 1775) -- ngatalla kula

CIRRHITIDAE (HAWKFISHES)

Amblycirrhitus bimacula (Jenkins, 1903)

Amblycirrhitus unimacula (Kamohara, 1957)
Cirrhitichthys falco Randall, 1963
Cirrhitichthys oxycephalus (Bleeker, 1855)
**Cirrhitus albopunctatus* Schultz, 1950
Cirrhitus pinnulatus (Bloch and Schneider, 1801) – ulutuki
Cyprinocirrhites polyactis (Bleeker, 1874)
Isocirrhitus sexfasciatus (Schultz, 1960)
Neocirrhites armatus Castelnau, 1873
Oxycirrhites typus Bleeker, 1875
Paracirrhites arcatus (Cuvier, 1829)
Paracirrhites forsteri (Bloch and Schneider, 1801)
Paracirrhites hemistictus (Günther, 1874)

KUHLIIDAE (FLAGTAILS)
Kuhlia mugil (Forster, 1801)

TERAPONIDAE (TERAPONS)
Terapon jarbua (Forsskål, 1775) -- kavakava

PRIACANTHIDAE (BIG EYES) -- mata heheva
Cookeolus japonicus (Cuvier, 1829)
Heteropriacanthus cruentatus (Lacepède, 1801)
Priacanthus hamrur (Forsskål, 1775)

PSEUDOCHROMIDAE (DOTTYBACKS)
Cypho purpurascens (De Vis, 1884)
Pseudochromis cyanotaenia Bleeker, 1857
Pseudochromis jamesi Schultz, 1943
Pseudochromis porphyreus Lubbock and Goldman, 1974
Pseudochromis n. sp. (Gill, in press); this and the above will be in a new genus.
Pseudoplesiops rosae Schultz, 1943
Pseudoplesiops sp.

PLESIOPIDAE (LONGFINS)
Acanthoplesiops indicus (Day, 1888)
Calloplesiops altivelis (Steindachner, 1903)
Plesiops coeruleolineatus Rüppell, 1835
Plesiops corallicola Bleeker, 1853
Plesiops insularis Mooi and Randall, 1991
Plesiops polydactylus Mooi, 1995
Plesiops verecundus Mooi, 1996
Steeneichthys plesiopsus Allen and Randall, 1985

APOGONIDAE (CARDINALFISHES) -- matapula
Apogon angustatus Smith and Radcliffe, 1912
Apogon aureus (Lacepède, 1803)
Apogon bandanensis Bleeker, 1854
Apogon caudicinctus Randall and Smith, 1988
Apogon cavitiensis (Jordan and Seale, 1907)
Apogon cf coccineus Rüppell, 1838
Apogon cookii Macleay, 1881

Apogon crassiceps Garman, 1903
Apogon cyanosoma Bleeker, 1853
Apogon doryssa (Jordan and Seale, 1906)
Apogon exostigma Jordan and Starks, 1906
Apogon fraenatus Valenciennes, 1832
Apogon fragilis Smith, 1961
Apogon fuscus Quoy and Gaimard, 1825
Apogon guamensis Valenciennes, 1832
Apogon indicus Greenfield, 2001
Apogon kallopterus Bleeker, 1856
Apogon lateralis Valenciennes, 1832
Apogon leptacanthus Bleeker, 1856
Apogon nigrofasciatus Lachner, 1953
Apogon novemfasciatus Cuvier, 1828
Apogon neotes Allen, Kuiter and Randall, 1994
*Apogon savayensi*s Günther, 1871
Apogon semiornatus Peters, 1876
Apogon cf talboti Smith, 1961
Apogon taeniophorus Regan, 1908
Apogon taeniopterus Bennett, 1835
Apogon trimaculatus Cuvier, 1828
Apogonichthys ocellatus (Weber, 1913)
Archamia biguttata Lachner, 1951
Archamia fucata (Cantor, 1850)
Cercamia cladara Randall and Smith, 1988
Cercamia eremia Allen, 1987
Cheilodipterus artus Smith, 1961
Cheilodipterus isostigma (Schultz, 1940)
Cheilodipterus macrodon (Lacepède, 1801)
Cheilodipterus quinquelineatus Cuvier, 1828
Foa fo Jordan & Seale, 1906
Fowleria aurita (Valenciennes, 1831)
Fowleria flamma Allen, 1993
Fowleria marmorata (Alleyne and Macleay, 1877)
Fowleria vaiuli (Jordan and Seale, 1906)
Fowleria variegata (Valenciennes, 1832)
Gymnapogon philippinus (Herre, 1939)
Gymnapogon urospilotus Lachner, 1953
Gymnapogon sp.
Pseudamia amblyuroptera (Bleeker, 1856)
Pseudamia gelatinosa Smith, 1954
Pseudamiops gracilicauda (Lachner, 1953)
Rhabdamia cypselura Weber, 1909
Siphamia fistulosa (Weber, 1909)
Siphamia jebbi Allen, 1993
Siphamia tubifer (Weber, 1909)

Siphamia versicolor (Smith and Radcliffe, 1911)
Sphaeramia nematoptera (Bleeker, 1856)
Sphaeramia orbicularis (Cuvier, 1828)

MALACANTHIDAE (TILEFISHES)
Hoplolatilus cuniculus Randall and Dooley, 1974
Hoplolatilus marcosi Burgess, 1978
Hoplolatilus starcki Randall and Dooley, 1974
Malacanthus brevirostris Guichenot 1848
Malacanthus latovittatus (Lacepède, 1801)

ECHENEIDAE (REMORAS)
Echeneis naucrates Linnaeus, 1758 -- teliteli'uli
Remora remora (Linnaeus, 1758)

CARANGIDAE (JACKS)
Alectis ciliaris (Bloch, 1787) -- lupo lave
Atule mate (Cuvier, 1833) -- otule
Carangoides caeruleopinnatus (Rüppell, 1830) -- lupo
Carangoides dinema Bleeker, 1851 -- lupo
Carangoides ferdau (Forsskål, 1775) -- lupo
Carangoides fulvoguttatus (Forsskål, 1775) -- lupo
Carangoides gymnostethus (Cuvier, 1833) -- lupo
Carangoides hedlandensis (Whitley, 1933) -- lupo
Carangoides oblongus (Cuvier, 1833) -- lupo
Carangoides orthogrammus Jordan and Gilbert, 1881 -- lupo
Carangoides plagiotaenia Bleeker, 1857 -- lupo
Caranx ignobilis (Forsskål, 1775) -- 'ulua
Caranx lugubris Poey, 1860 -- lupo moana
Caranx melampygus Cuvier, 1833 -- lupo lupo, 'ulua
Caranx papuensis Alleyne and Macleay, 1877
Caranx sexfasciatus Quoy and Gaimard, 1825 -- hiku malohi
Decapterus macarellus Cuvier, 1833 -- manaui
Decapterus macrosoma Bleeker, 1851 -- manaui
Decapterus tabl Berry 1868 -- manaui
Elagatis bipinnulata (Quoy and Gaimard, 1825) -- 'utumea
Gnathanodon speciosus (Forsskål, 1775) -- filu
Megalaspis cordyla (Linnaeus, 1758)
Naucrates ductor (Linnaeus, 1758)
Scomberoides lysan (Forsskål, 1775)
Scomberoides tol (Cuvier, 1832)
Selar boops (Cuvier, 1833) -- otule
Selar crumenophthalmus (Bloch, 1793) -- otule
Seriola dumerili (Risso, 1810)
Seriola rivoliana Valenciennes, 1833
Trachinotus baillonii (Lacepède, 1801) -- hoke lau
Trachinotus blochii (Lacepède, 1801) -- hoke lau
Uraspis helvola (Forster, 1801)

CORYPHAENIDAE (DOLPHINS)
Coryphaena hippurus Linnaeus, 1758 -- mahimahi
LEIOGNATHIDAE (PONYFISHES)
Gazza minuta (Bloch, 1797)
Leiognathus fasciatus (Lacepède, 1803) -- sepesipa
Leiognathus stercorarius Evermann and Seale, 1907
BRAMIDAE (POMFRETS)
Taractichthys steindachneri Döderlein, 1883) -- tukuku moana
LUTJANIDAE (SNAPPERS)
Aphareus furca (Lacepède, 1801) -- palu lina
Aphareus rutilans Cuvier, 1830 -- palu polosi
Aprion virescens Valenciennes, 1830 -- utu
Etelis carbunculus Cuvier, 1828 -- palu tavake
Etelis coruscans Valenciennes, 1862 -- palu tavake
Etelis radiosus Anderson, 1981
Lutjanus argentimaculatus (Forsskål, 1775) -- fate kula
Lutjanus biguttatus Valenciennes, 1830
Lutjanus boutton (Lacepède, 1802)
Lutjanus bohar (Forsskål, 1775) -- fangamea
Lutjanus fulviflamma (Forsskål, 1775) -- fate ila
Lutjanus fulvus (Bloch and Schneider, 1801) -- fate
Lutjanus gibbus (Forsskål, 1775) -- koango kula
Lutjanus kasmira (Forsskål, 1775) -- havane
Lutjanus lutjanus Bloch, 1790
Lutjanus malabaricus (Bloch and Schneider, 1801)
Lutjanus monostigma (Cuvier, 1828) -- tanga'u
Lutjanus quinquelineatus (Bloch, 1790)
Lutjanus rivulatus (Cuvier, 1828) -- hoputu
Lutjanus rufolineatus (Valenciennes, 1830) -- aeava
Lutjanus russelli (Bleeker, 1849)
Lutjanus semicinctus Quoy and Gaimard, 1824
Lutjanus timorensis (Quoy and Gaimard, 1824)
Macolor macularis Fowler, 1931
Macolor niger (Forsskål, 1775)
Paracaesio kusakarii Abe, 1960 -- palu mutu
Paracaesio sordida Abe and Shinohara, 1962
Paracaesio xanthura (Bleeker, 1869)
Pristipomoides argyrogrammicus (Valenciennes, 1831) -- palu
Pristipomoides auricilla (Jordan, Evermann and Tanaka, 1927) -- palu
Pristipomoides filamentosus (Valenciennes, 1830) -- palu
Pristipomoides flavipinnis Shinohara, 1963 -- palu
Pristipomoides multidens (Day, 1870) -- palu
Pristipomoides sieboldii (Bleeker, 1857) -- palu
Pristipomoides zonatus (Valenciennes, 1830) -- enge
Randallichthys filamentosus (Fourmanoir, 1970)
Symphorichthys spilurus (Günther, 1874)

CAESIONIDAE (FUSILIERS) -- huli
Caesio caerulaurea Lacepède, 1801
Caesio teres Seale, 1906
Pterocaesio digramma (Bleeker, 1865)
Pterocaesio marri Schultz, 1953
Pterocaesio tile (Cuvier, 1830)
Pterocaesio trilineata Carpenter, 1987
HAEMULIDAE (GRUNTS) -- fotu'a
Plectorhinchus albovittatus (Rüppell, 1838)
Plectorhinchus chaetodonoides (Lacepède, 1801)
Plectorhinchus picus (Cuvier, 1830)
LETHRINIDAE (EMPERORS)
Gnathodentex aureolineatus (Lacepède, 1802) -- tu'u mau
Gymnocranius euanus Günther, 1879 -- mu
Gymnocranius grandoculis (Valenciennes, 1830) -- mu
Gymnocranius sp.
Lethrinus atkinsoni Seale, 1909 -- hoputu
Lethrinus erythracanthus Valenciennes, 1830 -- manga
Lethrinus harak (Forsskål, 1775) -- tanutanu
Lethrinus lentjan (Lacepède, 1802) -- hoputu
Lethrinus nebulosus (Forsskål, 1775)-- koango
Lethrinus obsoletus (Forsskål, 1775) -- tanutanu
Lethrinus olivaceus Valenciennes, 1830 --ngutukau
Lethrinus rubrioperculatus Sato, 1978
Lethrinus variegatus Valenciennes, 1830 -- ngungutoa
Lethrinus xanthochilus Klunzinger, 1870 -- tokonifusi
Monotaxis grandoculis (Forsskål, 1775) -- mu
Wattsia mossambica (Smith, 1957)
NEMIPTERIDAE (BREAMS)`1
Pentapodus aureofasciatus Russell, 2001
Pentapodus caninus (Cuvier, 1830)
Scolopsis bilineatus (Bloch, 1793)
Scolopsis trilineatus Kner, 1868
GERREIDAE (MOJARRAS) -- matu
Gerres longirostris Lacepède, 1801
Gerres oblongus Cuvier, 1830
Gerres oyena (Forsskål, 1775)
POLYNEMIDAE (THREADFINS) -- kuru
Polydactylus plebeius (Broussonet, 1782)
Polydactylus sexfilis Valenciennes, 1831
MULLIDAE (GOATFISHES) -- vete
Mulloidichthys flavolineatus (Lacepède, 1801) -- vete
Mulloidichthys pfluegeri (Steindachner, 1900)
Mulloidichthys vanicolensis (Valenciennes, 1831) -- vete
Parupeneus barberinoides (Bleeker, 1852)

Parupeneus barberinus (Lacepède, 1801) -- hulifusi
Parupeneus ciliatus (Lacepède, 1801)
Parupeneus crassilabris (Valenciennes, 1831)
Parupeneus cyclostomus (Lacepède, 1801) -- memea
Parupeneus heptacanthus (Lacepède, 1801)
Parupeneus indicus (Shaw, 1803)
Parupeneus multifasciatus (Quoy and Gaimard, 1825) -- tukule'ia
Parupeneus pleurostigma (Bennett, 1831) -- malu
Parupeneus spilurus (Bleeker, 1854)
Upeneus vittatus (Forsskål, 1775) -- hiku manumanu
**Upeneus* sp.

PEMPHERIDAE (SWEEPERS)
Parapriacanthus sp.
Pempheris oualensis Cuvier, 1830 -- matapulu
Pempheris schwenkii Bleeker, 1855

KYPHOSIDAE (SEA CHUBS) -- nue
Kyphosus sp. A new species being described by Sakai and Nakabo.
Kyphosus cinerascens (Forsskål, 1775)
Kyphosus vaigiensis (Quoy and Gaimard, 1825)

CHAETODONTIDAE (BUTTERFLYFISHES) -- sifisifi
Chaetodon auriga Forsskål, 1775
Chaetodon baronessa Cuvier, 1829
Chaetodon bennetti Cuvier, 1831
Chaetodon burgessi Allen and Starck, 1973
Chaetodon citrinellus Cuvier, 1831
Chaetodon ephippium Cuvier, 1831
Chaetodon flavirostris Günther, 1873
Chaetodon guentheri Ahl, 1923
Chaetodon kleinii Bloch, 1790
Chaetodon lineolatus Cuvier, 1831
Chaetodon lunula (Lacepède, 1802)
Chaetodon lunulatus Quoy and Gaimard, 1825
Chaetodon melannotus Bloch and Schneider, 1801
Chaetodon mertensii Cuvier, 1831
Chaetodon meyeri Bloch and Schneider, 1801
Chaetodon ornatissimus Cuvier, 1831
Chaetodon pelewensis Kner, 1868
Chaetodon plebeius Cuvier, 1831
Chaetodon quadrimaculatus Gray, 1831
Chaetodon rafflesi Bennett, 1830
Chaetodon reticulatus Cuvier, 1831
Chaetodon semeion Bleeker, 1855
Chaetodon speculum Cuvier, 1831
Chaetodon trifascialis Quoy and Gaimard, 1825
Chaetodon ulietensis Cuvier, 1831
Chaetodon unimaculatus Bloch, 1787

Chaetodon vagabundus Linnaeus, 1758
Coradion chrysozonus (Cuvier, 1831)
Forcipiger flavissimus Jordan and McGregor, 1898
*Forcipiger longirostris (*Broussonet, 1782) -- sifisifi ihu
Hemitaurichthys polylepis (Bleeker, 1857)
Heniochus acuminatus (Linnaeus, 1758)
Heniochus chrysostomus Cuvier, 1831
Heniochus monoceros Cuvier, 1831
Heniochus singularis Smith and Radcliffe, 1911
Heniochus varius Cuvier, 1829

POMACANTHIDAE (ANGELFISHES) – tukutuku
Apolemichthys trimaculatus (Cuvier, 1831)
Centropyge bicolor (Bloch, 1787)
Centropyge bispinosa (Günther, 1860)
Centropyge flavicauda Fraser-Brunner, 1933
Centropyge flavissima (Cuvier, 1831)
Centropyge heraldi Woods, 1953
Centropyge loricula (Günther, 1874)
Centropyge multicolor Randall and Wass, 1974
Centropyge multifasciata (Smith and Radcliffe, 1911)
Centropyge nox (Bleeker, 1853)
Centropyge tibicen (Cuvier, 1831)
Centropyge vrolikii Bleeker, 1853
Genicanthus bellus Randall, 1975
Genicanthus melanospilos (Bleeker, 1857)
Genicanthus watanabei (Yasuda and Tominaga, 1970)
Pomacanthus imperator (Bloch, 1787)
Pomacanthus semicirculatus (Cuvier, 1831)
Pygoplites diacanthus (Boddaert, 1772)

OPISTOGNATHIDAE (JAWFISHES)
Opistognathus sp.

POMACENTRIDAE (DAMSELFISHES)
Abudefduf septemfasciatus (Cuvier, 1830) -- mutumutu
Abudefduf sexfasciatus (Lacepède, 1801)
Abudefduf sordidus (Forsskål, 1775) -- mutumutu
Abudefduf vaigiensis (Quoy and Gaimard, 1825) -- mamo
Amblyglyphidodon aureus (Cuvier, 1830)
Amblyglyphidodon curacao (Bloch, 1787)
**Amblyglyphidodon melanopterus* Randall and Allen, 2002
Amblyglyphidodon orbicularis (Hombron and Jacquinot, 1853)
Amphiprion akindynos Allen, 1972
Amphiprion chrysopterus Cuvier, 1830 -- umana
Amphiprion clarkii (Bennett, 1830) -- umana
Amphiprion melanopus Bleeker, 1852 -- umana
Amphiprion perideraion Bleeker, 1855 -- umana

Chromis acares Randall and Swerdloff, 1973
Chromis agilis Smith, 1960
Chromis analis (Cuvier, 1830)
Chromis alpha Randall, 1988
Chromis amboinensis (Bleeker, 1873)
Chromis atripectoralis Welander and Schultz, 1951
Chromis atripes Fowler and Bean, 1928
Chromis bami Randall and McCosker, 1992
Chromis chrysura Bliss, 1883
Chromis delta Randall, 1988
Chromis elerae Fowler and Bean, 1828
Chromis flavomaculata Kamohara, 1960
Chromis iomelas Jordan and Seale, 1906
Chromis lepidolepis Bleeker, 1877
Chromis margaritifer Fowler, 1946
Chromis retrofasciata Weber, 1913
Chromis ternatensis (Bleeker, 1856)
Chromis vanderbilti (Fowler, 1941)
Chromis viridis (Cuvier, 1830)
Chromis weberi Fowler and Bean, 1928
Chromis xanthura (Bleeker, 1854)
Chrysiptera biocellatus (Quoy and Gaimard, 1825)
Chrysiptera brownriggii (Bennett, 1828)
*Chrysiptera glauc*a (Cuvier, 1830)
Chrysiptera rollandi (Whitley, 1961)
Chrysiptera starcki (Allen, 1973)
Chrysiptera talboti (Allen, 1975)
Chrysiptera taupou (Jordan and Seale, 1906)
Chrysiptera traceyi (Woods and Schultz, 1960)
Chrysiptera tricincta (Allen and Randall, 1974)
Chrysiptera unimaculata (Cuvier, 1830)
Dascyllus aruanus (Linnaeus, 1758)
Dascyllus melanurus Bleeker, 1854
Dascyllus reticulatus (Richardson, 1846)
Dascyllus trimaculatus (Rüppell, 1829)
Lepidozygus tapeinosoma (Bleeker, 1856)
Neoglyphidodon carlsoni (Allen, 1975)
Neopomacentrus metallicus (Jordan and Seale, 1906)
Plectroglyphidodon dickii (Liénard, 1839)
Plectroglyphidodon imparipennis (Vaillant and Sauvage, 1875)
Plectroglyphidodon johnstonianus Fowler and Ball, 1924
Plectroglyphidodon lacrymatus (Quoy and Gaimard, 1824)
Plectroglyphidodon leucozona (Bleeker, 1859)
Plectroglyphidodon phoenixensis (Schultz, 1943)
Pomacentrus sp. Allen, pers. comm.
Pomacentrus adelus Allen, 1991

Pomacentrus amboinensis Bleeker, 1868
Pomacentrus bankanensis Bleeker, 1853
Pomacentrus brachialis Cuvier, 1830
Pomacentrus callainus Randall, 2002
Pomacentrus coelestis Jordan and Starks, 1901
Pomacentrus imitator (Whitley, 1964)
Pomacentrus moluccensis Bleeker, 1853
Pomacentrus pavo (Bloch, 1787)
Pomacentrus philippinus Evermann and Seale, 1907
Pomacentrus spilotoceps Randall, 2002
Pomacentrus vaiuli Jordan and Seale, 1906
Pomacentrus cf wardi Whitley, 1927
*Pomachromis richardsoni (*Snyder, 1909)
Stegastes albifasciatus Schlegel and Müller, 1839
Stegastes fasciolatus (Ogilby, 1889)
Stegastes lividus (Forster, 1801)
Stegastes nigricans (Lacepède, 1802)

LABRIDAE (WRASSES) -- meai
Anampses caeruleopunctatus Rüppell, 1829
Anampses geographicus Valenciennes, 1840
Anampses melanurus Bleeker, 1857
Anampses meleagrides Valenciennes, 1840
Anampses neoguinaicus Bleeker, 1878
Anampses twistii Bleeker, 1856
Bodianus sp. Gomon, MS submitted
Bodianus anthioides (Bennett, 1832)
Bodianus axillaris (Bennett, 1832)
Bodianus loxozonus (Snyder, 1908)
Bodianus mesothorax (Bloch and Schneider, 1801)
Bodianus perditio (Quoy and Gaimard, 1834) -- meai tangasila
Cheilinus chlorourus (Bloch, 1791)
Cheilinus fasciatus (Bloch, 1791)
Cheilinus oxycephalus Bleeker, 1853
Cheilinus trilobatus Lacepède, 1801-- lalafi
Cheilinus undulatus Rüppell, 1835 -- tangafa
Cheilio inermis (Forsskål, 1775) -- meai loloa
Choerodon anchorago (Bloch, 1791)
Choerodon jordani (Snyder, 1908)
**Cirrhilabrus* n. sp. Photographed by L. Sharron.
Cirrhilabrus exquisitus Smith, 1957
Cirrhilabrus punctatus Randall and Kuiter, 1989
Cirrhilabrus rubrimarginatus Randall, 1992
Cirrhilabrus scottorum Randall and Pyle, 1989
Coris aygula Lacepède, 1801
Coris batuensis (Bleeker, 1856)

Coris dorsomacula Fowler, 1908
Coris gaimard (Quoy and Gaimard, 1824)
Cymolutes praetextatus (Quoy and Gaimard, 1834)
Epibulus insidiator (Pallas, 1770)
Gomphosus varius Lacepède, 1801
Halichoeres argus (Bloch and Schneider, 1801)
Halichoeres biocellatus Schultz, 1960
Halichoeres chrysus Randall, 1981
Halichoeres hortulanus (Lacepède, 1801)
Halichoeres margaritaceus (Valenciennes, 1839)
Halichoeres marginatus Rüppell, 1835
Halichoeres melanurus (Bleeker, 1851)
Halichoeres melasmapomus Randall, 1981
Halichoeres ornatissimus (Garrett, 1863)
Halichoeres prosopeion (Bleeker, 1853)
Halichoeres trimaculatus (Quoy and Gaimard, 1834)
Hemigymnus fasciatus (Bloch, 1792)
Hemigymnus melapterus (Bloch, 1791)
Hologymnosus annulatus (Lacepède, 1801)
Hologymnosus doliatus (Lacepède, 1801)
Iniistius pavo (Valenciennes, 1840)
Labrichthys unilineatus (Guichenot, 1847)
Labroides bicolor Fowler & Bean, 1928
Labroides dimidiatus (Valenciennes, 1839)
Labroides pectoralis Randall and Springer, 1975
Labroides rubrolabiatus Randall, 1958
Labropsis australis Randall, 1981
Labropsis xanthonota Randall, 1981
Macropharyngodon kuiteri Randall, 1978
Macropharyngodon meleagris (Valenciennes, 1839)
Macropharyngodon negrosensis Herre, 1932
Novaculichthys macrolepidotus (Bloch, 1791)
Novaculichthys taeniourus (Lacepède, 1801)
Oxycheilinus arenatus (Valenciennes, 1840)
Oxycheilinus bimaculatus (Valenciennes, 1840)
Oxycheilinus celebicus (Bleeker, 1853)
Oxycheilinus digrammus (Lacepède, 1801) -- lalafi
Oxycheilinus spp. Randall, Westneat and Gomon, MS submitted
Oxycheilinus unifasciatus (Streets, 1877)
Paracheilinus carpenteri Randall and Lubbock, 1981
Pseudocheilinus evanidus Jordan and Evermann, 1903
Pseudocheilinus hexataenia (Bleeker, 1857)
Pseudocheilinus octotaenia Jenkins, 1901
Pseudocheilinus tetrataenia Schultz, 1960
Pseudocoris yamashiroi (Schmidt, 1931)
Pseudodax moluccanus (Valenciennes, 1839)

Pseudojuloides cerasinus (Snyder, 1904)
Pseudojuloides mesostigma Randall and Randall, 1981
Pteragogus cryptus Randall, 1981
Pteragogus enneacanthus (Bleeker, 1853)
Stethojulis bandanensis (Bleeker, 1851)
Stethojulis notialis Randall, 2000
Stethojulis strigiventer (Bennett, 1832)
Thalassoma amblycephalum (Bleeker, 1856)
Thalassoma hardwicke (Bennett, 1828)
Thalassoma lunare (Linnaeus, 1758)
Thalassoma lutescens (Lay and Bennett, 1839)
Thalassoma purpureum (Forsskål, 1775)
Thalassoma quinquevittatum (Lay and Bennett, 1839)
Thalassoma trilobatum (Lacepède, 1801)
Thalassoma sp. Randall, MS (formerly *T. jansenii*)
Wetmorella albofasciata Schultz and Marshall, 1954.
Wetmorella nigropinnata (Seale, 1901)

SCARIDAE (PARROTFISHES) -- hohomo

Bolbometopon muricatum (Valenciennes, 1840) -- menenga kalia
Calotomus carolinus (Valenciennes, 1840) -- holoholoveka
Calotomus spinidens (Quoy and Gaimard, 1824)
Cetoscarus bicolor (Rüppell, 1829) -- hololoelse loveka
Chlorurus bleekeri (de Beaufort, 1940)
Chlorurus frontalis (Valenciennes, 1840) - halakamu
Chlorurus japanensis (Bloch, 1789)
Chlorurus microrhinos (Bleeker, 1854) -- sitatoki
Chlorurus sordidus (Forsskål, 1775) - pose
Hipposcarus longiceps (Valenciennes, 1840)
Leptoscarus vaigiensis (Quoy and Gaimard, 1824)
Scarus altipinnis (Steindachner, 1879)
Scarus chameleon Choat and Randall, 1986
Scarus dimidiatus Bleeker, 1859
Scarus flavipectoralis Schultz, 1958
Scarus forsteni (Bleeker, 1861)
Scarus frenatus Lacepède, 1802
Scarus ghobban Forsskål, 1775
Scarus globiceps Valenciennes, 1840
Scarus longipinnis Randall and Choat, 1980
Scarus niger Forsskål, 1775
Scarus oviceps Valenciennes, 1840
Scarus psittacus Forsskål, 1775
Scarus rivulatus Valenciennes, 1840
Scarus rubroviolaceus Bleeker, 1847
Scarus schlegeli (Bleeker, 1861)
Scarus spinus (Kner, 1868)

Scarus tricolor Bleeker, 1847

PINGUIPEDIDAE (SAND PERCHES) -- loulile

Parapercis australis Randall, 2002
Parapercis clathrata Ogilby, 1911
Parapercis hexophtalma (Cuvier, 1829)
Parapercis millepunctata (Günther, 1860)
Parapercis schauinslandi (Steindachner, 1900)
Parapercis n. sp. Randall, in press

CREEDIIDAE (SANDBURROWERS)

Chalixodytes chameleontoculis Smith, 1957
Limnichthys fasciatus Waite, 1904
Limnichthys nitidus Smith, 1958

URANOSCOPIDAE (STARGAZERS)

Genyagnus monopterygius (Bloch and Schneider, 1801)
Uranoscopus sulphureus Valenciennes, 1832

TRIPTERYGIIDAE (TRIPLEFINS)

Ceratobregma helenae Holleman, 1987
Enneapterygius atrogulare (Günther, 1973)
Enneapterygius elegans (Peters, 1877)
Enneapterygius flavoccipitis Shen and Wu, 1994
Enneapterygius hemimelas (Kner and Steindachner, 1867)
Enneapterygius nanus (Schultz, 1960)
Enneapterygius nigricauda Fricke, 1997
Enneapterygius philippinus (Peters, 1869)
Enneapterygius pyranis Fricke, 1994
Enneapterygius rhabdotus Fricke, 1997
Enneapterygius rufopileus (Waite, 1904)
Enneapterygius signicauda Fricke, 1997
Enneapterygius triserialis Fricke, 1997
Enneapterygius tutuilae Jordan and Seale, 1906
Enneapterygius williamsi Fricke, 1997
Helcogramma capidatum Rosenblatt, 1960
Helcogramma chica Rosenblatt, 1960
Helcogramma sp. 1 Williams, MS
Helcogramma sp. 2 Williams, MS
Norfolkia brachylepis Schultz, 1960
Norfolkia thomasi Whitley, 1964
Springerichthys kulbickii Fricke and Randall, 1994
Ucla xenogrammus Holleman, 1993

BLENNIIDAE (BLENNIES) -- lokua

Alticus sertatus (Garman, 1903)
Alticus sp. Williams, MS
Aspidontus dussumieri (Valenciennes, 1836)
Aspidontus taeniatus Quoy and Gaimard, 1834
Atrosalarias fuscus holomelas (Günther, 1872))
Blenniella caudolineata (Günther, 1877)

Blenniella chrysospilos (Bleeker, 1857)
Blenniella paula (Bryan and Herre, 1903)
Cirripectes alboapicalis (Ogilby, 1899)
Cirripectes castaneus (Valenciennes, 1836)
Cirripectes chelomatus Williams and Maugé, 1983
Cirripectes fuscoguttatus Strasburg and Schultz, 1953
Cirripectes polyzona (Bleeker, 1868)
Cirripectes quagga (Fowler and Ball, 1924)
Cirripectes stigmaticus Strasburg and Schultz, 1953
Cirripectes variolosus (Valenciennes, 1836)
Cirrisalarias bunares Springer, 1976
Crossosalarias macrospilus Smith-Vaniz and Springer, 1971
Ecsenius bicolor (Day, 1888)
Ecsenius fourmanoiri Springer, 1972
Ecsenius midas Starck, 1969
Ecsenius portenoyi Springer, 1988
Enchelyurus ater (Günther, 1877)
Enchelyurus kraussi (Klunzinger, 1871)
Entomacrodus caudofasciatus (Regan, 1909)
Entomacrodus cymatobiotus Schultz and Chapman, 1960
Entomacrodus decussatus (Bleeker, 1858)
Entomacrodus epalzeocheilos (Bleeker, 1859)
Entomacrodus niuafoouensis (Fowler, 1932)
Entomacrodus sealei Bryan and Herre, 1903
Entomacrodus striatus (Quoy and Gaimard, 1836)
Entomacrodus thalassinus (Jordan and Seale, 1906)
Exallias brevis Kner, 1868
Glyptoparus delicatulus Smith, 1959
Istiblennius bellus (Günther, 1861)
Istiblennius edentulus (Forster, 1801)
Istiblennius lineatus (Valenciennes, 1836)
Meiacanthus bundoon Smith-Vaniz, 1976
**Meiacanthus procne* Smith-Vaniz, 1976
Meiacanthus ditrema Smith-Vaniz, 1976
**Meiacanthus tongaensis* Smith-Vaniz, 1987
Nannosalarias nativitatus (Regan, 1909)
Omobranchus obliquus (Garman, 1903)
Petroscirtes mitratus Rüppell, 1830
Plagiotremus laudandus flavus (Smith-Vaniz, 1976)
Plagiotremus rhinorhynchos (Bleeker, 1852)
Plagiotremus tapeinosoma (Bleeker, 1857)
Praealticus caesius (Seale, 1906)
**Praealticus multistriatus* Bath, 1992
Rhabdoblennius ellipes (Jordan and Starks, 1906)
Rhabdoblennius snowi (Fowler, 1928)

Salarias fasciatus (Bloch, 1786)
**Salarias nigrocinctus* Bath, 1996
Salarias sinuosus Snyder, 1908
Stanulus seychellensis Springer, 1968
Stanulus talboti Springer, 1968

GOBIESOCIDAE (CLINGFISHES)

Diademichthys lineatus (Sauvage, 1883)
Lepadichthys minor Briggs, 1955
Pherallodus indicus (Weber, 1913)
Gobiesocidae, n. g & n. sp. A Hutchins
Gobiesocidae, n. g & n. sp. B Hutchins
Gobiesocidae, n. g & n. sp. C Hutchins

CALLIONYMIDAE (DRAGONETS)

Callionymus simplicicornis Valenciennes, 1837
Diplogrammus goramensis (Bleeker, 1858)
Synchiropus corallinus (Gilbert, 1905)
Synchiropus laddi Schultz, 1960
Synchiropus morrisoni Schultz, 1960
Synchiropus ocellatus (Pallas, 1770)

GOBIIDAE (GOBIES) -- lokua

Amblyeleotris fasciata (Playfair, 1867)
Amblyeleotris guttata (Fowler, 1938)
Amblyeleotris periophthalma (Bleeker, 1853)
Amblyeleotris steinitzi (Klausewitz, 1974)
Amblygobius nocturnus (Herre, 1945)
Amblygobius phalaena (Valenciennes, 1837)
Asterropteryx ensiferus (Bleeker, 1874)
Asterropteryx semipunctatus Rüppell, 1830
Asterropteryx spinosus (Goren, 1981)
Bathygobius cocosensis (Bleeker, 1854)
Bathygobius cotticeps (Steindachner, 1880)
Bathygobius fuscus (Rüppell, 1830)
Bryaninops natans Larson, 1985
Bryaninops ridens Smith, 1959
Bryaninops yongei (Davis and Cohen, 1969)
Cabillus lacertops Smith, 1959
Cabillus tongarevae (Fowler, 1927)
Callogobius hasseltii (Bleeker, 1851)
Callogobius maculipinnis (Fowler, 1918)
Callogobius plumatus (Smith, 1959)
Callogobius sclateri (Steindachner, 1880)
Callogobius sp.
Cryptocentrus leptocephalus Bleeker, 1878
Cryptocentrus leucostictus (Günther, 1871)
Cryptocentrus strigilliceps (Jordan and Seale, 1906)
Ctenogobiops aurocingulus (Herre, 1935)

Ctenogobiops tangaroai Lubbock and Polunin, 1977
**Ctenogobiops sp.* Randall, Chen and Shao, MS submitted
Discordipinna griessingeri Hoese and Fourmanoir, 1978
Eviota afelei Jordan and Seale, 1906
Eviota cometa Jewett and Lachner, 1983
Eviota distigma Jordan and Seale, 1906
Eviota disrupta Karnella and Lachner, 1981
Eviota fasciola Karnella and Lachner, 1981
Eviota herrei Jordan and Seale, 1906
Eviota infulata Jordan and Seale, 1906
Eviota irrasa Karnella and Lachner, 1981
Eviota lacrimae Sunobe, 1988
Eviota latifasciata Jewett and Lachner, 1983
Eviota melasma Lachner & Karnella, 1980
Eviota monostigma Fourmanoir, 1971
Eviota nebulosa Smith, 1958
Eviota nigriventris Giltay, 1933
Eviota pellucida Larson, 1976
Eviota prasina (Klunzinger, 1871)
Eviota prasites Jordan & Seale, 1906
Eviota pseudostigma Lachner and Karnella, 1980
Eviota punctulata Jewett and Lachner, 1983
Eviota queenslandica Whitley, 1932
Eviota saipanensis Fowler, 1945
Eviota sebreei Jordan and Seale, 1906
Eviota sigillata Jewett and Lachner, 1983
Eviota smaragdus Jordan and Seale, 1906
Eviota sparsa Jewett and Lachner, 1983
Eviota zebrina Lachner and Karnella, 1980
Eviota zonura Jordan and Seale, 1906
Eviota sp.
Exyrius belissimus (Smith, 1959)
Favonigobius sp.
Feia nympha Smith, 1959
Fusigobius duospilus Hoese and Reader, 1985
Fusigobius inframaculatus (Randall, 1994)
Fusigobius neophytus (Günther, 1877)
Fusigobius signipinnis Hoese and Obika, 1988
Gnatholepis anjerensis (Bleeker, 1851)
Gnathlepis cauerensis (Bleeker, 1853)
Gobiodon brochus Harold and Winterbottom, 1999
Gobiodon citrinus (Rüppell, 1838)
Gobiodon histrio Valenciennes, 1837
Gobiodon quinquestrigatus (Valenciennes, 1837)
Gobiopsis spp.

Istigobius decoratus (Herre, 1927)
Istigobius goldmanni (Bleeker, 1852)
Istigobius ornatus (Rüppell, 1830)
Istigobius rigilius (Herre, 1953)
Kelloggella cardinalis Jordan and Seale, 1906
Kelloggella oligolepis (Jenkins, 1903)
Koumansetta rainfordi Whitley, 1940
Luposicya lupus Smith, 1959
Macrodontogobius wilburi Herre, 1936
Mugiligobius notospilus (Günther, 1877)
Paragobiodon echinocephalus (Rüppell, 1830)
Periophthalmus kalolo Lesson, 1831
Pleurosicya coerulea Larson, 1990
Pleurosicya fringilla Larson, 1990
Pleurosicya micheli Fourmanoir, 1971
Pleurosicya mossambica Smith, 1959
Pleurosicya muscarum (Jordan and Seale, 1906)
Pleurosicya plicata Larson, 1990
Priolepis cincta (Regan, 1908)
Priolepis compita Winterbottom, 1985
Priolepis fallacincta Winterbottom and Burridge, 1992
Priolepis kappa Winterbottom and Burridge, 1993
Priolepis semidoliata (Valenciennes, 1837)
Priolepis triops Winterbottom and Burridge, 1993
**Silhouettea* n. sp.
Sueviota aprica Winterbottom and Hoese, 1988
Sueviota sp.
Trimma anaima Winterbottom, 2000
Trimma benjamini Winterbottom, 1996
Trimma caesiura Jordan and Seale, 1906
Trimma emeryi Winterbottom, 1985
Trimma macrophthalma (Tomiyama, 1931)
Trimma okinawae (Aoyagi, 1949)
Trimma tevegae Cohen and Davis, 1969
Trimma unisquamis Gosline, 1959
Trimma spp.
Trimmatom eviotops (Schultz, 1943)
Trimmaton nanus Winterbottom and Emery, 1981
Valenciennea decora Hoese and Larson, 1994
Valenciennea immaculata (Ni, 1981)
Valenciennea longipinnis Lay and Bennett, 1839
Valenciennea puellaris (Tomiyama, 1956)
Valenciennea sexguttata (Valenciennes, 1837)
Valenciennea strigata (Broussonet, 1782)
Vanderhorstia ambanoro (Fourmanoir, 1957)
Vanderhorstia ornatissima Smith, 1959

Yongeichthys criniger (Valenciennes, 1837)
ELEOTRIDAE (SLEEPERS)
Calumia godeffroyi (Günther, 1877)
Eleotris fusca (Bloch and Schneider, 1801)
Eleotris melanosoma Bleeker, 1852
XENISTHMIDAE (WRIGGLERS)
Rotuma lewisi Springer, 1988
Xenisthmus polyzonatus (Klunzinger, 1871)
Xenisthmus sp.
KRAEMERIIDAE (SAND DARTS)
Kraemeria samoensis Steindachner, 1906
Kraemeria tongaensis Rofen, 1958
MICRODESMIDAE (WORMFISHES)
Gunnellichthys sp.
PTERELEOTRIDAE (DARTFISHES)
Nemateleotris decora Randall and Allen, 1973
Nemateleotris helfrichi Randall and Allen, 1973
Nemateleotris magnifica Fowler, 1938
Parioglossus raoi (Herre, 1939)
Ptereleotris evides (Jordan and Hubbs, 1925)
Ptereleotris hanae (Jordan and Snyder, 1901)
Ptereleotris heteroptera (Bleeker, 1855)
Ptereleotris microlepis (Bleeker, 1856)
Ptereleotris zebra (Fowler, 1938)
EPHIPPIDAE (SPADEFISHES)
Platax orbicularis (Forsskål, 1775) -- sifisifi
SCATOPHAGIDAE (SCATS)
Scatophagus argus (Bloch, 1788)
ZANCLIDAE (MOORISH IDOL FAMILY)
Zanclus cornutus (Linnaeus, 1758) -- sifisifi pulepule
ACANTHURIDAE (SURGEONFISHES)
Acanthurus achilles Shaw, 1803 -- palangi
Acanthurus albipectoralis Allen and Ayling, 1987
Acanthurus blochii Valenciennes, 1835 -- pone
Acanthurus dussumieri Valenciennes, 1835
Acanthurus guttatus Forster, 1801 -- hapi
Acanthurus lineatus (Linnaeus, 1758) -- pone tuhi
Acanthurus mata (Cuvier, 1829) -- pone
Acanthurus nigricans (Linnaeus, 1758) -- palangi
Acanthurus nigricauda Duncker and Mohr, 1929 -- pone
Acanthurus nigrofuscus (Forsskål, 1775) -- pone
Acanthurus nigroris Valenciennes, 1835
Acanthurus olivaceus Forster, 1801 -- pone
Acanthurus pyroferus Kittlitz, 1834 -- pone
Acanthurus thompsoni (Fowler, 1923)

Ctenochaetus tominiensis Randall, 1955
Acanthurus triostegus (Linnaeus, 1758) -- manini
Acanthurus xanthopterus Valenciennes, 1835 -- palangi
Ctenochaetus binotatus Randall, 1955
Ctenochaetus cyanocheilus Randall and Clements, 2001 -- pone
Ctenochaetus hawaiiensis Randall, 1955
Ctenochaetus striatus (Quoy and Gaimard, 1825) -- pone uli
Naso annulatus (Quoy and Gaimard, 1825)
Naso brachycentron (Quoy and Gaimard, 1825)
Naso brevirostris (Valenciennes, 1835)
Naso caesius Randall and Bell, 1992
Naso hexacanthus (Bleeker, 1855)
Naso lituratus (Forster, 1801) -- ume lei
Naso lopezi Herre, 1927
Naso thynnoides (Valenciennes, 1835)
Naso tonganus (Valenciennes, 1835)
Naso unicornis (Forsskål, 1775) -- ume ta
Naso vlamingii (Valenciennes, 1835)
Paracanthurus hepatus (Linnaeus, 1766)
Zebrasoma scopas (Cuvier, 1829)
Zebrasoma veliferum (Bloch, 1797) -- kilififisi

SIGANIDAE (RABBITFISHES) --pokomei
Siganus argenteus (Quoy and Gaimard, 1825) -- ma'ava
Siganus doliatus Cuvier, 1930
Siganus niger Woodland, 1990
Siganus puellus (Schlegel, 1852)
Siganus punctatus (Forster, 1801) -- pongongo
Siganus spinus (Linnaeus, 1758)
Siganus vulpinus (Schlegel and Müller, 1845)

SPHYRAENIDAE (BARRACUDAS)
Sphyraena barracuda (Walbaum, 1792) -- ono
Sphyraena flavicauda Rüppell, 1838 -- ono momoto
Sphyraena forsteri Cuvier, 1829 -- ono mototo
Sphyraena jello Cuvier, 1829 -- hapatu
Sphyraena qenie Klunzinger, 1870 -- hapatu

SCOMBRIDAE (TUNAS AND MACKERELS)
Acanthocybium solandri (Cuvier, 1831) -- valu louniu
Auxis thazard (Lacepède, 1800)
Euthynnus affinis (Cantor, 1849) -- kavakava
Grammatorcynus bilineatus (Rüppell, 1836)
Gymnosarda unicolor (Rüppell, 1836) -- valu tonga
Katsuwonus pelamis (Linnaeus, 1758) -- atu
Rastrelliger kanagurta (Cuvier, 1816) -- nga'a
Scomberomorus commerson (Lacepède, 1800)
Thunnus alalunga (Bonnaterre, 1788) -- takuo
Thunnus albacares (Bonnaterre, 1788) -- kahikahi

Thunnus obesus (Lowe, 1839)
GEMPYLIDAE (SNAKE MACKERELS)
Diplospinus multistriatus Maul, 1948
Gempylus serpens Cuvier, 1829
Lepidocybium flavobrunneum (Smith, 1843) -- valu puaka
Nealotus tripes Johnson, 1865
Nesiarchus nasutus Johnson, 1862
Thyrsitoides marleyi Fowler, 1929
Tongaichthys robustus Nakamura and Fujii, 1983
Promethichthys prometheus (Cuvier, 1832) -- lou lau moana
Ruvettus pretiosus Cocco, 1829 -- valu maka
TRICHIURIDAE (CUTLASSFISHES)
Trichiurus lepturus Linnaeus, 1758 -- loulau
ISTIOPHORIDAE (BILLFISHES) -- hakula
Istiophorus platypterus (Shaw and Nodder, 1792) -- hakula la
Makaira indica (Cuvier, 1832)
Makaira mazara (Jordan and Snyder, 1909)
Tetrapterus angustirostris Tanaka, 1915
Tetrapterus audax Philippi, 1887
XIPHIIDAE (SWORDFISH FAMILY)
Xiphias gladius Linnaeus, 1758 -- hakula puaka
BOTHIDAE (LEFTEYE FLOUNDERS) -- ali
Asterorhombus intermedius (Bleeker, 1866)
Bothus mancus (Broussonet, 1782)
Bothus pantherinus (Rüppell, 1830)
SAMARIDAE (CRESTED FLOUNDERS)
Samariscus triocellatus Woods, 1966
SOLEIDAE (SOLES) -- ali
Aseraggodes cf smithi Woods, 1966
Dexillus muelleri (Steindachner, 1879)
Pardachirus pavoninus (Lacepède, 1802)
Soleichthys heterorhinos (Bleeker, 1856)
BALISTIDAE (TRIGGERFISHES) -- humu
Abalistes stellatus [anonymous, 1798] -- humut avake
Balistapus undulatus (Park, 1797) -- humo moana
Balistoides conspicillum (Bloch and Schneider, 1801)
Balistoides viridescens (Bloch and Schneider, 1801)
Canthidermis maculatus (Bloch, 1786)
Melichthys vidua (Solander, 1845)
Odonus niger (Rüppell, 1837)
Pseudobalistes flavimarginatus (Rüppell, 1829)
Pseudobalistes fuscus (Bloch and Schneider, 1801)
Rhinecanthus aculeatus (Linnaeus, 1758)
Rhinecanthus lunula Randall and Steene, 1983
Rhinecanthus rectangulus (Bloch and Schneider, 1801)

Sufflamen bursa (Bloch and Schneider, 1801) -- humu fala
Sufflamen chrysopterus (Bloch and Schneider, 1801)
Sufflamen fraenatus (Latreille, 1804)
Xanthichthys auromarginatus (Bennett, 1831)

MONACANTHIDAE (FILEFISHES) – papae

Acreichthys tomentosus (Linnaeus, 1758)
Aluterus scriptus (Osbeck, 1765)
Amanses scopas (Cuvier, 1829)
Cantherhines dumerilii (Hollard, 1854)
Cantherhines fronticinctus Günther, 1867
Cantherhines pardalis (Rüppell, 1837)
Oxymonacanthus longirostris (Bloch and Schneider, 1801)
Paraluteres prionurus (Bleeker, 1851)
Pervagor alternans (Ogilby, 1899)
Pervagor aspricaudus (Hollard, 1854)
Pervagor janthinosoma (Bleeker, 1854)
Pervagor melanocephalus (Bleeker, 1853)

OSTRACIIDAE (BOXFISHES AND COWFISHES) -- momoa

Lactoria cornuta (Linnaeus, 1758)
Lactoria diaphana (Bloch and Schneider, 1801)
Ostracion cubicus Linnaeus, 1758
Ostracion meleagris Shaw, 1796
Ostracion solorensis Bleeker, 1853

TRIODONTIDAE (THREE-TOOTH PUFFER FAMILY)

Triodon macropterus Lesson, 1831

TETRAODONTIDAE (PUFFERS) - te'e te'e

Arothron hispidus (Linnaeus, 1758)
Arothron manilensis (Procé, 1822)
Arothron mappa (Lesson, 1830)
Arothron meleagris (Lacepède, 1798)
Arothron nigropunctatus (Bloch and Schneider, 1801)
Arothron stellatus (Bloch and Schneider, 1801)
Canthigaster amboinensis (Bleeker, 1865)
Canthigaster bennetti (Bleeker, 1854)
Canthigaster coronata (Vaillant and Sauvage, 1875)
Canthigaster epilampra Jenkins, 1903
**Canthigaster flavoreticulata* Matsuura, 1986
Canthigaster janthinoptera (Bleeker, 1855)
Canthigaster ocellicincta Allen & Randall, 1977
Canthigaster solandri (Richardson, 1844)
Canthigaster valentini (Bleeker, 1853)
Lagocephalus sceleratus (Gmelin, 1789) -- atu te'e te'e

DIODONTIDAE (PORCUPINEFISHES AND BURRFISHES)

Chilomycterus reticulatus (Linnaeus, 1758) -- to'utu
Diodon holocanthus Linnaeus, 1758 -- soki soki
Diodon hystrix Linnaeus, 1758 -- soki soki

Diodon liturosus Shaw, 1804 -- soki soki

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ATOLL RESEARCH BULLETIN

NO. 503

THE VASCULAR PLANTS OF MAJURO ATOLL, REPUBLIC OF THE MARSHALL ISLANDS

BY

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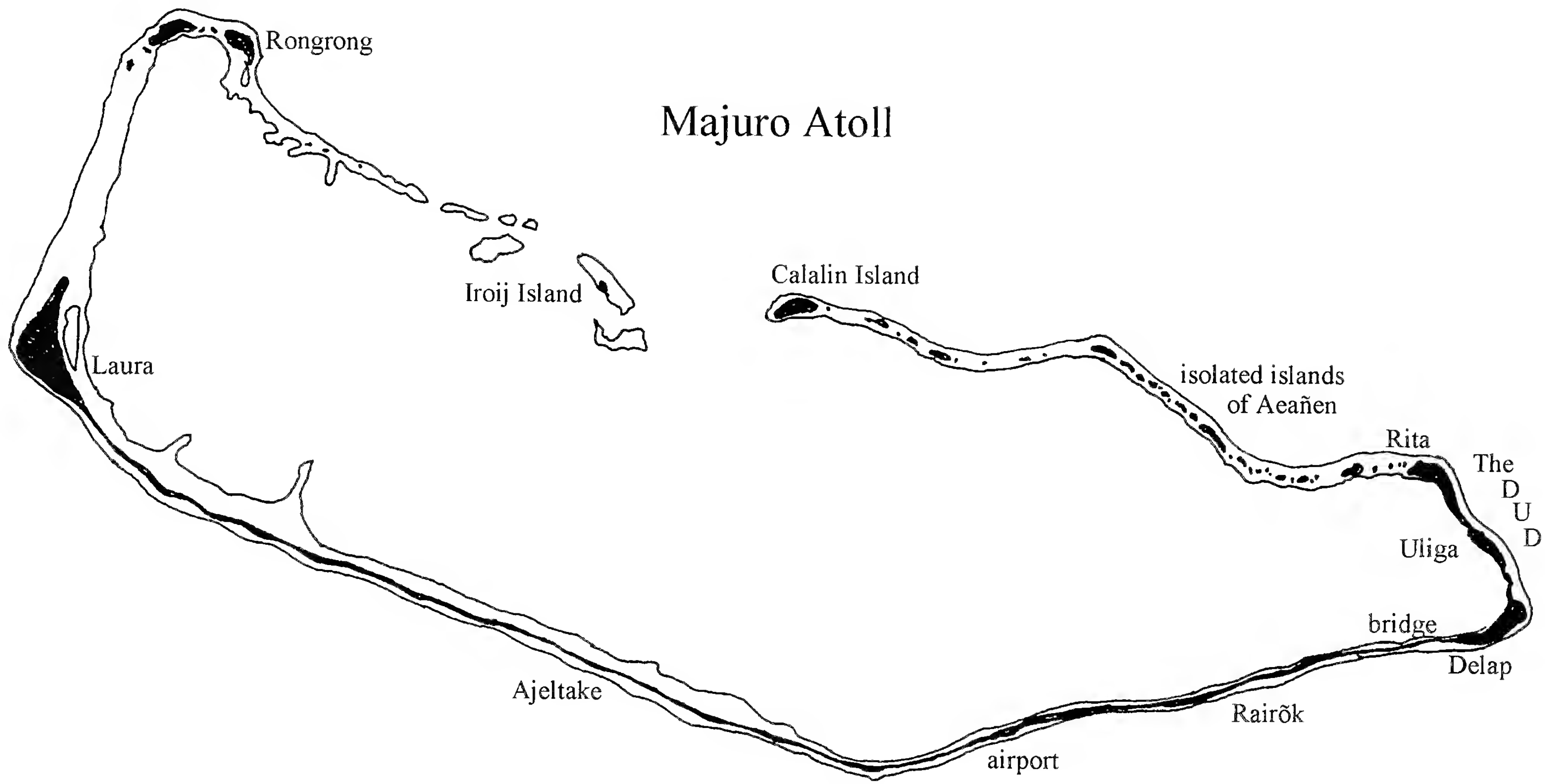

Figure 1. Majuro Atoll

THE VASCULAR PLANTS OF MAJURO ATOLL, REPUBLIC OF THE MARSHALL ISLANDS

BY

NANCY VANDER VELDE[1]

ABSTRACT

Majuro Atoll has been a center of activity for the Marshall Islands since 1944 and is now the major population center and port of entry for the country. Previous to the accompanying study, no thorough documentation has been made of the vascular plants of Majuro Atoll. There were only reports that were either part of much larger discussions on the entire Micronesian region or the Marshall Islands as a whole, and were of a very limited scope. Previous reports by Fosberg, Sachet & Oliver (1979, 1982, 1987) presented only 115 vascular plants on Majuro Atoll. In this study, 563 vascular plants have been recorded on Majuro.

INTRODUCTION

The accompanying report presents a complete flora of Majuro Atoll, which has never been done before. It includes a listing of all species, notation as to origin (i.e. indigenous, aboriginal introduction, recent introduction), as well as the original range of each. The major synonyms are also listed. For almost all, English common names are presented. Marshallese names are given, where these were found, and spelled according to the current spelling system, aside from limitations in diacritic markings. A brief notation of location is given for many of the species.

The entire list of 563 plants is provided to give the people a means of gaining a better understanding of the nature of the plants of Majuro Atoll. It provides a convenient checklist for scientists, students, visitors and the general public. It can also serve as a new reference for a flora of the entire Marshall Islands.

PREVIOUS REPORTS

Until Majuro became the military center in 1944 and subsequently the capital for the Republic of the Marshall Islands in 1979 (Sabath 1977, Hezel 1995), there was no justification for giving special attention to Majuro over any other "outer island." Early German and Japanese botanists focused their attention primarily on Jaluit Atoll, then the capital of the Marshall Islands. Okabe (1952) mentions the work of German botanists such as Betche (1884) who discussed 56 indigenous and nine introduced plants and Volkens (1903) who listed 126 species for the Marshall Islands and he himself presents 179 plants from 63 families.

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Subsequent to the United States Navy coming to Majuro, some reports apparently were made on the flora and/or vegetation observed. The earliest reports on Majuro accessible to the current authors were St. John (1951) and Sabath (1977). Fosberg, Sachet, & Oliver (1979, 1982, 1987) also have Majuro listings scattered among all their other Micronesian and Marshall Islands listings. Fosberg (1990) also listed species for Majuro.

According to the title, *A Brief Field Guide to the Plants of Majuro, Marshall Islands* (Stone & St. John 1956) would seem to have been the first report specifically to address the flora of Majuro. Unfortunately it is very limited and unfocused. Only a draft copy could be found of this report so it probably never achieved wide distribution.

The works of Taylor (1951) and Hatheway (1955) provide valuable insight into the overall flora and vegetation of the Marshall Islands. Merlin et al. (1994) provides a brief popularized view of some of the flora of the Marshall Islands. Whistler & Steele (1999) discuss Kwajalein, but only the areas leased by the U.S. Army. The most recent work by the RMI Biodiversity Team (2000) discusses Marshall Islands plants in general, along with a table of vascular plants.

METHODS

By using the checklist of Fosberg, Sachet, & Oliver (1979, 1982, 1987) as a base list on which to build, the nonresident author of the accompanying report, R. R. Thaman, during his first visit to Majuro in 1991 began an initial comparison and expansion of the current flora of Majuro. He continued this comparison and expansion during his 1999 visit. During this visit he was also able to enlist the assistance of the resident author (Vander Velde).

As a resident, Vander Velde was able to make very thorough investigations into all areas and ecosystems of Majuro. Then Thaman, by having a broader familiarization with Pacific species, was able to identify many species new both to the Majuro and the Marshall Islands. Many of these were confirmed during Thaman's subsequent two visits in 2000 and in 2001. Confirmation of others was made through electronic scanning of specimens collected and digital photos that were sent via e-mail. Collections and records were made until January 2002.

STUDY LOCATION

Majuro Atoll is located about 7° N, 171° E. Historically it consisted of 57 individual islets with total land area of only 3.75 square miles. However, a 30-mile-long road now connects about half of the islets. Many of the smaller islets on the north are still isolated at high tide (Fosberg 1990). According to the most recent census, 23,676 people live on Majuro Atoll, the majority or 15,486 being concentrated in the downtown DUD* area. The suburban area of Rairõk has 3,846 and 2,256 live in the more agricultural village of Laura (Office of Planning and Statistics 1999). All 30 miles of the islets connected by road were surveyed repeatedly in the course of preparing this flora.

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* DUD is an abbreviation for the three main islets, Djarrit (which is also referred to as Rita), Uliga and Delap.

Some were examined in great detail by actually walking through the areas examining gardens and yards. Other areas were simply perused while driving through.

Fosberg (1990) mentioned that: "Surprisingly nothing seems to be on record about the numerous north and northeast islets. They would repay a visit, which should be easy…." In the course of preparing the accompanying report (and, to some extent, during earlier independent visits by the resident author), most of these islets were examined. Thaman went by boat to Calalin and Eneko. Vander Velde has been able to visit most of the more distant islets by boat and all of Aeañen from Eneko to Ejit by foot at low tide. A few of the islands were not personally visited by either Vander Velde or Thaman but information regarding them and specimens from them were provided by people who frequent them.

An effort was made to examine all environments where plants were to be found. This included not only the uninhabited sparsely inhabited areas but also the urban sections, farmlands, private decorative gardens and indoor potted plants. Often new species first are introduced into the atoll via indoor potted plants which, when they become large enough, are moved outside into flower gardens. Many species subsequently "escape" and become naturalized, even invasive, in the tropical environment of Majuro.

RESULTS

Fosberg, Sachet, & Oliver (1979, 1982, 1987), have been the main references for the plants of Majuro. However, these reports deal with all of Micronesia making them rather cumbersome. One-hundred fifteen species were listed for Majuro. Other species were listed in a few other reports (St. John 1951, Sabath 1977, Watson 1993, RMI National Biodiversity Team 2000).

The current flora shows a total of at least 563 vascular plants. Included in this figure are a few widely accepted agricultural varieties, i.e. *Brassica chinensis* var. *chinensis* and *Brassica chinensis* var. *parachinensis*, which are so different from one another that they are considered by some to be distinct species. There are 12 ferns and allies, 5 gymnosperms, 193 monocots and 353 dicots. This number of 563 is significantly higher than the 468 listings that the RMI National Biodiversity Team (2000) had for vascular plants throughout the entire Marshall Islands which included Wake, geographically and traditionally part of the Marshalls. At times it was difficult to evaluate which category a species should be classified into, especially when some such as *Soulamea amara* and *Suriana maritima* are considered indigenous to other parts of the Marshalls but of recent introduction to Majuro. But even after taking these irregularities into account, only 56 indigenous species were identified (see Table 1). This figure is not too different from what Hatheway (1954) found almost half a century earlier when he surveyed Majuro's closest neighbor, Arno, and calculated that there were only 44 indigenous species on that atoll.

There were 18 species of aboriginal introduction or aboriginal horticultural origin found on Majuro (see Table 2).

Table 1 — Indigenous Plants of Majuro	
Ferns and allies	
1) Asplenium nidus	27) Ipomoea pes-caprae
2) Nephrolepis acutifolia	28) Ipomoea violacea
3) Ophioglossum nudicaule	29) Chamaesyce atoto
4) Phymatosorus grossus	30) Canavalia cathartica
5) Psilotum nudum	31) Canavalia rosea
6) *Pteris tripartita	32) Canavalia sericea
	33) Sophora tomentosa
Monocotyledons	34) Vigna marina
7) #Cocos nucifera	35) Scaevola taccada
8) +Nypa fruticans	36) Hernandia nymphaeifolia
9) Eleocharis geniculata	37) Cassytha filiformis
10) Fimbristylis cymosa	38) Barringtonia asiatica
11) Fimbristylis dichotoma	39) Pemphis acidula
12) Cyperus javanicus	40) Sida fallax
13) Cyperus odoratum	41) Boerhavia tetrandra
14) Cyperus polystachyos	42) Pisonia grandis
15) #Pandanus tectorius	43) Portulaca australis
16) Lepturus repens	44) +Colubrina asiatica
17) Cymodocea rotundata	45) Bruguiera gymnorrhiza
	46) Guettarda speciosa
Dicotyledons	47) Hedyotis biflora
18) Neisosperma oppositifolium	48) Allophylus timoriensis
19) Melanthera biflora	49) +Bacopa monnieri
20) Cordia subcordata	50) *Soulamea amara
21) Tournefortia argentea	51) *Suriana maritima
22) Caesalpinia bonduc	52) Triumfetta procumbens
23) Intsia bijuga	53) Laportea ruderalis
24) *Lumnitzera littorea	54) Pipturus argenteus
25) Terminalia samoensis	55) Clerodendrum inerme
26) Ipomoea littoralis	56) Premna serratifolia

* considered indigenous to some of the Marshall Islands but known to be introduced recently to Majuro through human activity
# wild varieties likely indigenous; aboriginal varieties also present
+ only of recent record, likely arriving apart from human activity, but has either already been extirpated or will be extirpated soon

Table 2 —Aboriginal Plants of Majuro	
Monocotyledons	**Dicotyledons**
1) Crinum bakeri	8) Centella asiatica
2) Alocasia macrorrhiza	9) Adenostemma lanceolatum
3) Colocasia esculenta	10) Calophyllum inophyllum
4) Cyrtosperma chamissonis	11) Terminalia catappa
5) Dioscorea bulbifera	12) Ocimum sanctum
6) Musa (ABB Group)	13) Hibiscus tiliaceus
7) Tacca leontopetaloides	14) Artocarpus altilis
	15) Artocarpus mariannensis
	16) Ficus tinctoria
	17) Ixora casei
	18) Morinda citrifolia

The remaining 489 species are of recent origin (see the accompanying Appendix: *Comprehensive Listing of the Vascular Flora of Majuro Atoll*).

There are 415 species newly recorded for Majuro. Of these, there were 229 first-time records for the entire Marshall Islands. An additional 186 were first-time records for Majuro although they had previously been recorded on other atolls of the Marshall Islands. There were 17 families new to the country and another 27 families new to Majuro.

Some of the previous reports on plants in the Marshall Islands list many plant species as only on Jaluit. A large number of these were based on old introductions when that atoll was the capital of the country. Many of these were ill-suited for the atoll environment and, furthermore, a devastating typhoon in 1958 wiped out a large number of these introductions (Fosberg & Sachet 1962). Therefore, some of the species currently listed with the accompanying report as first recorded for only Majuro are in reality the only plants of these species known to be in the country.

The high number of recently introduced species is not surprising. Sabath (1977) noted that "urbanization has altered indigenous and aboriginally introduced plant communities primarily by replacing forested areas with open yards." He also showed how the trend was away from subsistence horticulture towards both a money economy and imported ornamental plants. The accompanying report documented that this trend has not only continued but accelerated in recent years.

Plant introductions were made from a wide variety of locales. When investigating various gardens, the owners were often more than willing to tell how they brought in certain new species. Hawai'i was the most frequently mentioned, but Saipan, Chuuk, Kiribati, Fiji, Malaysia, Nauru and Guam were also often cited. For a while, one of the main retainers, Robert Reimers Enterprises, was regularly importing plants from Australia. Some of the newly introduced plants came through seeds imported by local stores or through catalogs. One of the more interesting tales told was how a certain fragrant flower was brought in by putting the sprig in a stylish manner behind a woman's ear.

Six of the species reported by Fosberg, Sachet, & Oliver (1979, 1982, 1987) were not found by the current authors. Some of these were of recent introduction and presumably did not survive in the atoll environment of Majuro. *Crinum bakeri* Schumann, which is figured to be of aboriginal horticultural origin and only from the Marshall Islands (Fosberg 1990), was not observed. No local people had any knowledge or recollection of it. All of the 66 species observed by St. John (1951) and 30 reported by Sabath (1977) were found.

The six newly recorded species that likely occurred on Majuro on their own, and hence are to be classified as indigenous, are particularly noteworthy. *Ophioglossum nudicalue* is so ephemeral that it is hard to determine when and how it might have arrived. *Eleocharis geniculata* was previously reported on Ailuk, Arno, Jaluit, Likeip and Kwajalein Atolls (Fosberg, Sachet, & Oliver 1987). The single shrub of *Colubrina asiatica* was found in an area away from any house and near the beach where its seeds could have cast ashore on their own. This was the first record for the Marshall Islands and the first time it was observed on any atoll by the current authors. It seems to be suffering badly from being overgrown by the parasitic vine *Cassytha filiformis* and may not survive.

The single sprouted fruit of *Nypa fruticans* may likewise not be able to survive on its own. The littoral environment of Majuro where it was found is certainly quite different from the mangrove areas where it is typically found. A small patch of *Bacopa monnieri* was located in an area where it was uncertain if it arrived on its own or through human intervention. However, *Fimbristylis dichotoma* was found in a wide variety of locations throughout the atoll, so it would seem that it is a long time native that was merely overlooked during earlier surveys.

CONCLUSION

As the current port of entry within an economically thriving nation, the number of plants will undoubtedly continue to grow. The species that are here will also continue to spread throughout the atoll and the country. The residents of Majuro are very proud of the new species and varieties of plants they are able to grow and are generous and anxious to share cuttings and seeds of the plants. When making records of new species, the authors found a network of gardeners who habitually exchanged whatever new or outstanding plants they had. The modern lifestyle is the main contributor to the great increase in the number of plants on Majuro. The increase of population and change from a subsistence lifestyle is frequently discussed in other reports as something occurring throughout the Pacific (Thaman 1994).

On Majuro there have been other significant changes as well. Regular air service allows live plants to be imported, which was never possible in the earlier days, and for the importation of plants that are not really well suited to the atoll environment. In times past, these would have quickly succumbed to the salt spray and heat of Majuro but now air conditioning allows them to survive. Air-conditioned homes and offices frequently seemed to serve as nurseries for starting plants from cuttings and seeds. Often, once they are larger, they can be moved outside without too many ill effects.

Some naturally occurring atoll soil is very good but, in general, it is low in nutrients. Many of the serious gardeners around Majuro use a large amount of imported potting mix for their decorative plants. Robert Reimers Enterprises imports approximately 25 bags per month of potting mix and 10 bags per month of manure. More economical soil improvement is often available for the taking in the form of copra cake at Tobolar, the copra processing plant.

Previously, storms and periodic droughts would limit the number and variety of plants able to survive on Majuro. For example, in the aftermath of Typhoon Axel in 1992, Majuro faced a critical shortage of freshwater. Some smaller, nonxerophytic/ halophytic plants were kept alive by some people using the water that dripped out of air conditioners. But when the drought became severe enough, this water was in demand for bathing and even drinking. Thus many imported plants died.

However, there was adequate warning given ahead of time for Majuro's latest severe drought of 1998 and preparations were made beforehand; thus this same scenario was not repeated. Early on in this drought which followed Typhoon Paka, large salt-to-fresh reverse osmosis machines were brought in. These were able to provide an abundance of high-quality water for the entire atoll. Unattended palms close to the sea, and breadfruit trees that evidently had their roots in the water lens that went brackish, did die (RMI National Biodiversity Team 2000). But the vast majority of garden plants were kept alive.

Waves washing across the atoll nevertheless can still be quite destructive to most nonnative plants. The most recent wave action occurred in January 2001 and many plants died in the flooding. The only *Cananga odorata* known by the authors in recent times was one of the victims. Yet many residents of the area evacuated their potted plants with them when fleeing to safer ground. Upon surveying the damaged area, the resident author was told by some plant owners of gardens she had surveyed that their flowers were unharmed.

The floras of Majuro are expected to thus continue in their dynamic state with some species dying off while new species are imported. One of the last species to be found as part of the recent report was *Chromolaena odorata* that is very invasive in other parts of Micronesia. As of this writing, it is known only in a small area but what it will do if it escapes out into the wilds is unknown. *Antigonon leptopus* is also a terrible invasive on Guam but it is confined in Majuro to a planter box and it did not survive on either Jaluit or Kwajalein where it was previously recorded (Space & Falanruw 1999; Fosberg & Sachet 1962, Whistler & Steele 1999). Other species now recognized to be invasive, such as *Turnera ulmerifolia*, have spread all across the atoll and onto the outer islands. (It has also been reported on Kwajalein. During the resident author's 1999 visit to Jaluit, it was said to be known as "Majuro flower"). Continuous monitoring of the flora of Majuro might to be a practical means to keep tabs on changes of the flora of the entire country.

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This flora is truly a reflection of the horticultural skills and kindness of the residents on Majuro. So many local homeowners and gardeners graciously allowed the authors to examine their gardens and then also enthusiastically gave guided tours of those gardens, providing specimens and allowing photographs to be taken. Maria Kabua Fowler showed exceptional kindness in showing off her own personal garden and also that of her late father, President Amata Kabua. We appreciated the Fowler family allowing botanical exploration to be included during their picnic to Calalin in July 2000.

The botanical expertise and experience of Art Whistler was an integral part of the success of the recent report, helping with the identifications of the more obscure species. Brian Vander Velde proved to be much more than a supportive husband. By drawing upon his long-time knowledge of Micronesian plants, many of the new records were actually first located by him. We appreciate the proofreading done by Leslie A. Mead, Archaeologist at the RMI Historic Preservation Office, and by James C. Space of Pacific Island Ecosystems at Risk (PIER).

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APPENDIX

COMPREHENSIVE LISTING OF THE VASCULAR FLORA OF MAJURO ATOLL

BY

R. R. THAMAN[1] and NANCY VANDER VELDE[2]

EXPLANATION OF THE ABBREVIATION, SYMBOLS, TERMINOLOGY, ETC.

1 DESIGNATION OF NEW RECORDS

* indicates a new record (at the species, genus and/or family levels) for Majuro, but reported present on other atolls in the Marshall Islands by Fosberg, Sachet & Oliver (1979, 1982 & 1987) or other authors listed in the bibliography.

** indicates a new record (at the species, genus and/or family levels) for the Marshall Islands, not listed as present on any of the atolls of the Marshall Islands by Fosberg, Sachet & Oliver (1979, 1982 & 1987) or other authors listed in the bibliography.

2 PRIMARY AUTHORITIES OR SOURCES OF DOCUMENTED SPECIES OCCURRENCES

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RRT 1991; 1999; 2000A; 2000B; 2001 – Observations by R. R. Thaman during visits to Majuro in February 1991, August 1999, and August-September 2000 (2000A), again in late October 2000 (2000B) and November 2001.

NVV 1999; 2000; 2001; 2002 – Observations or information gathered by Nancy Vander Velde. Although many observations were made from the start of continuous residence on Majuro in January 1988, the first date is based on when NVV joined the project. Only the first record is noted, although in most cases, observations were made every year during the process of the project. If RRT is placed after NVV, this indicates that RRT first recorded the presence of a given species after, and to verify, a previous identification made by NVV, in most cases in 2000 or before.

Other sources that are cited are done to a much more limited extent and often just when the listing of a plant changes the status of a species being a new record to Majuro or the Marshall Islands. Reference is also made to some persons, as well as businesses, which have been responsible for many the introductions of many ornamental species

3 VOUCHER SPECIMENS AND DIGITAL PHOTOGRAPHS

For most species, either voucher specimens were collected and/or digital images/photos taken to either validate the presence or to help confirm the identity of a given species. The respective numbers relating to both voucher specimens and digital photos are enclosed the second set of parentheses after the authorities and sources, e.g., (RRT 1991, 2000AB, 2001; NVV 2001) (2K00401; DPMJ0006, DPMJ0026). The voucher specimens, which have numbers beginning with 2K00001are lodged with the South Pacific Regional Herbarium at the University of the South Pacific, Suva, Fiji Islands. The digital photos/images of plants taken in the field in Majuro have numbers beginning with DPMJ0001 (DPMJ signifies "Digital Photo Majuro"). They have been copied onto computer files in both the Geography Department and the South Pacific Regional Herbarium at the University of the South Pacific, Suva, Fiji and at the College of the Marshall Islands Library. A digital photo number with a capital S after the number (e.g., DPMJ0123S) indicates that it is a digital photo of an herbarium specimen held at the SPRH, and not a photo of a live plant. A number with ab or abcde, etc (for example) after the number, indicates that a given photo is of 2 to as many as 5 species together, designated by ab, abc, abcd or abcde.

4 NOMENCLATURE

Scientific names – The scientific or Latin names are written in **bold** when used in the main heading for each species and *italicized* when listed as synonyms or used in the text of the introduction or in explanatory information for each species.

English names – English or common names have been included for most species. Most of these are based on usage in the literature, although some are based on translations of the scientific name. For some species, no commonly used English or common names exist, or the English name is only a general term. For some species, well-known common names from other foreign languages are also included, e.g., ylang-ylang for the perfume tree (*Cananga odorata*).

Marshallese names – When known, the Marshallese name (s) for given species are given in ***bold italics***, according to the current spelling system. Many species names are listed according to their spelling as they appear in the *Marshallese-English Dictionary*, third edition. (Abo et al. 1985) However, due to restraints in type font, some older style phonemic symbols were used, particularly the tilde ("~") and circumflex ("^") rather than the macron ("¯"). The few Marshallese letters that employ the cedilla (",") were not used. Some names were based on older references and may not have use the current alphabet with all its markings. Many of the names are widely known, others are more obscure. When no or few persons were found to know a certain name, notation of this was made, but not all names were checked out. The authors saw no need to list the wide range of spellings that have been reported for most species in the literature. When known, a brief translation of the Marshallese name is provided. (Place locations are given according to popular usage, which may at times vary slightly from the current spelling system).

5 CATEGORIES USED TO INDICATE "ANTIQUITY STATUS" OR NATURE OF DISPERSAL TO OR INTRODUCTION INTO MAJURO

Indigenous - a plant that is assumed to have dispersed naturally to, and became successfully established in the Marshall Islands, in almost all cases prior to the settlement of the atolls by the first indigenous human inhabitants. In some cases, a given species may have arrived and established itself naturally, subsequently disappeared (became locally extinct or extirpated) due to some extreme event, such as a prolonged drought or tidal wave, and then naturally recolonized the island, sometimes very recently. This could be the case, for example, with *Colubrina asiatica*, which has apparently arrived recently in Lomajurok west of the airport.

Aboriginal introduction - a plant believed to have been introduced into the Marshall Islands by the indigenous (aboriginal) people of the Marshall Islands or other Pacific Islanders before the time of first European contact with the Marshall Islands. In some cases aboriginal introductions could have been also made through traditional contacts between islands after European contact.

Aboriginal horticultural origin – a plant which appears to have been developed through the horticultural activity of the early inhabitants of the Marshall Islands

Horticultural origin – a plant developed through recent horticultural activity.

Recent introduction – a post-European-contact introduction after the time of first European contact with the Marshall Islands.

6 CATEGORIES USED TO INDICATE THE ABUNDANCE OF A GIVEN SPECIES

Extirpated – Reported present in past, but not seen during more recent surveys and now possibly extirpated (locally extinct) on Majuro. The term "extirpated" is used for a species that, although locally extinct or no longer present on Majuro, is still found, and in many cases abundant, on other islands in the Marshall Islands, on other Pacific Islands or in other parts of the world. There is also the possibility that the species was misidentified and perhaps never was present on Majuro.

Rare – Seen present in only one or two locations on Majuro and possibly in danger of extirpation (local extinction) or is a rare ornamental, food plant, etc. that may be a recent trial introduction, and not really well suited to the atoll environment.

Uncommon – Found present in only a few locations, such as in the relatively few undisturbed habitats on outer islets, in specialized habitats, such as swampy areas, or in a few houseyard gardens and experimental agricultural areas.

Occasional – Occasionally seen in a number of places, or locally common in only a few locations.

Common – Found present in a number of locations, but not really dominant, or locally common or abundant in some locations.

Abundant – Widespread in a range of habitats or dominant in a number of different habitats throughout the atoll.

Very abundant – Abundant in most habitats and found on almost all atoll islets and constituting the dominant species in numerous sites or habitats.

7 PLACE NAMES AND GEOGRAPHICAL LOCATIONS ON MAJURO ATOLL

In general, a brief description of where a species was found is provided. Usually just the islet, village, district or area is designated. Major landmarks, such as the Capital Building, businesses, schools and hotels are also specifically designated. Except in a limited number of cases, private residences are simple referred to in general with respect to their geographic location.

PTERIDOPHYTA (Ferns and Fern Allies)

ASPLENIACEAE (Spleenwort Fern Family)

Asplenium antiquum Osaka — Japanese bird's nest fern, "Victoria"

Recent introduction. Southern Japan. Rare. Introduced in 1998 by RRE as an ornamental houseplant. Some specimens may survive in houses and offices, but may be confused with the local indigenous species, *Asplenium nidus,* which is sometimes also utilized as an ornamental (NVV 1999).**

Asplenium nidus L. — bird's-nest fern

Marshallese: ***kartõp***

Indigenous. Paleotropical. Occasional to locally common. Uncommon as an epiphyte or a terrestrial species in abandoned or poorly maintained coconut plantations, secondary forest and inner coastal littoral forest on the main islets, particularly in Laura; more common to locally abundant on uninhabited islets in Aeañen, particularly on Calalin Islet; occasional as a planted ornamental or potted plant (StJ 1951; F, S & O 1982; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0037a, DPMJ0077, DPMJ0079, DPMJ0239).

AZOLLACEAE (Water Fern Family)**

Azolla pinnata R. Br. — ferny azolla, feathered waterfern

Syns. *Azolla imbricata* (Forst.) Nakai; *Azolla pinnata* var. *imbricata* (Forst.) Bonap.

Recent introduction. Paleotropics and subtropics and to Australia, New Caledonia and New Zealand. Rare or now extirpated. Found at one agricultural farm in Laura in 1991, but not seen since. Probably introduced as a natural fertilizer, because of its ability to take advantage of the nitrogen-fixing abilities of symbiotic blue-green algae (cyanobacteria). Could possibly have been another common species, red azolla (*Azolla filiculoides* Lam.). On the U. S. list of noxious weeds (RRT 1991).**

NEPHROLEPIDACEAE (Sword Fern Family)

Nephrolepis acutifolia (Desv.) Christ sword fern, fishtail fern

Marshallese: ***baidik*** (a name at times also applied to other sword ferns); ***iri; anmõkadede***

Indigenous. Paleotropics to Micronesia and Polynesia. Common. Found in colonies and dense populations as an understorey species in coconut plantations, shady ruderal sites and fallow areas, and in coastal vegetation; uncommon on Calalin Islet; occasional as a planted ornamental (StJ 1951; F, S & O 1982; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (2K00403; DPMJ0109, DPMJ0141, DPMJ0531).

Nephrolepis biserrata (Sw.) Schott var. **furcans** Hort. fishtail fern

Recent introduction. East Asia, Africa, Brazil, Florida. Uncommon. Ornamental potted plant in household gardens the DUD. Previously reported on Jaluit but did not survive (Fosberg & Sachet 1962) (NVV 2000; RRT 2000AB, 2001) (DPMK0114, DPMJ0184)*

Nephrolepis exaltata (L.) Schott Boston fern

Recent introduction. Pantropical. Rare. Ornamental potted plant (RRT 1991, 2000AB, 2001; NVV 2000) (DPMJ0114, DPMJ0167c).**

OPHIOGLOSSACEAE (Adder's Tongue Fern Family)*

Ophioglossum nudicaule L. f. adder's tongue fern

Indigenous, possibly ephemeral or perhaps of recent introduction. Tropical and subtropical areas throughout the world. Rare, seasonal and ephemeral. Small terrestrial fern found in parking lot of Majuro Clinic in February 2000, but not seen thereafter. Reported from Kwajalein by Whistler & Steele (1999) (NVV 2000) (DPMJ0159). *

POLYPODIACEAE (Common Fern Family or Polypody Fern Family)

Phlebodium aureum (L.) J. Sm. hare's foot fern, mamdaoami
Syn. *Polypodium aureum* L.

Recent introduction. Tropical America. Uncommon. Ornamental potted plant seen in a number of in household gardens in Delap, Rita and Rairõk (NVV 2000; RRT 2000AB) (DPMJ0183, DPMJ0379) **

Phymatosorus grossus (Langsd. & Fisch.) Brownlie scented fern

Syns. *Microsorum grossum* (Langsd. & Fisch.) S.B. Andrews; *Polypodium grossum* Langsd. & Fisch.

Misapplied names: *Phymatosorus scolopendria* (Burm.f.) Pichi-Serm.; *Polypodium scolopendria* Burm.f.; *Phymatodes scolopendria* (Burm.) Ching; *Microsorium scolopendria* (Burm.) Copel.; *Polypodium phymotodes* L.

Marshallese: ***kino***

Indigenous. Paleotropical. Very abundant. Terrestrial and epiphytic fern under coconut plantations, on the bases of coconut trunks, and in the coastal strand vegetation; occasional as a planted ornamental. *P. grossus* has been widely mistaken for the small, almost exclusively epiphytic species *P. scolopendria* (StJ 1951; F, S & O 1982; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0526).

PSILOTACEAE (Psilotum Family)

Psilotum nudum (L.) Beauv. psilotum, reed fern, whisk fern

Marshallese: ***bããñ***; ***martok*** ("weed that is approaching", a name not generally known)

Indigenous. Tropics and subtropics. Occasional. Reported on a wet mossy rock in Laura by St. John 1951; reported present on Majuro by F. S & O (1982). Not seen by current authors until September 2000 when RRT located a population on Calalin Islet. Subsequently it was found by both RRT and NVV in many other locations throughout the atoll, including abandoned, overgrown coconut plantations, and on the base of coconut trees in a undeveloped area of Rita, but also in the urban areas of Rita (StJ 1951; F, S & O 1982; FRF 1990; RRT 2000AB, 2001; NVV 2000) (2K00404; DPMJ0019, DPMJ0075, DPMJ0136S, DPMJ0137S, DPMJ0165, DPMJ0406, DPMJ0407).

PTERIDACEAE (Bracken Fern Family or Brake Fern Family)*

Pteris tripartita Sw. lacy fern, giant bracken fern, sword brake

Syn. *Pteris marginata* Bory

Marshallese: ?***kinien mãnnueal*** ('matress of the white-striped sand skink,' a large, secretive and diurnal ground lizard; name based on Stone & St. John's [1956] for a similar species which has never been recorded elsewhere for the Marshall Islands and hence was probably a misidentification of this species)

Indigenous? (perhaps only to the southern Railik atolls, but not Majuro). Paleotropical to Micronesia and Polynesia. Rare. Planted ornamental in the DUD and at the former President Amata Kabua's garden, where reportedly introduced from Pohnpei. Previously reported from

Namdrik, Jaluit and Ebon by F, S & O (1982) (RRT 1991, 2000A; NVV 2000) (DPMJ0026, DPMJ0648).*

SYNOPTERIDACEAE (Cliff Brake Fern Family)**

Pellaea rotundifolia (Forst. f.) Hook button fern

Recent introduction. New Zealand. Uncommon. Planted ornamental potted plant. Found in Rita, Delap, Rairõk and Ajeltake (NVV 2000; RRT 2000AB, 2001) (DPMJ0195, DPMJ0372).**

GYMNOSPERMAE (Gymnosperms)

ARAUCARIACEAE (Araucaria Family)

Araucaria heterophylla (Salisb.) Franco Norfolk Island pine, star pine
Syn. *Araucaria excelsa* (Lamb.) R. Br.

Marshallese: ***kûrijmõj teri*** ("Christmas tree")

Recent introduction. Norfolk Island. Common. Planted ornamental in home gardens and along roads. Reported present on Kwajalein and Jaluit by F, S & O (1982) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0553).*

CUPRESSACEAE (Cypress Family)

Thuja orientalis L. Chinese arborvitae, Chinese thuja, biota, eastern arborvitae
Syn. *Biota orientalis* (L.) Endl.

Recent introduction. China. Rare. Single ornamental tree, about 4 m high, planted in Robert Reimer's household garden in Rita. Previously noted on Majuro (but no location specified) by RMI Biodiversity Team (2000), and reported on Kwajalein by Whistler & Steele (1999) (NVV 1999; RRT 2000AB, 2001) (2K00407; (DPMJ0010, DOMJ0011, DPMJ0139S, DPMJ0140S, DPMJ0151a).

CYCADACEAE (Cycad Family)

Cycas circinalis L. cycad, sago palm, king sago

Syn. *Cycas rumphii* Miq. (some authorities)

Marshallese: ***ni baam*** ("palm tree"), ***laukok***

Recent introduction. India to Micronesia and Polynesia. Occasional. Planted ornamental around houses. One very old tree along main road in Laura. According to some authorities, such as Fosberg & Sachet, take *C. circinalis* as an inclusive and highly variable species in Micronesia that includes C. *rumphii* and a number of other species (Smith 1979) (StJ 1951; F, S & O 1982; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Cycas revoluta Thunb. cycad

Recent introduction. Japan. Uncommon. Planted ornamental in household gardens and in front of Capital Building. Previously reported on Jaluit and Kwajalein by F, S. & O (1982), but apparently extirpated from both locations (Fosberg & Sachet 1962, Whistler & Steele 1999) (NVV 1999; RRT 2000AB).*

ZAMIACEAE (Zamia Family)*

Zamia furfuracea L. f. Jamaica sago tree, cardboard plant

Recent introduction. Mexico. Uncommon. Single plant at Capitol Building, another potted plant at Ajidrik Hotel in Uliga, and several at Amata Kabua's residence. *Zamia* sp. reported on Kwajalein by Whistler & Steele (1999) (NVV 2000; RRT 2000AB, 2001) (DPMJ0090, DPMJ0635).**

ANGIOSPERMAE (Angiosperms)

MONOCOTYLEDONAE (Monocotyledons)

AGAVACEAE (Agave Family)

Agave sisalana L. century plant, sisal, sisal hemp

Recent introduction. Mexico. Common. Planted for landscaping around various residences and buildings, including the planted area in the center of the divided road near the Capital Building. Previously reported on Jaluit, Jemo, Kwajalein and Likiep by F. S. & O (1987). Can become invasive and has become naturalized in Fiji (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0219) *

Aloe vera (L.) Burm. f. aloe vera
Syn. *Aloe barbadensis*

Recent introduction. Southwest Arabia and North Africa. Occasional. Potted plant around a few houses. Previously reported on Kwajalein by Whistler & Steele (1999) (NVV 2000; RRT 2000AB, 2001) (DPMJ0122).*

Cordyline fruticosa (L.) A Chev. cordyline, ti-plant
Syns. *Cordyline terminalis* (L.) Kunth; *Taetsia fruticosa* (L.) Merr.; *Draecena terminalis* L.

Recent introduction. Tropical Asia. Common. Planted ornamental in household gardens and commercial areas. Sabath (1977) reports only observing this species in Uliga, but it is now to be found throughout the atoll. It is easy to propagate and is one of the species introduced by the Division of Agriculture. There are numerous cultivars with varying leaf colors and shapes. Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce this species (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0720, DPMJ0737).

Dracaena angustifolia Roxb. narrow-leafed dracaena
Syn. *Pleomele angustifolia* (Roxb.) N.E. Br.

Recent introduction. India to Australia and Melanesia. Occasional. Planted ornamental and potted plant in household gardens (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0045, DPMJ0299).**

Dracaena deremensis Engler dracaena
Syn. *Pleomele deremensis* (Engler) N.E. Br.

Recent introduction. Tropical Africa. Occasional. Ornamental and potted plant. Both the 'Janet Craig' and 'Warnackei' varieties present (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0604).**

Dracaena fragrans (L.) Ker-Gawl. fragrant dracaena, dragon flower, pleomele
Syn. *Pleomele fragrans* (L.) Salisb.

Marshallese: ***ut*** (general term for flower or hedge)

Recent introduction. Tropical West Africa. Occasional. Ornamental potted plant and planted ornamental shrub. Mainly young plants, but a large woody shrub in the interior of Rita. Leaves are attractively banded in shades of green and used in making flower garlands (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0148, DPMJ0300, DPMJ0576).*

Dracaena marginata Lam. Madagascar dragon tree, rainbow tree
Syn. *Pleomele marginata* (Lam.) N. E. Br.

Recent introduction. Madagascar. Occasional. Planted ornamental in household gardens and commercial areas, both in outside planter boxes and as indoor potted plants. Both the larger, dark green variety and the colorful variegated form or "rainbow tree" (*D. marginata* "Tricolor") exist. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0124b, DPMJ0548).*

Sansevieria cylindrica Bojer cylindrical bowstring hemp

Recent introduction. Tropical Africa, Natal. Rare. Single plant seen in container at a private household garden in Woja (RRT 2000B; NVV 2000) (DPMJ0413).**

Sansevieria trifasciata Prain bowstring hemp, mother-in-law's tongue

Recent introduction. Tropical West Africa. Common. Planted ornamental and potted plant in household gardens and commercial areas. Previously recorded on Jaluit and Kwajalein by F. S & O (1987). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0414).*

Yucca gloriosa L. yucca, Spanish bayonet

Recent introduction. Tropical America and southeastern United States. Uncommon. Planted ornamental in household gardens and commercial areas (RRT 1991, 1999, RRT 2000AB, 2001; NVV 1999).**

ALLIACEAE (Onion Family)*

Allium cepa L. onion

Recent introduction. Central Asia. Rare. Periodically planted from seed or onion tops in household gardens and in container gardens. Previously reported on Jaluit and Kwajalein by F. S & O (1987) and Enewetak by St. John (1960) (NVV 1999).*

Allium fistulosum L. green onion, spring onion, Welsh onion, Japanese bunching onion

Recent introduction. East Asia. Uncommon. Planted in container at Japanese Takeout Restaurant (1991) and in commercial vegetable gardens and the Chinese experimental garden at Laura. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, RRT 2000A; NVV 2000).*

Allium sativum L. garlic

Recent introduction. Southern Asia. Rare. Found planted at K & P Gardens at Laura and household gardens in the DUD (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0224).**

Allium schoenoprasum L. chives

Recent introduction. North Hemisphere. Rare. Found planted at K & P Gardens at Laura and household gardens in the DUD (RRT 1999; NVV 2000).**

Allium tuberosum Rottler ex. Sprengle Chinese chives

Recent introduction. East Asia. Rare. Planted in container at Japanese Takeout Restaurant (1991) and in Chinese experimental garden at Laura. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000A).*

AMARYLLIDACEAE (Amaryllis Lily Family)

Crinum asiaticum L. false spider lily, crinum lily, grand crinum

Marshallese: ***kieb*** (general term for most lilies)

Recent introduction. Tropical Asia. Common. Planted ornamental lily with green leaves; often planted along borders (StJ 1951; F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0273, DPMJ0719).

Crinum augustum Roxb. Queen Emma lily

Syn. *Crinum amabile* Don var. *augustum*; possibly not distinct from *C. amabile* Donn. and *C. pedunculatum* R. Br.

Marshallese: ***kieb*** (general term for most lilies)

Recent introduction. Indian Ocean islands. Occasional. Planted ornamental lily with red or purple tinted leaves. Planted around the grounds of the Outrigger Marshall Islands Resort and other business and residential locations (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0274).**

Crinum bakeri Schumann Marshall Islands crinum lily

Marshallese: ***kieb*** (general term for most lilies)

Aboriginal horticultural origin. Known only from the Marshall Islands (and possibly from some of nearby atolls). Classified as among some of the most primitive of the crinums, with ancient ties with species in the wetlands of Asia and Malaysia. F. S. & O. 1987 and Fosberg 1990 list it as also recorded on Rongelap, Utdrik, Wotho, Likiep, Ailinglaplap, Mili and Jaluit.

The only description that could be found was the original description by Schuman in 1888 in *Engler's Jahrbuch IV*, p. 149: "Leaves lineary, 1- 1 ½ ft. long by 1 ¼ to 1 ½ inches wide, rather undulated on smooth margins. Perianth tube to blossom rather curves, only 1 ½ to 2 inches long by ¼ inch wide. Filaments rather shorter than the petals. Anthers linear, an inch long. Habitat: Marshall Islands."

Fosberg 1990 speculates that it was "probably brought by the Marshallese, but possibly a cultivar of local origin from *Crinum asiaticum* L." L. S. Hannibal (pers. comm. 2000) stated that it has similarities with the smaller *C. japanicum* (Baker) Stenaster, which is at times classified as a variety of *C. asiaticum*, although there is sufficient justification for a separate species status. Also bears a similarity with *C. watti*. Not seen by any of the current authors, upon inquiring, no people indicated any knowledge of it (Hannibal undated, F, S & O 1987; FRF 1990).

Crinum xanthophyllum Hannibal yellow crinum lily

Marshallese: ***kieb*** (general term for most lilies)

Recent introduction. Fiji, New Caledonia. Occasional. Planted ornamental lily with yellow to yellow-green leaves; found in the garden area of Robert Reimers Enterprises. Often mistaken for *C. asiaticum*, which is larger and has green, rather than yellow, mature leaves (RRT 1991, 1999, 2000AB, 2001; NVV 2000).**

Crinum zeylanicum L. milk-and-wine lily

Syns. *Crinum latifolium* var. *zeylanicum* (L.) Hook. ex Trimen; *C. scabrum* Herbert

Recent introduction. Africa to tropical Asia. Occasional. Planted ornamental in household gardens; planted near sign near the street of Marshall Islands High School (NVV 2000; RRT 2000B).**

Eucharis grandiflora Planch. & Lind. Amazon lily, eucharis lily
Syn. *Eucharis amazonica* Lind.

Recent introduction. Colombia. Rare. Potted plant in household garden in Rita; also found in Amata Kabua's garden (NVV 2000; RRT 2000A, 2001) (DPMJ0650).**

Hippeastrum reticulatum (L'Héritier) Herb.

Recent introduction. Southern Brazil. Rare. Single plant seen in private flower gardens Delap and Rita. White lily with red linear or reticulate markings (RRT 2000B; NVV 2000) (DPMJ0330).**

Hippeastrum striatum (Lam.) Moore Barbados lily, amaryllis
Syns. *Hippeastrum equestre* (Ait.) Herb.; *Amaryllis equestris* Ait.
Misapplied name: *Hippeastrum puniceum* (Lam.) Urban

Recent introduction. Tropical America. Occasional. Planted ornamental lily with salmon-orange colored flowers. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0121, DPMJ0609).*

Hymenocallis petalis Herbert spider lily
Misapplied syn. *Hymenocallis littoralis* (Jacq.) Salisb., *Pancratium littorale* Jacq.

Marshallese: ***kieb*** (general term for most lilies); ***kieb wau*** ('lily of Oahu')

Recent introduction. Tropical America. Common. Planted ornamental in household; a couple of plants growing near the lagoon coast in Ajeltake (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Narcissus pseudo-narcissus L. daffodil, tete-a-tete

Recent introduction. Europe. Four young potted plants imported from Hawai'i by Bilimon's Store in Uliga, January 2001 (NVV 2001).**

Proiphys amboinensis (L.) Herbert Amazon lily, Brisbane lily, Cardwell lily
Syns. *Eurycles amboinensis* (L.) Lind.; *E. sylvestris* Salisb.

Recent introduction. Malaysia and northern Australia. Uncommon. Planted ornamental and potted plant in household gardens. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV 2000) (2K00418; DPMJ0400, DPMJ0401). *

Zephyranthes candida (Lindl.) Herb.
zephyr flower, white star of Bethlehem, westwind flower, storm lily

Recent introduction. Argentina and Uruguay. Rare. Planted ornamental in private garden (RRT 1991, NVV 2000).**

Zephyranthes citrina Baker yellow zephyr flower, yellow rain lily
Syn. *Zephyranthes eggersiana* Urb.

Recent introduction. Cuba. Rare. Planted ornamental. In planter box at the Bank of Hawaii near the Capitol Building growing together with *Z. rosea (*NVV 2000; RRT 2000A).**

Zephyranthes rosea (Lindl.) Green
pink lady, pink star of Bethlehem, pink zephyr lily, pink rain lily

Recent introduction. Guatemala and West Indies. Abundant. Planted ornamental used as a border in many private gardens. Extensively planted in planter boxes in front of the Capital Building and Gibson's Supermarket. Naturalized in some household gardens and rural ruderal sites (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0443, DPMJ0444, DPMJ0618).

ARACEAE (Arum Family)

Aglaonema commutatum Schott Chinese evergreen, aglaonema

Recent introduction. Indonesia to the Pacific Islands. Occasional. Ornamental potted plant. Previously reported on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0031, DPMJ0034a, DPMJ0220, DPMJ0660a, DPMJ0661).*

Aglaonema costatum N.E. Br. ribbed aglaonema

Recent introduction. Southeast Asia. Rare. Ornamental potted plant, possibly now extirpated (RRT 1991).**

Aglaonema crispum (Pitcher & Manda) D.H Nicholson curly aglaonema
Syns. *Schismatoglottis crispa* Pitcher & Manda; *S. robelinii* Lind.; *Aglaonema robelinii* (Lind.) Hort. ex Gentil

Recent introduction. Philippines. Rare. Ornamental potted plant, found in the main office of the Outrigger Marshall Islands Resort (NVV 2000; RRT 2000A) (DPMJ0030).**

Aglaonema treubii Engl. ribbon aglaonema

Recent introduction. Celebes, Indonesia. Rare. Ornamental potted plant in Amata Kabua's garden (RRT 2001) (DPMJ0660b).*

Alocasia cucullata (Lou.) G. Don Chinese taro

Recent introduction. India. Occasional. Planted ornamental and potted plant (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0226, DPMJ0646).**

Alocasia cuprea C. Koch. giant alocasia

Recent introduction. Borneo. Occasional. Planted ornamental and potted plant in household gardens and offices (NVV 2000; RRT 2000AB, 2001) (DPMJ0169a, DPMJ0227, DPMJ0565).**

Alocasia indica (Roxb.) Schott var. **metallica** Schott
hybrid alocasia, hybrid elephant ears

Recent introduction. Java. Rare. Ornamental potted plant in household garden in Rairõk (RRT 2000A) (DPMJ0446).**

Alocasia longiloba Miq. x **sanderiana** Bull. hybrid alocasia

Recent introduction. Philippines and Malaysia. Rare. Planted ornamental potted plant at Ajidrik Hotel in Uliga and in another household garden (NVV 2000; RRT 2000AB) (DPMJ0125, DPMJ0228).**

Alocasia macrorrhiza (L.) Schott giant taro, elephant ears
Syn. *Alocasia indica* (Roxb.) Schott

Marshallese: ***wõt***

Aboriginal introduction. Tropical Asia. Occasional. Found naturalized in taro pits, other moist garden areas and under neglected coconut plantations in Laura; also found as a planted ornamental (StJ 1951; F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0511).

Alocasia regina N.E. Br. queenly alocasia

Recent introduction. Borneo. Rare. Ornamental potted plant at Ajidrik Hotel in Uliga and in a private garden in Rita (NVV 2000; RRT 2000A) (DPMJ0050, DPMJ0115).**

Alocasia sanderiana Bull. alocasia, kris plant

Recent introduction. Philippines. Occasional. Ornamental potted plant (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0207, DPMJ0229).**

Anthurium andraeanum Lind. common anthurium, hornet anthurium

Recent introduction. Tropical America. Uncommon. Ornamental potted plant in private garden in Rita and at Amata Kabua's residence. Previously reported from Kwajalein by F. S & O (1987) but evidently did not survive then was reintroduced (Whistler & Steele 1999) (RRT 1991, 2000AB, 2001; NVV 2000) (DPMJ0185, DPMJ0206, DPMJ0662).*

Caladium bicolor (Ait.) Vent artist's pallet, caladium

Recent introduction. Brazil. Common. Planted ornamental and potted plant in private gardens, as landscaping for some businesses and in offices. A range of different cultivars with a range of leaf color patterns are planted. Previously reported on Jaluit and Kwajalein by F. S & O (1987), did not survive on the former (Fosberg & Sachet 1962) but did on the latter (Whistler & Steele 1999) (RRT 1991, 1999, 2000AB, 2001: NVV 2000) (DPMK0113, DPMJ0607, DPMJ0645).*

Colocasia esculenta L. taro

Syns. *Colocasia antiquorem* Schott; *Caladium esculentum* Vent.

Marshallese: ***kõtak***; ***jibabwãi*** (variety)

Aboriginal introduction. Tropical Asia. Occasional. Staple food plant found as a minor component in *Cyrtosperma* taro pits and planted at Laura Experimental Farm as an irrigated monoculture; also found in local household gardens, including a couple of gardens planted by workers from Fiji and in a Filipino garden east of the airport (StJ 1951; F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0537).

Cyrtosperma chamissonis (Schott) Merr. giant swamp taro

Syns. *Cyrtosperma edule* Schott; *C. merkusii* (Hask.) Schott

Marshallese: ***iaraj***

Aboriginal introduction. New Guinea and Western Pacific Islands, to Micronesia and Polynesia. Common. Planted in taro pits in Laura, in pits at the Laura Experimental Farm and at Marshall Islands High School, Rita (1991), Robert Reimers Enterprises Hotel garden area and occasionally in some household gardens. Very important staple root crop and ceremonial food in the past. Corms cooked as a staple vegetable (StJ 1951; F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0523).

Dieffenbachia amoena Bull giant dumb cane

Syn. *Dieffenbachia seguine* (Jacq.) Schott "amoena"

Recent introduction. Tropical America. Uncommon. Ornamental potted plant in household gardens and offices (NVV 2000; RRT 2000AB, 2001)**

Dieffenbachia maculata (Lodd.) Bunt. spotted dumb cane

Syn. *Dieffenbachia picta* Schott

Recent introduction. Brazil. Occasional. Ornamental potted plant in household gardens and commercial areas (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0034a, DPMJ0124a, DPMJ231a, DPMJ0476, DPMJ0629).**

Dieffenbachia seguine (Jacq.) Schott dumb cane

Recent introduction. Northern South America and Caribbean. Occasional. Ornamental potted plant and garden plant. Previously reported on Kwajalein by F. S & O (1987). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0213b).*

Dieffenbachia splendens Hort. Bull. splendid dumb cane

Syn. *Dieffenbachia leopoldii* Bull. X *Dieffenbachia maculata* (Loddiges) D. Don

Recent introduction. Tropical America. Rare. Ornamental potted plant in Amata Kabua's garden (RRT 2001) (DPMJ0655).**

Epipremnum aureum (Lind. ex Andre) Bunt.

taro vine, pothos aureus, money plant, devil's ivy

Syns. *Rhaphidophora aurea* (Lind. ex Andre) Birds.; *Scindapsus aureus* (Lind. ex Andre) Engl.; *Pothos aureus* Lind. ex Andre; *Epipremnum pinnatum* (L.) Engler cv. "Aureum"; *Epipremnum pinnatum* (L.) Engler cv. "Pothos"

Recent introduction. Solomon Islands. Occasional. Planted ornamental high-climbing vine in household gardens; occasionally as a potted plant. Seems to be adventive and growing naturally on trees along the back road of Laura. Previously reported on Enewetak, Kwajalein and Jaluit by F. S & O (1987) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0535).*

Monstera deliciosa Liebm. var. **minima** small monstera

Recent introduction. Tropical America. Rare. Potted ornamental climbing plant in office at the Outrigger Hotel (NVV 2000; RRT 2000A) (DPMJ0049).**

Monstera obliqua Miq. window-leaf taro vine

Recent introduction. Tropical America. Uncommon. Potted ornamental climbing taro-like vine with regularly spaced holes in the leaves found a couple household gardens in Rita and one in Woja (NVV 2000; RRT 2000B) (DPMJ0194).**

Philodendron andreanum Devansaye velour philodendron

Syn. *Philodendron melanochryson* Lind. & André

Recent introduction. Colombia and Costa Rica. Rare. Ornamental potted plant in household garden east of airport, at Ajidrik Hotel and the U. S. Embassy (NVV 2000; RRT 2000AB).**

Philodendron hastatum C. Koch & Sellow. spear-shaped philodendron

Recent introduction. Brazil. Rare. Ornamental potted plant seen in household garden in Rairõk (RRT 1991, 2000B; NVV 2000) (DPMJ0375, DPMJ0480).**

Philodendron lacerum (Jacq.) Schott. lacerated philodendron

Recent introduction. Cuba. Uncommon. Ornamental potted plant, often planted indoors; found in planter box at Ajidrik Hotel (RRT 2000AB; NVV 2000) (DPMJ0126).**

Philodendron lehmannii Engl. Lehmann's philodendron

Recent introduction. Columbia. Rare. Ornamental potted plant with shiny *Aglaonema*-like leaves in garden in Rita (RRT 2000A; NVV 2000) (DPMJ0002).**

Philodendron oxycardium Schott var. **variegatum** sharp-heart philodendron
Syn. *Philodendron scandens* C. Koch & Sellow ssp. *oxycardium* (Schott) Bunt.

Recent introduction. Tropical America. Occasional. Ornamental potted plant; most commonly with variegated leaves. Previously recorded on Kwajalein by F. S & O (1987) (RRT 1991, 2000AB; NVV 2000) (DPMJ0020, DPMJ0376).*

Philodendron panduraeforme (HBK.) Kunth. fiddle-leaf philodendron

Recent introduction. Venezuela. Rare. Ornamental potted plant at Amata Kabua's residence (RRT 2001) (DPMJ0653).**

Philodendron radiatum Schott. rayed philodendron

Recent introduction. Central America. Uncommon. Ornamental houseplant, in office of Outrigger Marshall Islands Resort (NVV 2000; RRT 2000AB, 2001) (DPMJ0048, DPMJ0179).**

Philodendron squamiferum Peopp. squamiferous philodendron

Recent introduction. South America. Uncommon. Ornamental potted plant seen in a number of places as an indoor and outdoor plant (NVV 2000; RRT 2000AB, 2001) (DPMJ0017, DPMJ0377).**

Philodendron williamsii Hook. f. Williams' philodendron

Recent introduction. Tropical America. Rare. Potted plant in household garden in Rita and Rairõk (NVV 2000; RRT 2000AB) (DPMJ0378).**

Philodendron sp. philodendron

Recent introduction. Tropical America. Rare. Ornamental potted plant. Previously reported on Kwajalein by F. S & O (1987) (RRT 2000AB, 2001; NVV 2000) (DPMJ0049).*

Spathiphyllum cv. "**Clevelandii**" spathiphyllum, white sails

Recent introduction. Horticultural origin. Uncommon. Ornamental potted plant in offices and private gardens; imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants. (RRT 1991, 1999, RRT 2000A; NVV 1999).**

Syngonium augustatum Schott syngonium, arrowhead vine, goosefoot
Syn. *Syngonium podophyllum* sensu Souder non Schott

Recent introduction. Mexico. Occasional. Potted plant and planted ornamental in household gardens. Previously reported on Kwajalein by F. S & O (1987) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0172, DPMJ0520a).*

Syngonium wendlandii Schott. velvety syngonium

Recent introduction. Costa Rica. Uncommon. Potted plant seen in two houseyard gardens (RRT 2000A, 2001) (DPMJ0123, DPMJ0448, DPMJ0579).**

Xanthosoma sagittifolium (L.) Schott tannia, yautia, cocoyam, American taro

Marshallese: ***alõklõk*** ("thorn"); ***kãlõklõk*** ("thorns", "brambles", a name also applied to *Ximenia americana*, which is native to other Marshall Islands' atolls but not present on Majuro, *Cenchrus echinatus*, and *Caesalpinia bonduc*)

Recent introduction. West Indies. Uncommon. Food crop planted in some household gardens, in some taro pits and gardens in Laura and at the Laura Experimental Farm and Marshall Islands High School in 1991. Previously reported on Ailinglaplap, Arno and Jaluit by F. S & O (1987) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0578).*

Zantedeschia rehmanii Engl. red calla lily, pink calla lily

Recent introduction. South Africa. Rare. Ornamental household garden and potted plant (RRT 1991; NVV 2000).**

ARECACEAE or **PALMAE** (Palm Family)

Areca catechu L. betelnut palm

Recent introduction. Malaya. Rare. A number of seedlings about 25 cm high from seed brought from Palau. Seen in a houseyard garden in Rairõk. Previously reported on Jaluit by F. S & O (1987) but did not survive (Fosberg & Sachet 1962) (RRT 2000B) (DPMJ0237).*

Caryota urens L. fishtail palm, wine palm, toddy palm

Recent introduction. Tropical. Asia. Uncommon. Ornamental potted plant; single palms seen in two household gardens in Rita and another in the compound of the Chinese Embassy in Delap. Previously reported on Jaluit by F. S & O (1987) but did not survive (Fosberg & Sachet 1962). One or more could also be *C. mitus* recorded on Kwajalein by Whistler & Steele (1999) (NVV 2000; RRT 2000AB).*

Chamaedorea elegans Mart. parlor palm, neanthe bella palm
Syns. *Collinia elegans* (Mart.) Liebm.; *Neanthe bella* O.F. Cook

Recent introduction. Central America. Uncommon. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants; some survive in household gardens and in houses and offices (NVV 1999).**

Chrysalidocarpus lutescens H. Wendl. golden cane palm, golden-fruited palm

Recent introduction. Madagascar. Uncommon. Planted ornamental. A few trees planted on the grounds of the Capital Building and in household gardens in Rita. Previously reported on Kwajalein by F. S & O (1987) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0056).*

Cocos nucifera L. coconut palm

Marshallese: ***ni***

Indigenous and aboriginal introduction. Southern Asia, Indian Ocean and Pacific Islands. Very abundant. Found in coastal strand vegetation, household gardens, and as a roadside tree throughout Majuro. Planted in coconut plantations in rural Majuro and on uninhabited islets of Aeañen. The major cash crop for making copra which is processed into coconut oil and a wide range of other products, much of which is processed at Tobolar Copra facilities in Delap (StJ 1951; MDS 1977; F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0598).

Howea forsteriana (C. Moore & F. Muell.) Becc. kentia palm, sentry palm, thatch palm

Recent introduction. Lord Howe Island. Uncommon. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants; some remaining in household gardens, houses and offices (NVV 1999).**

Latania lontaroides (Gaertn.) H.E. Moore red latan palm
Syns. *Latania borbonica* Lam.; *Latania commersonii* J.F. Gmelin; *Latania rubra* Jacq.

Recent introduction. Réunion Island. Rare. Ornamental palm planted at the Lojkar Resort (NVV 2000; RRT 2000AB) (DPMJ0478).**

Latania verschaffeltii Lem. yellow latan palm

Recent introduction. Mascarene Islands. Uncommon. A number of young trees planted at the Lojkar Resort (NVV 2000; RRT 2000AB).**

Licuala grandis Wendl. ruffled fan palm

Recent introduction. New Britain and Vanuatu. Rare. Ornamental potted plant found in Rita and in Amata Kabua's garden. Grows well even under other trees and is showing invasive properties in some parts of Polynesia (NVV 2000; RRT 2000AB, 2001) (DPMJ0043, DPMJ0642).**

Livistona carinensis (Chiov.) J. Dransfield & N.W. Uhl banouale palm
Syn. *Wissmannia carinensis* Chiov.

Recent introduction. Somalia and Arabia. Uncommon. A number of young trees planted at the Lojkar Resort (NVV 2000; RRT 2000AB, 2001).**

Livistona chinensis (Jacq.) R. Br. ex Mart. Chinese fan palm, fountain palm
Syn. *Latania chinensis* Jacq.

Recent introduction. China, Ryukyu and Bonin Islands. Uncommon. Planted ornamental. Some trees planted on grounds of Outrigger Marshall Islands Resort, others at the Lojkar Resort and in a few other areas. *Livistona* sp. recorded earlier on Jaluit by F, S & O (1987), but did not survive (Fosberg & Sachet 1962) (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0354, DPMJ0478).**

Livistona rotundifolia (Lam.) Mart. biroo palm, footstool palm

Recent introduction. Indonesia and Malaysia. Rare. Single plant in household garden along main road in Rita (RRT 2000B; NVV 2000) (DPMJ0355).**

Nypa fruticans Wurmb nipa palm, nypa

Indigenous. Ceylon to Soloman Islands, Ryuku Islands, Queenslands and the Caroline Islands. Rare as drift fruit, likely not to survive. One sprouted drift fruit found along the beach near the airport in early 2002, along with several other non-sprouting fruit. All these possibly drifted in following the major tropical storm/typhoon that hit Kosrae and Pohnpei in late 2001, as other non-Marshalls drift seeds were also found with them (NVV 2002) (DPMJN010802).**

Phoenix dactylifera L. date palm

Recent introduction. North Africa. Rare. Single seedling growing in a container in Maria Fowler's garden; started from seed brought in from California. Previously reported on Jaluit by F, S & O (1987) and on Kwajalein by Herbst (1988), but did not survive on either (Fosberg & Sachet 1962; Whistler & Steele 1999) (NVV 2001).*

Phoenix roebelenii O'Brian ex. C. Roebelen dwarf date palm, pygmy date palm

Recent introduction. Sri Lanka. Uncommon. One young tree by entrance of Outrigger Marshall Islands Resort; others planted at the Lojkar Resort and in household gardens in Delap and Rairõk. Some individuals could be *P. pusilla*, the Ceylon date palm (NVV 2000; RRT 2000AB, 2001) (DPMJ0380).**

Pritchardia pacifica Seem. & Wendl. Pacific fan palm, Fiji fan palm

Recent introduction. Fiji, Tonga, and Samoa. Common. Planted ornamental behind Robert Reimers Hotel, Outrigger Marshall Islands Resort and in a number of other locations. Previously recorded on Ailinglaplap, Jaluit and Kwajalein by F. S & O (1987) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0399).*

Ptychosperma macarthuri (Wendl.) Nicholson MacArthur palm, hurricane palm

Recent introduction. Cape York Peninsula, Australia to New Guinea. Rare. Planted ornamental in a few household gardens and hotels. Previously reported on Kwajalein and Jaluit by F. S & O (1987) but did not survive (Fosberg & Sachet 1962; Whistler & Steele 1999) (RRT 1999, 2001; NVV 2000) (DPMJ0564a).*

Rhapis excelsa (Thunb.) Henry ex Rehder lady palm, bamboo palm

Recent introduction. Southern China. Uncommon. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants; some remaining in household gardens, houses and offices. Previously reported on Kwajalein by F. S & O (1987) but did not survive (Whistler & Steele 1999) (NVV 1999; RRT 2000AB, 2001) (DPMJ0160, DPMJ0615, DPMJ0643).*

Sabal sp. palmetto palm

Recent introduction. Tropical America. Rare. A number of trees planted at the Lojkar Resort (NVV 2000; RRT 2000AB).**

Veitchia merrilli (Becc.) H.E. Moore Manila palm, Christmas palm

Recent introduction. Philippines. Uncommon. A number of trees planted at the Lojkar Resort, on the grounds of the Capitol Building and in some other locations (NVV 2000; RRT 2000AB, 2001) (DPMJ0439).**

BROMELIACEAE (Pineapple Family)

Ananas comosus (L.) Merrill pineapple

Recent introduction. Brazil. Uncommon. Planted food plant in pots and sometimes in the ground in household gardens; one planted in container at Ajidrik Hotel. Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce pineapple (F, S & O 1987; RRT 1991, 1999, 2000AB; NVV 2000).

Billbergia pyramidalis (Sims) Lindl. billbergia, summer torch

Recent introduction. Brazil. Rare. Ornamental potted plant in Rita (RRT 2001).**

Nidularium innocentii Lem. bird's nest bromeliad, nidularium

Recent introduction. Brazil. Rare or extirpated. Ornamental potted plant (RRT 1991).**

Tillandsia cyanea Linden ex. K. Koch pink quill

Recent introduction. Equador. Rare. Single potted plant imported from Hawai'i for sale at Bilimon's Store in Uliga, January 2001 (NVV 2001).**

CANNACEAE (Canna Family)*

Canna x **generalis** L.H. Bailey — Indian shot, canna lily
Syn. often misidentified as *Canna indica* L.

Marshallese: ***añ***

Recent introduction. West Indies. Occasional. Planted hybrid ornamental in household gardens; seen in Rita and at U. S. Embassy. Previously reported on Kwajalein, Arno and Jaluit by F. S & O (1987) as *C. indica*. Has the potential of becoming invasive and is difficult to remove when established in an area (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0246).*

COMMELINACEAE (Dayflower Family or Spiderwort Family)*

Callisia fragrans (Lindl.) Woodson — fragrant inch plant, basketplant
Syns. *Spironema fragans* Lindl.; *Rectanthera fragrans* (Lindl.) Degener

Recent introduction. Tropical America. Rare. Planted ornamental in a private garden in Rita. Can become invasive (NVV 2000; RRT 2000A) (DPMJ0196). **

Callisia repens (Jacq.) L. — mini turtle vine, creeping inch plant

Recent introduction. Tropical America. Uncommon. Potted plant at the University of the South Pacific Center in Delap and in a couple of other household gardens, one in Rairõk (RT2000AB, 2001; NVV 2000) (DPMJ0102, DPMJ0105, DPMJ0106, DPMJ0266, DPMJ0602).**

Commelina diffusa Burm. f. — dayflower

Recent introduction. Southern Asia. Rare or extirpated. Growing against wall, possibly as an ornamental, in the garden of the Japanese Takeout Restaurant in 1991; not seen during any subsequent surveys. Previously reported on Jaluit by F. S & O 1987, but identification was uncertain and it did not survive (Fosberg & Sachet 1987). Can become invasive (RRT 1991).*

Dichorisandra thyrsiflora Mikan — blue ginger, purple ginger

Recent introduction. Brazil. Uncommon. Found as a potted plant in a number of household gardens in Rita, Rairõk and Ajeltake (NVV 2000; RRT 2000AB).**

Tradescantia pallida (Roxe) D. Hunt — purple tradescantia, purple heart
Syn. *Setcreasia purpurea* B. K. Boom

Recent introduction. Mexico. Occasional. Ornamental potted plant in household gardens throughout the atoll. Previously reported on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0435).*

Tradescantia spathacea Swartz — oyster plant, Moses-in-a-boat, dwarf oyster plant
Syns. *Rhoeo spathacea* (Sw.) Stearn; *Rhoeo discolor* (L'Her.) Hance.

Recent introduction. Mexico and West Indies. Common. Potted plant and planted ornamental; planted along borders and pathways in ornamental gardens. Previously reported on Kwajalein, Ailuk, Likiep, Arno, Ailinglaplap, Jaluit and Ebon by F. S & O (1987). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0605).*

Tradescantia zebrina Bosse — wandering Jew, silver inch plant
Syn. *Zebrina pendula* Schnizl.

Recent introduction. Mexico. Occasional. Ornamental potted plant in private household gardens in Rita. Can become invasive (NVV 2000; RRT 2000AB) (DPMJ0168b, DPMJ0436)**

COSTACEAE (Costus Family or Crepe Ginger Family)**

Costus malortianus H. Wendland — stepladder plant

Recent introduction. Costa Rica. Rare. Planted ornamental in household gardens (RRT 2000AB, 2001; NVV 2000) (DPMJ0271).**

Costus speciosus (Koen.) Sm. — crepe ginger, Malay ginger, spiral flag

Recent introduction. Malaysia to India. Rare. Planted ornamental. Has become invasive in some areas but not yet in Micronesia (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0208, DPMJ0270, DPMJ0465).**

CYPERACEAE (Sedge Family)

Cyperus compressus L. summer sedge

Recent introduction. Pantropical. Abundant. Weed growing in rather dense populations in low ground near abandoned taro pits and poorly-drained areas in Laura; common in weedy areas in the industrial area (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0284, DPMJ0285, , DPMJ0592, DPMJ0686, DPMJ0745).

Cyperus difformis L. smallflower umbrella sedge

Recent introduction. Old World tropics, now pantropical weed. Rare. A number of plants found in a swampy area in field and near dump area near Majuro Bridge in late 2001. Can become a weed of agricultural areas (RRT 2001, NVV 2001) (DPMJ0682, DPMJ0683, DPMJ0731) .**

Cyperus involucratus Rottb. umbrella sedge, umbrella plant
Syn. *Cyperus alternifolius* L.

Recent introduction. Madagascar. Uncommon. Planted as an ornamental in planter boxes of the Riwut Corner Gas Station in Delap and in household gardens. Previously reported on Jaluit by F. S & O (1987) but did not survive (Fosberg & Sachet 1962). Can become invasive (NVV 2000; RRT 2000AB, 2001) (DPMJ0286, DPMJ0630). *

Cyperus javanicus (Houtt.) marsh sedge
Syn. *Mariscus javanicus* Houtt. Merr.

Marshallese: ***wûjooj-in-eoon-bõl*** ("grass of the edge of the taro pit")

Indigenous. Paleotropical. Common. Found growing wild in isolated clusters and tufts and in colonies in moist habitats on the coastal strip, in and around taro pits in Laura, on the inner border of the coastal strand, and in ruderal habitats (StJ 1951; F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0360, DPMJ0361, DPMJ0362, DPMJ0527, DPMJ0536, DPMJ0539, DPMJ0586c).

Cyperus lingularis L. rocket sedge; swamp flatsedge; Caribbean sedge

Recent introduction. Tropical America and Africa. Uncommon. A large number of plants in a field where IBC's heavy equipment is stored, next to the south end of the water catchment. Also near the container yard of Delap Dock. Previously reported on Guam, so this species could have been brought in with heavy equipment or containers. Has spread to other ruderal and roadside sites in Rairõk. Potentially invasive and its attractive nature cause further spread if used in flower arrangements (NVV 2000, RRT 2001) (DPMJ0730, DPMJ0740).**

Cyperus odoratus L. fragrant flatsedge

Syn. *Torulinium odoratum* (L.) S. Hooper

Marshallese: ***bûkõr***

Indigenous or possibly a weed of aboriginal introduction. Southern Asia to the Pacific Islands. Uncommon. Weed in moist ruderal sites, in and around taro pits and in other wet sites; found in a moist site just east of Majuro Bridge (F, S & O 1987; FRF 1990; RRT 1999, 2001; NVV 2001) (DPMJ0482, DPMJ681, DPMJ0732).

Cyperus polystachyos Rottb. wild sedge

Syn. *Pycreus polystachyos* (Rottb.) P. Baeuv.

Indigenous? Uncertain origin, but now found throughout tropical and subtropical regions. Possibly native on at least some atolls and of aboriginal or recent introduction on others. Common. Weed in waste places and near giant swamp taro pits; common near the industrial area in some waste places (F, S & O 1987; RRT 1991, 1999; 2000AB, 2001; NVV 2000) (DPMJ0409).

Cyperus rotundus L. nut sedge, nut grass; flat sedge

Marshallese: ***tuteoneon***

Recent introduction. Cosmopolitan. Common. Weed in gardens, at Laura Experimental Farm, in other vegetable farms at Laura and along roadsides, other ruderal sites and in sandy areas. Can become invasive (FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0740).**

Eleocharis geniculata (L.) Roem. & Schulte spike rush

Marshallese: ***pãdãdijmaan***; ***pãdãlimaan*** (names also applied to *Fimbristylis cymosa*, *Fimbristylis dichotoma* and sometimes to similar sedges)

Indigenous. Pantropical and subtropical. Rare. Seen present in one small, scattered population in a natural depression of freshwater of Lobat, Laura, along the back road. Previously reported present on Ailuk, Arno, Jaluit, Likiep, and Kwajalein by F, S & O (1987) (RRT 2000AB, 2001; NVV 2000) (2K0042; DPMJ129S; DPMJ0130S, DPMJ0303, DPMJ0304, DPMJ0305, DPMJ0528, DPMJ0529, DPMJ0530).*

Fimbristylis cymosa R. Br. beach sedge

Marshallese: ***pãdãdijmaan***; ***pãdãlimaan*** (names also applied to *Eleocharis geniculata, Fimbristylis dichotoma* and sometimes to similar sedges)

Indigenous. Pantropical. Abundant. Found growing in clusters or tufts in open and semi-open places along ocean and lagoon coasts and in disturbed and open inland sites dominated by limestone rock and debris (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Fimbristylis dichotoma (L.) Vahl tall fringe rush

Syn. *Scirpus dichotomus* L.; *Fimbristylis diphylla* (Retz.) Vahl

Marshallese: ***pãdãdijmaan***; ***pãdãlimaan*** (names also applied to *Fimbristylis cymosa, Eleocharis geniculata* and sometimes to similar sedges)

Indigenous or possibly a weed of aboriginal introduction. Pantropical. Abundant. Found in grassy areas and ruderal sites throughout the atoll. Easily confused with *F. cymosa*, but has looser inflorescence, often of a lighter color and thus probably escaped notice in earlier surveys (RRT 2000A, 2001; NVV 2001) (DPMJ0743, DPMJ0744b).**

Kyllinga brevifolia Rottb. green watersedge, green kyllinga

Syn. *Cyperus brevifolius* (Rottb.) Hassk.

Recent introduction. Old World tropics, now pantropical. Occasional. Small patch found growing in wet area near Uliga dock and in lawns in Rita, Delap, Botkan and Lojkar Resort. Previously reported present on Jaluit but did not survive (Fosberg & Sachet 1962). An invasive weed of much of the Pacific (NVV 2000; RRT 2000AB, 2001) (DPMJ0168b, DPMJ0175).*

Kyllinga nemoralis (Forst.) Dandy ex Hutchinson and Dalziel

white watersedge, white-flowered kyllinga

Syn. *Cyperus kyllingia* Endl.

Recent introduction. Old World tropics. Common to locally abundant. Found growing on the border of a giant swamp taro pit in Laura, in lawns at Gibson's Laura Superette and Lojkar Resort, and in many ruderal sites and gardens in the DUD. Previously reported on Jaluit and Arno by F. S & O (1987). An invasive weed (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0345, DPMJ0725, DPMJ0558, DPMJ0595, DPMJ0725).*

DIOSCOREACEAE (Yam Family)

Dioscorea alata L. greater yam

Recent. introduction. Southeast Asia. Three plants planted in drums in nursery behind the Resources and Development Building in September 2000; reportedly introduced from Ebon Atoll. Large yam, which could be *D. nummularia* instead, climbing tree at Amata Kabua's in November 2001. Previously reported on Jaluit by F. S & O (1987) by did not survive (Fosberg & Sachet 1962). Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce this species (RRT 2000AB, 2001; NVV 1999) (DPMJ0296, DPMJ0574, DPMJ0669, DPMJ0670).*

Dioscorea bulbifera L. bitter yam, air yam, aerial yam, air potato

Marshallese: ***mata*** (?) (name given by Fosberg & Sachet 1962 for *Dioscorea* sp.)

Aboriginal introduction? Tropical Asia to Africa. Uncommon. Growing wild in roadside vegetation and thicket in interior Laura and in another site near the Taiwanese Vegetable project (F, S & O 1987; RRT 1999, RRT 2000B; NVV 1999) (DPMJ0297, DPMJ0298).

HAEMODORACEAE (Hemodora Family)**

Xiphidium caeruleum Aublet xiphidium

Recent introduction. Caribbean. Rare. Single potted plant in household garden in Delap (NVV 2000; RRT 2000A) (DPMJ0005).**

HELICONIACEAE (Heliconia Family)**

Heliconia lathispatha Benth. red gyro, golden lobster's claw

Recent introduction. Central America to northern South America. Rare. Planted ornamental in household garden near end of Rita (NVV 2000; RRT 2000A, 2001) (DPMJ0118).**

Heliconia psittacorum L. f. parakeet heliconia, parrot flower

Recent introduction. Tropical South America. Uncommon. Ornamental potted plant in a private walled garden, at the U. S. Embassy and in a couple of other gardens (NVV 2000; RRT 2000AB, 2001) (DPMJ0192b, DPMJ0599).**

IRIDACEAE (Iris Family)**

Trimeza martinicensis (Jacq.) Herb. trimeza, yellow walk iris

Recent introduction. Tropical America. Rare. Planted ornamental in household gardens in Rita and Ajeltake (NVV 2000; RRT 2000A) (DPMJ0146b).**

LILIACEAE (Lily Family)

Agapanthus praecox Willd. African lily, lily of the Nile, agapanthus
Syns. *Agapanthus orientalis* F.M. Leighton; *Agapanthus africanus* (L.) Hoffmannsegg

Recent introduction. South Africa. Rare or extirpated. Planted ornamental; not seen since 1991 (RRT 1991).**

Asparagus densiflorus (Kunth) Jessup
coarse asparagus fern, Sprenger's asparagus, regal fern
Syns. *Asparagus sprengeri* Regel; *Asparagus aethiopicus* L.

Recent introduction. South Africa. Uncommon. Ornamental potted plant. Imported by Robert Reimers Enterprises in 1998 and 1999 as houseplants. Previously reported on Kwajalein by F. S & O (1987). Has invaded coastal forest and rainforests in Australia (RRT 1991, 2000AB, 2001; NVV 1999) (DBMJ0015c).

Asparagus setaceus (Kunth) Jessup lacy asparagus fern, climbing asparagus fern
Syns. *Asparagus setacea* Kunth; *Asparagus plumosus* Baker

Recent introduction. South Africa. Rare. Ornamental potted plant; brought in by Bilimon's Store from Hawai'i. Previously recorded on Kwajalein but did not survive (Whistler & Steele 1999). Has become a serious weed on Lord Howe Island (NVV 2000; RRT 2000AB) (DPMJ0015a, DPMJ0238).*

Aspidistra elatior Bl. aspidistra, cast-iron plant

Recent introduction. China. Rare. Ornamental potted plant in Amata Kabua's garden and in one other houseyard garden in Rita (RRT 2000B, 2001) (DPMJ0047, DPMJ0644).**

Chlorophytum comosum (Thunb.) Jacq. spider plant, ribbon plant, bracket plant
Syns. *Chlorophytum elatum* R. Br.; *Chlorophytum capense* (L.) Voss

Recent introduction. Africa. Occasional. Ornamental potted plant. Previously reported on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0601, DPMJ0603).*

Gloriosa superba L. climbing lily, gloriosa lily, glory lily, fire lily
Syn *Gloriosa rothschildiana* O'Brien

Recent introduction. Tropical Africa in the areas of Uganda. Rare. Ornamental found in garden of Good Earth Apartments, Delap (NVV 2000; RRT 2000A) (DPMJ0157).**

Hemerocallis fulva L. orange day lily, fulvous day lily, pumpkin lily

Recent introduction. Europe and Asia. Uncommon. Ornamental lily with a compound orange flower found in household gardens in Rita, Lojkar Resort and a number of other locations. *H. fulva* var. "Kwanso" was seen at Lojkar Resort (NVV 2000; RRT 2000AB, 2001) (DPMJ0203).**

Tulipa sp. tulip

Recent introduction. Europe and Asia. Rare. Four potted plants with withering yellow flowers imported from Hawai'i by Bilimon's Store in Uliga, January 2001; a species not suited to tropical climates and it is unlikely any survived (NVV 2000).**

MARANTACEAE (Arrowroot Family)**

Calathea makoyana (Mor.) Nichols peacock plant

Recent introduction. Brazil. Rare. Ornamental potted plant in Amata Kabua's garden (RRT 2001) (DPMJ0641, DPMJ0647).**

Calathea ornata (Lind.) Koern. ornate calathea, ornate peacock plant
Syn. *Maranta ornata* Lind.

Recent introduction. Northern South America. Occasional. Ornamental potted plant in offices and homes. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants (RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0006, DPMJ0116).**

Calathea picturata (Lind.) K. Koch — picture calathea
Syn. *Calathea vandenheckei* (Lem.) Reg.

Recent introduction. Brazil. Rare. Ornamental potted plant in offices and homes (NVV 2000: RRT 2000B) (DPMJ0029c).**

Calathea zebrina (Sims) Lindl. — zebra calathea, zebra plant
Syn. *Maranta zebrina* Sims

Recent introduction. Brazil. Rare. Ornamental potted plant in offices and homes (RRT 1991, 2000AB; NVV 2000).**

Maranta leuconeura Morr. — prayer plant, ten commandments

Recent introduction. Brazil. Rare. Small potted plant found at a private household garden in Rairõk (RRT 2000B) (DPMJ0359).**

MUSACEAE (Banana Family)

The nomenclature for the genus *Musa* is confused, with most of the common seedless cultivars or clones being triploid crosses of the fertile species *Musa acuminata* Colla and *M. balbisiana* Colla. The Latin binomials *M. nana* Loureiro, *M. sapientum* L., and *M. paradisiaca* L. are commonly used as follows: *M. nana* for the dwarf Cavendish, and *M. sapientum* for the taller bananas, which are generally eaten ripe, but which are also cooked throughout the Pacific as starchy staples, and *M. paradisiaca* for the starchier bananas or plantains, which are usually eaten cooked as a staple starch, but occasionally eaten ripe as fruit. The nomenclature most widely used by agronomists is that developed by Simmonds, which classifies all cultivars or clones on the basis of their assumed genetic background, e.g., *Musa* ABB Group would be a triploid cross of one *M. acuminata* group and two *M. balbisiana* groups. Both nomenclature systems are presented here to more precisely identify the clones that are currently present in Majuro or the Marshall Islands.

Musa (AA Group) Simmonds — banana

Marshallese: ***lõktaan***; ***pinana*** (from English "banana", general term); ***keeprañ*** (general term, obsolete)

Recent introduction. Southeast Asia. Common. Planted food plant in many gardens throughout the atoll (Abo et al. 1985; Watson 1993, NVV 2001; RRT 2001).

Musa (AAA Group) Simmonds banana, robusta, poyo, mons marie
Syns. *Musa sapientum* L.; *Musa paradisiaca* L. var. *sapientum* (L.) Kuntze; *Musa paradisiaca* L. ssp. *sapientum* (L.) Kuntze; *Musa acuminata* Colla cvs.

Marshallese: ***jeina*** (from English word"China"); ***pinana*** ("banana", general term), ***keeprañ*** (general term, obsolete)

Recent introduction. Southeast Asia. Occasional. Planted food plant in some garden areas and at Laura Experimental Farm and other farms in Laura (StJ 1951; F, S & O 1987; RRT 1991, 1999, 2000, 2001; NVV 1999).

Musa (AAB Group) "Ney Poovan", "Lady's finger" Simmonds lady's finger banana
Syn. *Musa acuminata* Colla x *Musa balbisiana* Colla

Marshallese: ***jilubukwi*** ("three-hundred", in reference to abundant number of fruit); ***abōl*** ("apple"); ***Manila***; ***aelōñ kein*** (this country/domain); ***jokuwa***; ***pinana*** (from English "banana", general term), ***keeprañ*** (general term, obsolete)

Recent introduction. South India. Abundant. Planted in household gardens throughout atoll. One of the most popular of the eating bananas (Abo et al. 1985; Watson 1993, RRT 1991, 1999, RRT 2000AB, 2001; NVV 1999) (DPMJ0727, DPMJ0519).

Musa (AAB Group) "Meika Maohi" Simmonds Pacific plantain

Recent introduction. Pacific Islands. Rare. Planted in gardens of some Fijian families; known in Fiji as "vudi" (RRT 2000) (DPMJ0198).**

Musa (ABB Group) Simmonds
cooking banana, plantain, bluggoe, Ney Mannan (blue Java)
Syn. *Musa* x *paradisiaca* L. var. hort. Bluggoe (*M. acuminata* Colla x *M. balbisiana* Colla); Saba (BBB?)

Marshallese: ***jook*** (from English "chalk" because of the whitish, waxy covering of fruits); ***mikenji*** ("McKenzie" after Boyd McKenzie, Trust Territory agriculturist who introduced this variety); ***pinana*** (from English "banana", general term); ***keeprañ*** (general term, obsolete)

Aboriginal introduction? Southeast Asia and Pacific. Common. Important traditional supplementary staple in many areas of the Pacific, where it also seems to be an aboriginally introduced cultivar. One of the most common cooking bananas in Majuro. Planted in household gardens, near taro pits and in rural areas (Abo et al. 1985; Watson 1993, RRT 1991, 1999, 2000A, 2001; NVV 1999) (DPMJ0534, DPMJ0727).

Musa cultivars bananas and plantains

There are a number of banana and plantain cultivars of uncertain identity with the following Marshallese names, some of which may refer to some of the cultivars described above: ***inajio***; ***jolukur***; ***jorukwōd***; ***kaboj***; ***kai mana***; ***kilbōt*** (Kiribati); ***lōjennomaj***; ***manlui***; ***mile***; ***mōkadkad*** ("tramp")

ORCHIDACEAE (Orchid Family)*

Arundina graminifolia (D. Don) Hochr. bamboo orchid

Syns. *Cymbidium bambusifolium* Roxb.; *Bletia graminifolia* D. Don; *Arundina bambusifolia* Roxb. Ex Lindl.

Recent introduction. India, southern China, southeastern Asia and Malaysia as far east as Celebes. Rare. Planted ornamental in houseyard gardens; planted in former President Amata Kabua's garden (NVV 2000; RRT 2000AB, 2001).**

Dendrobium bigibbum Lindl. pink dendrobium

Recent introduction. Australia, Torres Strait Islands and New Guinea. Rare. Mauve to pink orchid in planter in houseyard garden (RRT 2000A; NVV 2000) (DPMJ0467).**

Dendrobium gracilicaule F. Muell. yellow dendrobium

Recent introduction. Australia, Lord Howe Island, New Caledonia and Fiji. Rare. Yellow orchid with red-brown markings on the lip. Ornamental in the household garden near the airport; also possibly in private garden in Woja (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0288, DPMJ0289).**

Dendrobium lasianthera J.J. Smith dendrobium orchid

Recent introduction. Lowland New Guinea. Rare. Single plant grown in a private garden in Woja (RRT 2000B; NVV 2000) (DPMJ0290, DPMJ0291).**

Dendrobium lineale Rolfe dendrobium orchid

Syn. *Dendrobium veratrifolium* Lindl.

Recent introduction. Lowland New Guinea and adjacent islands. Uncommon. Planted ornamental with twisted purplish-pink petals. Ornamental in the private household garden near the airport and in a number of other gardens. This large section *Spathulata* is quite variable in color, and some of these plants could be color variants of *D. gouldii* Reichb. f., which is native from New Ireland to Solomon Islands (RRT 1999, 2000AB; NVV 2000) (DPMJ0215b, DPMJ0292, DPMJ0295).**

Dendrobium nobile Lind. var. **virginalis** virginal orchid, "virginale"

Recent introduction. India, Burma, Thailand, Laos, Vietnam and China. Rare. Ornamental potted plant (NVV 2000; RRT 2000AB, 2001) (DPMJ0181, DPMJ0293).**

Epidendrum ibaguense H.B.K. crucifix orchid
Syn. *Epidendrum radicans* Paxón ex Lind (misapplied)

Recent introduction. Columbia. Rare. Found in a private garden just east of the airport. Apparently a hybrid cross between *E. evectum* J.D. Hooker and *E. radicans* Pavón ex Lindly (RRT 1999, 2000AB; NVV 2000) (DPMJ0215a).**

Oncidium bifolium Sims dancing ladies, dancing dolls, butterfly orchid

Recent introduction. Bolivia, Brazil and Uruguay. Rare. Butterfly-like small yellow orchid with brown blotches in a private garden near the airport. An *Oncidium* sp., recorded on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB; NVV 2000) (DPMJ0369).**

Papilionanthe teres (Lind.) Schlect. vanda orchid
Syn. *Vanda teres* Lindl.

Recent introduction. Burma. Rare. Planted ornamental in household gardens (NVV 2000; RRT 2000A) (DPMJ0016, DPMJ0163).**

Papilionanthe 'Agnes Joaquim' Ridley hybrid vanda orchid
Syn. *Vanda* 'Miss Joaquim'

Recent introduction. Tropical Asia. Uncommon. On a trellis of the garden of former President Amata Kabua's residence; also found in several private gardens on Rairõk, where it was said to have been brought from Saipan. Naturally occurring vanda orchid hybrid between *Papilionanthe hookeriana* (Reich. F.) Schlect. and *P. teres* (Lind.) Schlect. Reportedly found in Miss Agnes Joaquim's garden in Singapore. Previously recorded on Kwajalein by F. S & O (1987) (NVV 2000; RRT 2000A).*

Spathoglottis plicata Blume Philippine ground orchid

Recent introduction. Ryukyu Islands to Australia and Caroline Islands. Common. Planted ornamental in gardens throughout the atoll. Deep purple variety is popular and said to have been brought in from Hawai'i in recent years. Previously recorded on Jaluit by F. S & O (1987) but did not survive (Fosberg & Sachet 1962), and on Kwajalein by Whistler & Steele (1999) (NVV 2000; RRT 2000AB, 2001) (DPMJ0107, DPMJ0631)*

PANDANACEAE (Pandanus Family)

The nomenclature for the genus *Pandanus* is, like *Musa*, confused, with some taxonomists classifying many of the common cultivars and wild clones or species, both edible and non-edible, as forms or varieties of *P. tectorius*. Other taxonomists consider them distinct species, often listing numerous species or varieties for a given area. For example, *P. odoratissimus* L. f. has long been thought to be synonymous with *P. tectorius*, but is not considered, by many authorities, to occur east of Malaysia. Similarly, *P. odoratissimus* L. f. var. *performs* Mart. has been used as a synonym for a wild and doubtful variety of *P. tectorius*, whereas Stone (1970) considers *P. fragrans* Gad. to be the common wild species on Guam, and does not consider *P. tectorius* to be present. Thus, the identifications are provisional, with most named cultivars being grouped under *P. tectorius*. In the 1930s, R. Kanehira, who studied dried collections shipped to him in Japan, considered many of the Marshall Islands pandanus to be endemic species, 12 said to be endemic just to the Marshall Islands, and another two to the Marshall Islands and nearby Caroline atolls. (Stone 1960) However, most recent research indicates that these are all probably just forms or horticultural clones of *P. tectorius*.

Pandanus tectorius Warb. pandanus, screw pine

Syns. for Marshall Islands primarily *Pandanus carolinianus* Martelli; *Pandanus pulposus* (Warb.) Martelli; *Pandanus fischerianus* Martelli; *Pandunus odoratissimus* L. f; others include many so-called endemics which are now considered invalid, such as *Pandanus jaluitensis* Kaneh., *Pandanus lakatwa* Kaneh., *Pandanus rhombocarpus* Kaneh.

Marshallese: ***bõb*** (general term for edible 'varieties' or horticultural clones); ***edwaan*** (wild 'varieties')

Indigenous as the wild ***edwaan***; probably an aboriginal introduction or locally horticulturally developed in the case of edible and particularly useful 'varieties', which are clones rather than actual horticultural varieties. Pacific Islands. Abundant. Found in coastal strand and lagoon forest, in rural agricultural areas, around taro pits and in household gardens. Very important fresh fruit and staple food in the Marshall Islands and other atoll countries. Named varieties listed for Majuro Atoll by Stone (1963) include: ***aelok, aelua, ajbwirik, bwiken, bûkõr, dubijin, edwaan-en-an-Nelu, edwaan-in-matolej, idebdin, inietok, jabwanbwok, jajloed; jatũrwee, joibeb, jonman, kõpnaan, kinwum, kounmaañ, kõmãlij,***

kûbwejeñõn, lañlõñ, leikmaan, lepni, libwijinmede, loarmwe, lõjokdãd, lõjmoa, lõkõtwa, lõmõen, lopiñpiñ, luwaju, mwajaal, nibuñ, tobwotin, utõttõt and ***wûnmaañ*** (other names are recorded for other atolls) (StJ 1951; MDS 1977; F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0698).

Pandanus sanderi Hort. ex Masters variegated pandanus

Recent introduction. Indomalaysia to the Pacific Islands. Occasional. Planted ornamental; a large, very old tree in the garden of Amata Kabua, where it was imported from Australia and may be the original plant. Also planted on the grounds of the Capitol Building, the Outrigger Marshall Islands Resort and various other business and residential locations (RRT 1991, 1999, 2000AB, 2001; NVV 1999).**

POACEAE or **GRAMINAE** (Grass Family)

Bambusa spp. bamboo

Marshallese: ***bae***; ***koba***

Recent introduction. Tropical Asia. Rare. Found at the Outrigger Marshall Islands Resort and in few other locations. A long-standing patch in Rairõk of a large type. Positive identity unsure and should be investigated further; *B. blumeana* and *B. multiplex* were recorded on Jaluit by F, S & O (1987) but neither species survived (Fosberg & Sachet 1962) (RRT 1999, 2000AB; NVV 1999).**

Bothriochloa bladhii (Retz.) S.T. Blake blue grass, Australian beadgrass
Syns. *Dichanthium bladhii* (Retz.) Clayton; *Andropogon bladhii* Retz.; *Dichanthium intermedium* (R. Br.) De Wit & Harl.; *Andropogon intermedius* R. Br.; *Bothriochloa intermedia* (R. Br.) Camus

Recent introduction. Tropical Africa through India to China and Australia. Abundant. Grass in open lots, roadsides and ruderal sites. Can become invasive (F, S & O 1987; RRT 1999, 2000AB, 2001; NVV 1999) (2K00401; DPMJ0134S, DPMJ0135S, DPMJ0687).

Cenchrus echinatus L. burrgrass, sand burr

Marshallese: ***lõklõk*** ("prickly, prick"); ***kãlõklõk*** ("thorns", "brambles", a name also applied to *Ximenia americana*, which is native to other Marshall Islands' atolls but not present on Majuro, and *Xanthosoma sagittifolium*) ***karumwij*** ("to make late")

Recent introduction. Tropical America. Common. Weed occurring in clusters or tufts in open and ruderal habitats and in sandy areas near the coast. A weed and/or invasive in most tropical countries (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0517).

Chloris inflata Link finger grass, swollen fingergrass
Syn. *Chloris barbata* sensu auct. non (L.) Sw.

Recent introduction. Tropical America. Rare. Weed occurring locally in isolated clusters or tufts in open and ruderal places, particularly along roadsides. Easily confused with *Bothriochloa bladhii* and *Eustachys petrea*, which look superficially the same and are abundant throughout most of the atoll. An invasive weed (F, S & O 1987; RRT 1991, 1999; NVV 2001) (DPMJ0747b).

Chrysopogon aciculatus (Retz.) Trin. golden beardgrass, love grass, Mackie's pest
Syns. *Andropogon aciculatus* Retz.; *Rhaphis aciculata* (Retz.) Desv.

Recent introduction. Tropical Asia to Western Polynesia and possible western Micronesia. Rare. Found in a private lawn in Rita. Previously reported on Kwajalein by F. S & O (1987) but not found in later surveys (Whistler & Steele 1999). Its seeds are spikelets with pointed tips that easily attach to clothing and fur. Seeds not only spread this way but can also work their way into the flesh of people and animals causing sores. A major invasive, which can tolerate poor soil, trampling and moving. On the U. S. Federal noxious weed list (NVV 2001) (DPMJ0746).*

Cymbopogon citratus (DC. ex Nees) Staph lemongrass
Syn. *Andropogon citratus* DC. ex Nees

Recent introduction. East Indies. Uncommon. Planted in household gardens and multiplied for distribution at Marshall Islands High School in 1991. Previously reported on Kwajalein by Hebst (1988) (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0562).*

Cynodon dactylon (L.) Pers. Bermuda grass

Recent introduction. Old World. Occasional. Found in open places, along roadsides and forming mats or sod in some areas, such as by Alele Museum in Uliga. Can become invasive (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000).

Dactyloctenium aegyptium (L.) Beauv.
four-finger grass, beach wiregrass, crowfoot grass

Recent introduction. Paleotropics. Occasional to locally abundant. Weed in clusters or tufts in open and ruderal habitats; seen along roadsides in the DUD and interior of Laura; locally common in the industrial area to the east of the Majuro Bridge. Previously recorded on Jaluit by F. S & O (1987) but did not survive (Fosberg & Sachet 1962) and as naturalized on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0287).*

Digitaria ciliaris (Retz.) Koeler large crabgrass, smooth crabgrass

Marshallese: ***wûjooj*** ("grass", general); ***wûjooj aetok*** ("tall grass")

Recent introduction. Tropical Asia. Uncommon. Tall grass with spreading inflorescence. Found along the far end of the runway, a small patch near the U. S. Embassy area of Rairõk and another at the east end of Didij in Aeañen. Previously reported on Rongelap and Kwajalein by F. S. & O (1987), and is naturalized on Kwajalein (Whistler & Steele 1999). Can become invasive and is a naturalized weed in many parts of the world (NVV 2001) (DPMJN122501).*

Digitaria setigera Roth itchy crabgrass, slender crabgrass
Syns. *Digitaria pruriens* (Fisher ex Trin.) Buse; *Digitaria microbachne* (J.S. Presl) Henr.

Marshallese: ***wûjooj*** ("grass", general)

Recent introduction. Southeast Asia to Polynesia. Uncommon. Weed occurring in clusters or tufts in open and ruderal habitats (F, S & O 1987; FRF 1990; RRT 1999, 2001; NVV 2000) (DPMJ0547).

Eleusine indica (L.) Gaertn. wiregrass, goosegrass

Marshallese: ***katejukjuk*** ("try to stay put"; "make a community")

Recent introduction. India; long naturalized in Old World. Abundant. Growing in rather dense concentrations or colonies in gardens, waste places, along roadsides and in other ruderal habitats. An invasive of many regions (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0306, DPMJ0567, DPMJ0747a).

Eragrostis ciliaris (L.) R. Br. gophertail lovegrass

Recent introduction. Old World. Occasional. Weed occurring in open fields (F, S & O 1987; NVV 2001) (DPMJN112701, DPMJN121101).

Eragrostis scabriflora Swallen Fijian lovegrass

Recent introduction. Fiji. Common to locally abundant. Weed occurring in open lots, along roadsides, other ruderal places, and in sandy areas near the coast. Previously reported as present on Majuro and other atolls (Whistler & Steel 1999; RRT 1999, 2000AB; NVV 2001) (DPMJ0308, DPMJ0588, DPMJ0589).*

Eragrostis tenella (L.) Beauv. ex Roem. & Schult. delicate lovegrass, Japanese lovegrass
Syn. *Eragrostis amabilis* (L.) Wight & Arn. ex Hook. & Arn.

Recent introduction. Old World. Common. Weed occurring in scattered clusters around buildings, along paths, in other ruderal places, and in sandy areas near the coast (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0308, DPMJ0571).

Eustachys petrea (Sw.) Desv. pinewoods fingergrass
Syn. *Chloris petrea* Sw.

Recent introduction. Tropical America. Very abundant. Weed of roadsides, airports, waste places and ruderal sites; also found on Calalin Islet. One of the most dominant grass species (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0314, DPMJ0506).

Lepturus repens (G. Forst.) R. Brown beach bunch grass

Marshallese: ***wûjooj*** (general term for grass); ***wûjooj aetok*** ("tall grass"); ***ut madi*** ('spear-flower', a name given by some of the participants at the University of the South Pacific herbal medicine workshop)

Indigenous. Pacific Islands. Abundant. Occurring in clusters among strand vegetation on both ocean and lagoon shores and in other sandy habitats including uninhabited islets. According to Fosberg 1990, this is: "The commonest, most ubiquitous plant in the Marshalls." (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0144b, DPMJ0704).

Oplismenus compositus (L.) Beauv. basket grass
Syn. *Panicum compositum* L.

Marshallese: ***wûjooj-in-Ep*** ("grass of Ep", a mythical land to the West)

Recent introduction. Ceylon. Occasional. Weedy understorey species found around taro pits in Laura (F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB; NVV 2000) (2K00405; DPMJ0138S).

Paspalum conjugatum Berg. T-grass, sour grass

Recent introduction. Tropical America. Occasional. In tended lawns and disturbed sites; locally common in Laura, especially in moist sites. Previously recorded on Arno and Jaluit by F. S & O 1987. A hardy and persistent species which easily becomes invasive (RRT 1999, 2000AB; NVV 1999).*

Paspalum setaceum Michx. bullgrass, thin paspalum

Recent introduction. Mexico and the southeastern United States. Common. Weed of roadsides and ruderal sites (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (2K00411; DPMJ0132S, DPMJ0133S, DPMJ0174a, DPMJ0371, DPMJ0548).

Paspalum vaginatum Sw. seashore grass, knottgrass, saltgrass, knottweed
Syns. *Paspalum distichum* L.; *Paspalum littorale* R. Br.

Marshallese: ***wûjooj katejukjuk*** ("grass"-"try to stay put"; "make a community")

Recent introduction. Tropical America, but now pantropical. Common. Weedy plant forming dense patches near beaches and brackish marshy areas; often found in, or bordering, taro pits (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0144c).

Pennisetum polystachion (L.) Schult. mission grass, feathery pennistem
Syns. *Pennisetum polystachyon* (L.) Schult (alternate spelling); *Pennistem setosum* (Sw.) L. Rich.; *Cenchrus setosus* SW.; *Panicum polystachion* L.

Recent introduction. Tropical Africa. Occasional. Roadside and ruderal weed, particularly in recently cleared areas along the Laura Back Road and near the Laura Experimental Farm. An aggressive invasive weed with seeds that disperse in the wind, water or by sticking to clothing; on the U. S. list of noxious weeds and declared a noxious weed in the Northern Territory, Australia (F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0373).

Pennisetum purpureum Schumach. elephant grass, Napier grass
Syn. *Pennisetum merkeri* Leeke

Recent introduction. Tropical Africa. Uncommon. Locally common and spreading in dense stands along the Laura Back Road from the former Government agricultural farm; reportedly introduced as a fodder grass. Identified on Majuro by the RMI Biodiversity Team and included in 2000 report, but location not specified. Can become invasive and has become a problem in the Galapagos (NVV 1999; RRT 2000AB, 2001) (DPMJ0374, DPMJ0551).

Saccharum officinarum L. sugar cane

Marshallese: ***to***

Recent introduction. New Guinea and Tropical Asia. Uncommon. Planted bordering taro pits in Laura and at the Laura Experimental Farm. According to St. John, the one variety that he encountered in Laura was introduced from Kosrae by the Japanese; the local name is the same as the Kosraean name. Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce sugar cane (StJ 1951; F, S & O 1987; RRT 1991, 2000AB, 2001; NVV 1999) (DPMJ0192a).

Sorghum bicolor (L.) Moench. broomcorn

Recent introduction. India. Rare and probably extirpated. Reported present on Majuro by F. S & O (1987); not seen by current authors (F, S & O 1987).

Sorghum vulgare Pers. sorghum, Guinea corn

Recent introduction. India. Rare. A couple of plants planted inside a fenced area at College of the Marshall Islands, but extirpated when new buildings were constructed. Imported in wild birdseed mix that has been used as chicken feed, and periodically grows from spilt seeds, but does not survive. (RRT 1999, 2000A; NVV 1999).**

Sporobolus fertilis (Steud.) Clayton Indian dropseed

Recent introduction. Southern Asia. Uncommon. Growing along roadsides and in disturbed sites; reported on Kwajalein by Whistler & Steele (1999). Could possibly be *Sporobolus diander* (Retz.) P. Beauv., the branches of which spread at maturity. According to Whistler (1995), the taxonomy of this genus is not clear (RRT 1999, 2000B, 2001; NVV 2000) (DPMJ0425, DPMJ0688).*

Stenotaphrum micranthum (Desv.) Hubb. small-flowered buffalo grass
Syns. *Ophiurinella micrantha* Desv.; *Stenotaphrum subulatum* Trin.

Recent introduction. Mascarine Islands to Malesia, Micronesia, and Polynesia. Uncommon. Found in a few sites slightly inland from the coast in Laura and in Rita in undeveloped areas (RRT 1999; RRT 2000B; NVV 2000) (DPMJ0427, DPMJ0428a, DPMJ0429).*

Thuarea involuta (Forst. f.) R. Br. ex R. & S beach grass

Marshallese: ***wûjooj maroro*** ("green grass"); ***kakkûmkûm*** ("suspenseful"; " risky"); ***wûjooj-en-kijen-bao*** ("chicken food grass", a name given by some of the participants at the University of the South Pacific herbal medicine workshop)

Indigenous. Madagascar to Eastern Polynesia and Micronesia. Occasional to locally common. Found in strand vegetation and sandy areas on both ocean and lagoon coasts (StJ 1951; F, S & O 1987; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0097, DPMJ0509).

Zea mays L. maize, corn

Marshallese: ***koon*** (a corruption of the English common name)

Recent introduction. South, Central and warm North America. Uncommon. Planted at Laura Experimental Farm, at the Chinese vegetable farm and periodically in private gardens in Laura. Large plot of mature corn seen in a private garden along the Laura Back Road in November 2001. Previously recorded on Kwajalein by F. S & O (1987) (RRT 1991, 1999, 2000A, 2001; NVV 1999) (DPMJ0543, DPMJ0544).*

Zoysia japonica Steud. Japanese lawngrass, Korean lawngrass

Recent introduction. Japan. Rare. Ground cover in some residential lawns. Further investigation is needed for all the *Zoysia* spp. found on Majuro, in order to better understand which species, hybrids and/or varieties exist. (NVV 2000).**

Zoysia matrella (L.) Merr. Manila grass, temple grass, siglap grass
Syn. *Agrostis matrella* L.

Recent introduction. Southern Asia and Malaysia. Uncommon. Ground cover in some residential lawns and in front of CMI and at a residence in Delap, often forming small patches in association with other grasses and ground cover species. Could also be one of the other species. Previously reported on Jaluit by F. S & O (1987) (NVV 2000; RRT 2000A, 2001).*

Zoysia tenuifolia Willd. Korean velvetgrass, Mascarenegrass

Recent introduction. Southeast Asia. Rare. Ground cover in some residential lawns. Further investigation is needed for all the *Zoysia* spp. found on Majuro, in order to better understand which species, hybrids and/or varieties exist. (NVV 2000).**

PONTEDERIACEAE (Pickerel Weed Family)*

Eichhornia crassipes (Mort.) Solms. water hyacinth

Recent introduction. Tropical and subtropical America. Uncommon. Planted ornamental in water-filled tubs and containers of residential gardens. Subsequently recorded on Kwajalein by Whistler & Steele (1999). Considered to be one of the "One Hundred of the World's Worst Invasive Alien Species" by the Global Invasive Species Database (RRT 1991, 2000B; NVV 2000) (DPMJ0302).**

POTAMOGETONACEAE (Pondweed Family or Seagrass Family)

Cymodocea rotundata Ehremb. & Hempr. ex. Aschers rounded seagrass

Marshallese: ***wûjooj-in-lojet*** ("grass of the ocean", general term for sea plants, including algae)

Indigenous. Indian Ocean through Melanesia to Solomon Islands and the Marshall Islands. Occasional. A number of seagrass meadows or populations found on Majuro; a large one along the lagoonside of Laura, a smaller one on the oceanside near the end of Laura, one in the embayment south of CMI, and another in Aeañen (Tsuda, Fosberg & Sachet 1977; NVV 1999; RRT 2000AB, 2001) (DPMJ0098, DPMJ0099).

TACCACEAE (Polynesian Arrowroot Family)

Tacca leontopetaloides (L.) O. Kuntze Polynesian arrowroot
Syn. *Tacca pinnatifida* Forst.

Marshallese: ***makmõk***

Aboriginal introduction. Malay Archipelago. Occasional to Common. Occurring spontaneously in old gardens and in sandy areas in interior coastal strand forest; more common on outer atoll islets, but rare in areas with high population density on Majuro. Corms traditionally an important source of starch; abundance said to have declined in recent years, both in number and size, which is believed by many residents to be a result of fallout from the nuclear weapon testing programs of the 1940s and 1950s (StJ 1951; F, S & O 1987; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0081, DPMJ0510).

ZINGIBERACEAE (Ginger Family)*

Alpinia purpurata (Viell.) K. Schum red ginger

Recent introduction. Indonesia to Pacific Islands. Common. Planted ornamental in household gardens and around businesses. Previously recorded on Kwajalein by F. S & O (1987). Can become naturalized and invasive (RRT 1991, 1999, 2000B, 2001; NVV 2001).*

Alpinia vittata Bull variegated ginger
Syn. *Alpinia sanderae* Sand.

Recent introduction. New Guinea. Rare. Ornamental in household garden in Rita (NVV 2000; RRT 2000AB, 2001) (DPMJ0003, DPMJ0739).**

Hedychium coronarium Koen. white ginger

Recent introduction. Himalayas and southwestern China. Rare. Planted ornamental in household garden in Rita. Previously recorded on Kwajalein by F. S & O (1987). Has become a major problem in Hawai'i but so far not in Micronesia (NVV 2000; RRT 2000AB, 2001) (DPMJ0112).*

Kaempferia ovalifolia Roxb. peacock ginger
Syn. *Kaempferia pasishii* Hook f. form

Recent introduction. Burma to Malaya. Rare. Ornamental in a planter box around breadfruit tree in private residence in Rita; also a potted plant at U. S. Embassy and growing unattended by the hospital. Positive identification should be reconfirmed, as it could also be *K. pulchra* (NVV 2000; RRT 2000B) (DPMJ0167a).**

Kaempferia rotunda L. peacock ginger

Recent introduction. Southeast Asia. Rare. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants; seen in a private household garden in Woja (NVV 2000; RRT 2000B) (DPMJ0343). **

Zingiber officinale Roscoe ginger, common ginger
Syn. *Zingiber zingiber* Karst.

Recent introduction. India and China. Rare. Planted in soil at Royal Garden Hotel and occasionally in private herb gardens; seen growing in settlement on Calalin Islet in 2000 and in a container at the R & D Building in 2001 (RRT 1999, 2000A, 2001; NVV 1999) (DPMJ0575).**

Zingiber zerumbet (L.) Sm. wild ginger

Recent introduction. Tropical Asia. Rare. Planted medicinal plant in household gardens of Fijian and Rotuman expatriate workers; introduced by contract workers from Fiji. Important medicinal plant in tropical Asia and the Pacific Islands (RRT 2000AB).**

DICOTYLEDONAE (Dicotyledons)

ACANTHACEAE (Acanthus Family)

Asystasia gangetica (L.) Anders. asystasia, Chinese violet, Philippine violet, coromandel
Syns. *Justicia gangetica* L.; *Asystasia coromandeliana* Nees

Recent introduction. Paleotropics. Occasional. Planted ornamental, often forming a semi-hedge around homes. The lavender variety is the most frequent, but the white variety is also present. Previously reported on Kwajalein by F. S & O (1972). Can become invasive and has become a potential problem in French Polynesia (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0117, DPMJ0147c, DPMJ0147e, DPMJ0472).*

Blechum pyramidatum (Lam.) Urb. green shrimp plant
Syns. *Blechum brownei* Juss.; *Blechum pyramidata* (Lam.) Urb.; *Barleria pyramidatum* Lam.; *Barleria pyrimidalis* Lam. ex Nees

Recent introduction. Peru. Occasional. Naturalized weed along road in banana plantation in Laura and a number of other ruderal places; also found in a number of locations in Rita. Appears to be spreading. Previously reported on Jaluit by F. S & O (1972) and was one of the few plants to survive the typhoon (Fosberg & Sachet 1962). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0182).*

Crossandra infundibuliformis (L.) Nees firecracker flower; crossandra
Syns. *Justicia infundibuliformis* L.; *Crossandra undulaefolia* Salisb.

Recent introduction. India and Sri Lanka. Rare. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants. Previously reported on Kwajalein by F. S & O (1979) but not observed since, according to Whistler & Steele (1999) (NVV 1999).*

Fittonia argyroneura Coem. snail plant, nerve plant, silver-net leaf
Syn. *Fittonia verschaffeltii* var. *argyroneura* Nichols.

Recent introduction. Peru. Rare. Ornamental potted plant; imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants, some surviving in CMI Land Grant Office (RRT 1991; NVV 2000).**

Graptophyllum pictum (L.) Griff. caricature plant, morado
Syn. *Justicia picta* L.

Recent introduction. New Guinea. Occasional. Planted ornamental, sometimes as hedges around houses. Previously reported on Likiep by F. S & O (1972) and subsequently on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 2000).*

Hemigraphis alternata (Burm. f.) T. Anders. metal leaf, cemetery plant, red ivy
Syns. *Ruellia alternata* Burm. F.; *Ruellia colorata* Bl.; *Hemigraphis colorata* (Bl.) Hall f.

Recent introduction. Java. Rare. Planted ornamental ground cover. Can become invasive (RRT 1991, 2000AB, 2001; NVV 2000) (DPMJ0146a).**

Hemigraphis reptans (Forst. f.) T. Anders. waffle plant
Syn. *Ruellia reptans* Forst. f.

Marshallese: ***utilõmjãn*** ("flower of Lõmjãn" – a woman's name)

Recent introduction (although Fosberg 1990 lists it as indigenous). Indonesia. Uncommon. Seen as an adventive in swampy area along the Laura back road in September and October 2000, growing in shade near the base of a coconut tree in Ajeltake, in Amata Kabua's garden and other private gardens (StJ 1951; F, S & O, 1979; FRF 1990; RRT 2000AB, 2001; NVV 2000) (DPMJ0327, DPMJ0524, DPMJ0525, DPMJ0649).

Justicia brandegeeana Wassh & L.B. Sm. shrimp plant
Syns. *Beloperone guttata* Brandegee; *Justicia fulvicoma* Schlect. & Chamisso

Recent introduction. Mexico. Rare. Planted ornamental in a private walled garden in Rita and alongside another potted plant in Laura. Previously reported on Kwajalein by Whistler & Steele (1999) (NVV 2000; RRT 2000A).*

Odontonema cuspidatum (Nees) Kuntze
fire spike, cardinal flower, odontonema, red justicia
Syns. *Odontonema tubiforme* (Bertol) Kuntze; *Justicia tubaeformis* Bertol; *Odontonema strictum* (Nees) Kuntze

Recent introduction. Central America. Rare. Potted plant in a few household gardens. Can become invasive (NVV 2000; RRT 2000A).**

Pachystachys lutea Nees yellow shrimp plant, lollypop plant

Recent introduction. Brazil. Rare. On sale at Bilimon's store in Rita; imported from Hawai'i in late 2000, unknown if it survived (NVV 2000) (DPMJ0015b).**

Pseuderanthemum bicolor (Schrank) Radlk bicolor false eranthemem
Syn. *Eranthemum bicolor* Schrank

Recent introduction. Eastern Malaysia. Rare. Planted ornamental (RRT 1991, 1999, 2000A; NVV 2000)**

Pseuderanthemum carruthersii (Seem.) Guill. false eranthemum
Syn.: (var. carruthersii): *Eranthemum carruthersii* Seem. (var. atropurpureum): *Pseuderanthemum atropurpureum* (Bull) Radlk.; *Eranthemum atropurpureum* Bull.

Marshallese: ***tirooj*** (a combination of "ti"in reference to *Cordyline fruticosa* and "rose" the general term for *Hibiscus* and other flowers)

Recent introduction. Melanesia? Var. *carruthersii*, occasional; var. *atropurpureum* (Bull) Fosb. (the purple or false face variety) more common. Planted ornamental shrub and hedge plant. Sabath (1977) lists *Pseuderanthemum* sp. as only observed in Uliga (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0583).

Pseuderanthemum reticulatum (Bull) Radl yellow-vein pseuderanthemum
Syn. *Pseuderanthemum carruthersii* (Seem.) Guill. var. *reticulatum* (Bull) Fosb.

Marshallese: ***tirooj*** (a combination of "ti"in reference to *Cordyline fruticosa* and "rose" the general term for *Hibiscus* and other flowers)

Recent introduction. Melanesia? Uncommon. Planted ornamental shrub and hedge plant. Previously reported on Kwajalein by F. S & O (1972) (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0402, DPMJ0403, DPMJ0404, DPMJ0405).*

Ruellia brittoniana Leonard bellweed

Recent introduction. Mexico. Uncommon. Planted ornamental, seen as a potted plant at the College of the Marshall Islands and in several household gardens. Previously reported on Kwajalein by Whistler & Steele (1999) (NVV 1999; RRT 2000AB, 2001) (DPMK0058, DPMJ0158).*

Thunbergia erecta (Bentham) T. Anders. king's mantle, bush thunbergia

Recent introduction. Tropical West Africa. Occasional. Planted ornamental erect shrub in houseyard gardens, usually with purple flowers, although a white cultivar (*T. erecta* var. *alba*) is also present in a private garden in Rita, reportedly imported from Fiji. Subsequently reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0057, DPMJ0518, DPMJ0632).**

AMARANTHACEAE (Amaranth Family)

Alternanthera brasiliana (L.) Kuntze purple alternanthera

Recent introduction. Tropical South America. Uncommon. Ornamental in household gardens. Has become weedy in some parts of the Pacific Islands, since its recent introduction in the 1980s (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0230, DPMJ0664).**

Alternanthera sessilis (L.) R. Br. ex R. & S. sessile joyweed, dwarf copperleaf

Recent introduction. Pantropical. Occasional. Weed of gardens and around houses in the DUD area. On the U. S. list of noxious weeds (RRT 1991, 1999, 2000A; NVV 2000) (DPMJ0170).**

Alternanthera sissoo Brazilian spinach

Recent introduction. Brazil? Occasional. Food plant found in some household gardens and in student garden at the College of the Marshall Islands. Introduced in the early 1990s from Hawai'i as part of the PRAP Atoll Agriculture Programme to improve nutrition through increasing the supply of fresh vegetables. Grows very well on atolls (RRT 2000AB, 2001; NVV 2000) (DPMJ0573).**

Alternanthera tenella Colla joyweed, alternanthera, telanthera, calico plant

Syns. *Alternanthera bettzickiana* (Reg.) Voss; *Alternanthera ficoidea* L. var. *bettzickiana* (Reg.) Backer; *Alternanthera amoena* (Lem.) Regel; *Alternanthera versicolor* (Lemaire) Seubert; *Telanthera bettzickiana* Reg.

Recent introduction. Brazil. Uncommon. Planted ornamental and border plant in household gardens. Both variegated red and green and white and green varieties present. Previously reported on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0104, DPMJ0232, DPMJ0521).*

Amaranthus dubius Mart. ex Thell. spleen amaranth

Recent introduction. Tropical America. Occasional. Weed around houses in Rita and near vegetable garden in Laura (F, S & O 1979; FRF 1990; RRT 2000A, 2001A; NVV 2000) (DPMJ0171, DPMJ0594).

Amaranthus tricolor L. Chinese spinach, amaranth spinach

Syns. *Amaranthus gangeticus* L.; *Amaranthus melancholis* L.

Recent introduction. Southeast Asia. Rare. Raised as a pot herb in garden behind Gibson's supermarket in Delap. Possibly introduced from Fiji where it is the most common spinach grown by Fiji Indians (RRT 2000B; NVV 2001) (DPMJ0233, DPMJ0234).**

Celosia argentea L. cock's comb

Recent introduction. Tropical Asia. Rare. Planted annual potted plant in nursery near Lojkar Resort (NVV 2000; RRT 2000AB) (DPMJ0475).**

Celosia cristata L. cock's comb, coral garden

Syn. *Celosia argentea* L. var. *cristata* (L.) Ktze.

Recent introduction. Tropical Asia. Uncommon. Planted annual potted plant and garden flower in some houseyard gardens and in nursery at Lojkar Resort. An attractive plant with bright red flowers (NVV 2000; RRT 2000AB) (DPMJ0190, DPMJ0474).**

Gomphrena globosa L. globe amaranth, pearly everlasting

Marshallese: ***ablajtiiñ*** (a corruption of the English common name "everlasting")

Recent introduction. Tropical America. Common. Planted ornamental annual potted plant; the purple-flowered cultivar is most common (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0193).

Iresine herbstii Hook. f. iresine, bloodleaf

Recent introduction. Brazil. Rare. Ornamental potted plant. Subsequently reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000A; NVV 2000).*

ANACARDIACEAE (Cashew or Rhus Family)*

Mangifera indica L. mango

Marshallese: ***mañko*** (a corruption of the English common name)

Recent introduction. Indo-Burma. Uncommon. One tree growing at the edge of a taro pit in Laura, another in a container in Delap. Smaller trees often seen in containers in private gardens. Previously reported on Arno and Jaluit by F, S & O (1979) but did not survive on Jaluit (Fosberg & Sachet 1962), and on Kwajalein by Whistler & Steele (1999) where it also did not survive (RRT 1999, 2000AB, 2001; NVV 1999).*

ANNONNACEAE (Custard Apple Family)

Annona muricata L. soursop

Marshallese: ***jojaab*** (a corruption of the English common name)

Recent introduction. Tropical America. Uncommon. One tree in household garden in Laura, one at R & D, one in Delap and another in a Filipino garden just east of the airport. Reportedly extensively planted throughout the atoll in the past by the Agricultural Department, with many trees bearing abundant fruit. Can become invasive in other areas but does not seem to do well in the Marshall Islands' environment (StJ 1951; F, S & O 1979; RRT 1999, 2000AB, 2001; NVV 2000).

Annona squamosa L. sweetsop, sugar apple

Recent introduction. Tropical America. Rare. Fruit tree introduced by Jimmy Joseph at the Government Agricultural Farm in Laura. Can become invasive in other areas but does not seem to do well in the Marshall Islands' environment (NVV 2000).**

Cananga odorata (Lam.) Hook. f. and Thoms. ylang-ylang, perfume tree
Syns. *Canangium odoratum* (Lam.) Baill. ex King; *Uvaria odorata* Lam.

Marshallese: ***ilañlañ*** (a corruption of the English common name)

Recent introduction. Indomalaysia. Rare. One large tree on the ocean road in Rita introduced from Chuuk; seems to have died during the flooding of January 2001; another flowering tree in Rairõk destroyed by flooding in 1991. Reported as being present by the participants in the Namdrik Biodiversity Workshop and recorded as such by the RMI National Biodiversity Team (2000) . Can become adventive but does not seem to do well in atoll environment (NVV 1999; RRT 2000A).*

APIACEAE (Carrot Family or Parsley Family)

Centella asiatica (L.) Urb. Asiatic pennywort
Syn. *Hydrocotyle asiatica* L.

Marshallese: ***mariko***

Aboriginal introduction, perhaps as a weed. Pantropical. Common. Found along roadsides and in somewhat shady areas, often at the bases of coconut palms; abundant on Calalin Islet. Important medicinal plant in the Marshall Islands and elsewhere in the Pacific Islands (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0082, DPMJ0706).

APOCYNACEAE (Dogbane Family)

Adenium obesum (Forssk.) Roem. & Schultes desert rose, mock azalea, impala lily
Syn. *Adenium coetanum* Stapf.

Recent introduction. East Africa. Occasional. Ornamental and potted plant in household gardens. Previously reported on Kwajalein by Whistler & Steele (1999). Parts of the plant are poisonous (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0217, DPMJ218, DPMJ0654).*

Allamanda blanchetti DC. purple allamanda

Syn. *Allamanda violacea* Gardn. and Field

Recent introduction. Brazil. Occasional. Planted ornamental climbing shrub (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0221).**

Allamanda cathartica L. allamanda, cup of gold

Syns. *Allamanda hendersonii* Bull; *Allamanda cathartica* L. var. *hendersonii* (Bull) Bailey and Raff.

Recent introduction. Brazil. Uncommon. Planted ornamental climbing shrub with bright yellow hibiscus-like flowers; one large plant in houseyard garden in Rairõk. Previously reported on Kwajalein by F. S & O (1979). Has become invasive in northern Australia (RRT 1991, 2000AB; NVV 2000) (DPMJ0222, DPMJ0223).*

Carissa macrocarpa (Ecklon) DC. Natal plum, Christ's thorn

Syn. *Carissa grandiflora* (E. Meyer) DC.

Recent introduction. South Africa. Uncommon. Ornamental potted plant in garden in Rita and Uliga and another near the airport. Previously reported on Kwajalein by Whistler & Steele (1999) (NVV 200o; RRT 2000AB, 2001) (DPMJ0153d).*

Cascabela thevetia (L.) Lippold be-still tree, yellow oleander

Syn. *Thevetia peruviana* (Pers.) K. Schum.

Recent introduction. Peru. Uncommon. Planted ornamental in residential areas; yellow and light orange cultivars seen in Amata Kabua's garden in 2001. Previously reported on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999). All parts of the plant are poisonous, especially the sap and seeds. Can become invasive, preferring drier areas (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0624, DPMJ0626, DPMJ0718).*

Catharanthus roseus (L.) G. Don Madagascar periwinkle

Syns. *Vinca rosea* L.; *Lochnera rosea* (L.) Reich.

Marshallese: ***raan-ñan-raan*** ("day-to-day", in reference its continuous flowering)

Recent introduction. Madagascar. Common. Planted ornamental and potted plant. Often used as a border planting around private homes, schools and businesses. The lavender flowered variety is the most common but white flowered and deep pink varieties also present (FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0186, DPMJ0249, DPMJ0619, DPMJ0656, DPMJ0659).

Mandevilla splendens (Hook.) Woodson red riding hood
Syns: *Mandevilla sanderi* (Hemsl.) Woodson; *Dipladenia splendens* Hook.

Recent introduction. Tropical America. Rare. Four young potted plants imported for sale by Bilimon's Store in Uliga, January 2001 (NVV 2001).**

Neisosperma oppositifolium (Lam.) Fosb. & Sachet
Syns. *Ochrosia oppositifolia* Lam.; *Neisosperma oppositifolia* (Lam.) Fosb. & Sachet

Marshallese: ***kõjbar***

Indigenous. Philippines to southeast Polynesia and Micronesia. Occasional. Single trees, probably deliberately planted, on lagoon coast in DUD and in a household garden in Woja; a number of mature trees present on a few of the islets of Aeañen; common on the windward side and slightly inland on Calalin Islet. Considered to be one of the dominant climax species of the original inland mixed forest of the Marshall Islands (MDS 1977; FRF 1990; RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0366, DPMJ0367).

Nerium oleander L. oleander

Marshallese: ***oliaanta*** (a corruption of the English common name)

Recent introduction. Asia. Occasional. Planted ornamental shrub. Many variations in flower colors and shape found. All parts of the plant are highly poisonous (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NV.V 1999).

Plumeria obtusa L. white frangipani, Singapore plumeria

Marshallese: ***meria*** (a corruption of the English common name)

Recent introduction. Tropical America. Common. Planted ornamental tree. Flowers used for making garlands and leis, and for scenting coconut oil. Sabath (1977) lists two species of *Plumeria* for Majuro, presumably both of the ones included here (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Plumeria rubra L. frangipani, plumeria, temple tree
Syns. *Plumeria acuminata* Ait. f.; *Plumeria acutifolia* Poir.

Marshallese: ***meria*** (a corruption of the English common name)

Recent introduction. Tropical America. Common. Planted ornamental. Flowers used for making garlands and leis, and for scenting coconut oil (StJ 1951; MDS 1977; F, S & O

1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0717).

Tabernaemontana divaricata (L.) R. Br.

false gardenia, paper gardenia, crepe jasmine, scentless gardenia

Syns. *Tabernaemontana coronaria* (Jacq.) Willd.; *Ervatamia divaricata* (L.) Burkill; *Ervatamia coronaria* (Jacq.) Stapf

Recent introduction. India. Rare. Planted ornamental shrub. Previously reported on Kwajalein by F. S & O (1979) (RRT 1991, 2000A; NVV 2000) (DPMJ0145a).*

ARALIACEAE (Panax Family)

Dizygotheca elegantissima Vig. and Guill. false aralia, dizygotheca

Recent introduction. Pacific Islands. Rare. Ornamental potted plant in Amata Kabua's garden (NVV 2000, RRT 2000A) (DPMJ0033).**

Polyscias filicifolia (C. Moore ex. Fourn.) L. H. Bailey

golden prince panax, fern-leaf aralia, angelica

Syn. *Polyscias cumingiana* (Presl.) Fern.-Vill.

Recent introduction. Polynesia and Tropical Asia. Occasional. Planted ornamental in household gardens in Rita, Jenrok, Ajeltake and the residence of the former president, Amata Kabua (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0389, DPMJ0658).**

Polyscias fruticosa (L.) Harms parsley panax, ming aralia

Syn. *Nothopanax fruticosum* (L.) Miq.

Marshallese: ***ut kakinono*** (general term for flower or hedge; mixture of several different types of flowers; in reference to it frequent use in garlands; a term not necessarily in general use)

Recent introduction. India to western Polynesia. Occasional. Ornamental commonly planted as a hedge or living fence (F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0393).

Polyscias guilfoylei (Cogn. and March.) Bailey Guilfoyle's panax

Syn. *Nothopanax guilfoylei* (Cogn. and March.) Merr.

Marshallese: ***ut*** (general term for flower or hedge)

Recent introduction. Melanesia to Southern Polynesia. Common. Ornamental shrub commonly planted as a hedge or living fence (StJ 1951; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0390, DPMJ0520b).

Polyscias scutellaria (Burm. f.) Fosb. saucer panax

Syns. *Polyscias balfouriana* (Sander ex André) L.H. Bailey; *Polyscias pinnata* J.R. & J.G.A. Forst.

Marshallese: ***ut lot*** ('coconut shell flower), ***ut kup*** ('cup flower')

Recent introduction. Southeast Asia. Abundant. Ornamental planted in hedgerows or living fences (F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0391, DPMJ0556).

Polyscias tricochleata (Miq.) Fosb. panax

Syns. *Nothopanax trichochleatus* Miq.; *Polyscias pinnata* Forst. var. *tricochleata* Stone

Recent introduction. Pacific Islands. Common. Planted erect ornamental shrub. Previously reported on Kwajalein, Arno and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0392).*

Schefflera actinophylla (Endl.) Harms

Queensland umbrella tree, octopus tree, umbrella plant

Syn. *Brassaia actinophylla* Endl.

Recent introduction. Northern Australia. Occasional. Planted ornamental tree. Previously reported on Kwajalein and Jaluit by F. S & O (1979). A very invasive species which has invaded undisturbed forests in other areas of Micronesia and in French Polynesia (RRT 1991, 2000AB, 2001; NVV 1999).*

Schefflera arboricola (Hayata) Merr. dwarf umbrella tree, dwarf schefflera

Recent introduction. Taiwan. Uncommon. Ornamental potted plant. Among unspecified species imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants. A variegate variety, *S. arboricola* var. *variegata* seen in a houseyard garden in Rita. Previously reported on Kwajalein by Hebst (1988). Can become invasive (RRT 1991, 2000AB, 2001; NVV 2000) (DPMJ0053, DPMJ0420, DPMJ0564b).*

Schefflera taiwaniana (Nakai) Kanehira Taiwan dwarf umbrella tree

Recent introduction. Rare. Single plant in household garden in Rita and Woja. (RRT 2000A; NVV 2000) (DPMJ0023, DPMJ0420).**

ASCLEPIADACEAE (Milkweed Family)

Asclepias curassavica L. milkweed, butterflyweed, red cotton bush

Marshallese: ***kabbok*** ("to cause or attract butterflies"), ***ialo*** ("yellow")

Recent introduction. Tropical America. Rare. Planted ornamental. Recorded by St. John in Laura. In recent times, only found in a single planter box in a household garden in Uliga, in front of the newly opened Middle School Building and in a private garden in Laura (StJ 1951; F, S & O 1979; FRF 1990; NVV 2000).

Calotropis gigantea (L.) R. Br. crown flower, giant milkweed

Recent introduction. India to Indonesia. Uncommon. Planted ornamental shrub in cemetery in Delap and in one household garden. Has become invasive in Timor (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Hoya australis R. Br. wax flower, wax plant
Syn. *Hoya bicarinata* A. Gray

Recent introduction. Australia to Samoa. Uncommon.. Planted ornamental found as a climbing plant in a number of household gardens. Previously reported on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0331, DPMJ0577).*

Hoya sp. wax plant

Recent introduction. Tropical Asia. Rare. Small waxy vine with almost circular, shallowly-toothed leaves found as a potted plant in Amata Kabua's garden in 2000 and 2001 (RRT 2000A, 2001; NVV 2000) (DPMJ061, DPMJ0651).**

Stephanotis floribunda Brongniart Madagascar jasmine

Recent introduction. Madagascar. Uncommon. Ornamental vine climbing on a fence in Rita and in one garden in Rairõk. Previously reported on Kwajalein by Herbst (1988) (NVV 2000, RRT, 2000A) (DPMJ0199, DPMJ0430).*

ASPHODELACEAE (Asphodel Family) **

Gasteria sp. gasteria, ox tongue

Recent introduction. South Africa. Rare. Ornamental potted plant, in household garden in Rita. Could be *Gasteria brevifolia* Haw., but *Gasteria* spp. easily hybridize, yielding many hybrid crosses. They also cross with *Aloe* spp. to produce what are known as "gaster-aloes" (NVV 2000).**

ASTERACEAE or **COMPOSITAE** (Aster, Sunflower or Composite Family)

Adenostemma lanceolatum Miq. adenostema

Syn. *Adenostemma lavenia* sensu auct. Micr. non (L.) O. Ktze.

Marshallese: ***bwilbwilikkaj*** (a name probably originally applied to *Chamaesyce hyper*icifolia, but by extension sometimes applied to this species as well as to *Synedrella nodiflora*)

Aboriginal introduction. Pantropical, possibly of Tropical American origin. Rare or extinct. Reported present on Majuro by F. S & O (1979) and Fosberg (1990) and as occasional on Ailinglaplap, Arno, Jaluit, Lae, as well as Majuro; not seen in recent times by current authors (F, S & O 1979, FRF 1990).

Bidens pilosa L. var. **radiata** Sch.-Bip.

cobbler's peg, Spanish needles, beggars tick, burr-marigold

Syn. *Bidens alba* (L.) DC.

Recent introduction. Tropical America; now pantropical. Very abundant. Dominant weed of roadsides, waste places, around houses and other ruderal sites. Spreading rapidly throughout atoll, even on to isolated islands of Aeañen. Previously reported on Kwajalein by F. S & O (1979) and on Enewetak by Lamberson (1982) Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0242, DPMJ0568).*

Chromolaena odorata (L.) King and Robinson. Siam weed, jack-in-the-bush

Recent introduction. Tropical America. Rare. Major invasive in other parts of Micronesia. Small patch located by the former garment factory in Laura during a weed and invasive plants workshop in the summer of 2001. Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop. Considered to be among "One Hundred of the World's Worst Invasive Alien Species" by the Global Invasive Species Database (NVV 2001).**

Conyza canadensis (L.) Cronq. var. pusila (Nutt.) Cronq. hairy horseweed

Recent introduction. Pantropical. Abundant. Weed in waste places and ruderal sites and along the borders of the airport (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0269, DPMJ0505, DPMJ0586b).

Eclipta prostrata (L.) L. false daisy
Syn. *Eclipta alba* (L.) Hassk.

Recent introduction. Tropical Asia, now pantropical weed. Uncommon. Weed of moist waste places and edges of lawns near building or cement paths; in moist sites between Gibson's Supermarket and the Capitol Building (F, S & O 1979; FRF 1990; RRT 1999, 2000AB; NVV 2000) (DPMJ0149, DPMJ0180c, DPMJ0301).

Emilia fosbergii Nicholson red sow thistle

Recent introduction. Pantropical. Rare, possibly extirpated. Weed in ruderal sites; not seen in after 1999 (F, S & O 1979; FRF 1990; RRT 1991, 1999).

Erigeron belloides DC. fleabane daisy

Recent introduction. Greater Antilles. Uncommon. Ground cover and locally common and apparently spreading weed in lawns and planter boxes around Royal Garden Hotel and near Marshall Islands High School. Previously reported as naturalized on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB; NVV 2000) (DPMJ0101, DPMJ0180a).*

Gerbera jamesonii Bolus Transvaal daisy, gerbera, African daisy

Recent introduction. South Africa. Rare. Recently imported potted plant (NVV 1999).**

Gynura aurantiaca (Bl.) DC. purple passion flower, velvet plant

Recent introduction. Java. Occasional. Ornamental potted plant and decorative garden plant around houses (RRT 1991, 2000AB; NVV 1999).**

Gynura bicolor (Willd.) DC. gynura

Recent introduction. Moluccas. Rare. Food plant introduced by the PRAP Atoll Agricultural Programme as a nutritious cooked vegetable; also grown in student garden at the

College of the Marshall Islands (RRT 1999, 2000AB; NVV 2000).**

Helianthus annuus L. common sunflower

Recent introduction. Western United States. Rare, probably extirpated, at least periodically. Planted ornamental observed in household garden adjacent to Lojkar Resort, also sometimes sprouts from imported bird seed mixes (NVV 1999; RRT 2000A).**

Lactuca sativa L. lettuce

Recent introduction. Southern Europe and western temperate Asia. Uncommon. Seasonal food plant planted at Marshall Islands High School (1991) and at K & P Farm, Laura (1999) Previously reported from Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999) (RRT 1991, 1999, 2000B).*

Melanthera biflora (L.) Wild. beach sunflower
Syn. *Wollastonia biflora* (L.) DC.; *Wedelia biflora* (L.) DC.

Marshallese: ***marjej***, ***markûbwebwe*** ('toilet paper bush')

Indigenous. Tropical Asia to eastern Polynesia and Micronesia. Very abundant. Weedy species in coastal strand on ocean and lagoon shores, in neglected coconut plantations, around taro pits and in ruderal sites (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Pluchea indica (L.) Less. Indian pluchea

Recent introduction. Southern Asia. Occasional. Weed of roadsides and waste places. A number of good-sized bushes around Majuro bridge and the nearby industrial area, spreading in recent years (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0388, DPMJ0733).

Pluchea carolinensis (Jacq.) G. Don pluchea, shrubby fleabane, sourbush
Syns. *Pluchea odorata* (L.) Cass; *P. symphytifolia* (Mill.) Gillis

Recent introduction. Tropical America. Uncommon. A single plant seen just to the west of the Airport, near IBC. Has become invasive in Hawai'i and is spreading rapidly in parts of Tonga (MDS 1977; F, S & O 1979; FRF 1990; RRT 1999, 2000AB; NVV 2000).

Senecio confusus Britt. Mexican flamevine, orange-flowered senecio
Syns. *Senecio chenopodioides* HBK; *Pseudogynonix chenopodioides* (HBK) Canberra

Recent introduction. Mexico. Uncommon. Planted ornamental in a few household gardens in the DUD (NVV 2000; RRT 2000AB (DPMJ0054, DPMJ0062).**

Sphagneticola trilobata (L.) Pruski wedelia, trailing daisy, Singapore daisy
Syns. *Wedelia trilobata* (L.) Hitchc.; *Telechitonia trilobata* (L.) H. Rob. & Cautrec.; *Silphium trilobatum* L.

Marshallese: ***ut mõkadkad*** ("flower"-"tramp", "move from one place to another" in reference to how it easily spreads); ***ut telia*** (based on the generic name *Wedelia,* arbitrarily contrived during a weed workshop in connection with the South Pacific Commission)

Recent introduction. Tropical America. Abundant. Planted ornamental groundcover also planted in roadside planter boxes; naturalized in some sites and spreading rapidly, covering large areas near the Royal Garden Hotel and the new Capital Building. Was spreading rapidly and very invasive in late 2000 at Mile 0 on the north end of Rita, where is was replacing native coastal plants. By 2001 had also invaded taro pits and swamps along the Laura Back Road. Previously reported on Enewetak and Kwajalein by F. S & O (1979). Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop. Considered to be among the "One Hundred of the World's Worst Invasive Alien Species" by the Global Invasive Species Database (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0027, DPMJ0028, DPMJ0513a, DPMJ0532, DPMJ0540).*

Synedrella nodiflora (L.) Gaertn. synedrella, nodeweed, Cinderella weed

Marshallese: ***bwilbwilikkaj*** (a name probably originally applied to *Chamaesyce hypericifolia*, but by extension also applied to this species and *Adenostemma lanceolatum*)

Recent introduction. Tropical America. Abundant. Weed of waste places and ruderal sites around houses in the DUD and in Laura (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0673).

Tagetes erecta L. marigold

Recent introduction. Mexico. Uncommon. Planted ornamental annual that is planted from year to year (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0432).*

Tridax procumbens L. wild daisy, coat buttons

Recent introduction. Tropical America. Abundant. Weed of roadsides, wasteplaces, ruderal sites and occasionally near beaches. Previously reported on Kwajalein by F. S & O (1979), where it is naturalized (Whistler & Steele 1999) and as an established weed on Enewetak by Lamberson (1982). On the U. S. Federal list of noxious weeds (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0008, DPMJ0507, DPMJ0513c).*

Vernonia cinerea (L.) Less. ironweed

Marshallese: ***jãn-aelõñ-ñan-aelõñ*** ("from-island-to-island"; name not generally known and may be in complete disuse)

Recent introduction. Tropical Asia. Common. Weed around houses, along roadsides, in waste places and ruderal sites (F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0685).

Zinnia violacea Cav. zinnia
Syn. *Zinnia elegans* Jacq.

Recent introduction. Mexico. Occasional. Planted ornamental annual and potted plant in household gardens. Previously reported on Kwajalein and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0445).*

BALSAMINACEAE (Balsam Family)*

Impatiens balsamina L. balsam, garden balsam

Recent introduction. India. Uncommon. Planted ornamental. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) and subsequently on Kwajalein by Whistler & Steele (1999). Can become invasive (RRT 1991, 2000AB; NVV 2000) (DPMJ0332).*

Impatiens wallerana Hook. sultan's flower, sultans balsam, busy lizzie
Syn. *Impatiens sultani* Hook.

Recent introduction. Tropical Africa. Uncommon. Planted ornamental potted plant; found in a private walled garden and in Bilimon's store as an import from Hawai'i. Previously reported on Kwajalein by Whistler & Steele (1999). Can become invasive (RRT 1999, 2000A; NVV 2000).*

BASELLACEAE (Basella Family)**

Basella rubra L. Indian spinach, Ceylon spinach, Malabar nightshade
Syn. *Basella alba* L.

Recent introduction. Tropical Asia. Rare. Succulent dark-green herbaceous, perennial twining vine grown as a food plant in Chinese gardens in Rita (RRT 2000B) (DPMJ0241).**

BEGONIACEAE (Begonia Family)*

Begonia coccinea Hook. f. angel-wing begonia

Recent introduction. Brazil. Uncommon, possibly extirpated. Ornamental potted plant (RRT 1991, 1999).**

Begonia × hiemalis Fotsch Reiger begonia

Recent introduction. Horticultural origin. Rare. Two potted plants brought in from Hawai'i by Bilimon's store, January 2001 (NVV 2001)**

Begonia rex Putz hybrid begonia

Recent introduction. Tropical America. Occasional. Ornamental potted plant represented by a range of horticultural varieties, including a red leafed variety. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants (RRT 1991, 2000AB; NVV 1999) (DPMJ0036).**

Begonia sp. unidentified begonia

Recent introduction. Tropical America. Occasional. Potted plants and planted ornamentals. Similarly unidentified begonia(s) reported on Kwajalein by F. S & O (1979) (RRT 1991, 1999, 2000A; NVV 1999).*

BIGNONIACEAE (Bignonia Family)

Tabebuia heterophylla (DC). Britt. pink tecoma, pink tabebuia
Syns. *Tabebuia pallida* Miers; *Tecoma pentaphylla* (L.) Hemsley

Recent introduction. Tropical America. Occasional. Planted ornamental around a few houses and in the yard of the Capitol Building. Previously reported on Kwajalein by F. S & O (1979), having become naturalized there, according to Whistler & Steele (1999). Can become invasive (RRT 1999, 2000AB, 2001; NVV 1999).*

Tecoma stans (L.) Juss. ex HBK. tecoma, yellow elder, ginger Thomas
Syn. *Stenolobium stans* (L.) D. Don

Recent introduction. Tropical America. Common. Planted ornamental shrub with bright yellow flowers, beginning to become naturalized in some areas. Has become a serious invasive in French Polynesia (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0542).

BOMBACACEAE (Bombax Family)*

Durio zibethinus Murray durian

Recent introduction. Southeast Asia. Rare. A few small seedlings in the experimental garden of Jesse Napolitano at the College of the Marshall Islands; grown from seeds imported from the Philippines (NVV 2000).**

BORAGINACEAE (Heliotrope Family or Borage Family)

Cordia subcordata Lam. sea trumpet, island walnut

Marshallese: ***kōno*** ("pink"?)

Indigenous. Indian Ocean to Hawai'i. Common. In coastal strand forest throughout atoll; occasionally planted in household gardens and as ornamental shade trees, as in front of Alele Museum and at the courthouse. Small nutlike kernels are often eaten as a snack (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0684, DPMJ0705).

Heliotropium procumbens Mill. var. **depressum** (Cham.) Fosb. and Sachet
prostrate heliotrope

Recent introduction. Tropical America. Common. Weedy species found along roadsides and in wasteplaces and ruderal sites (F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0326, DPMJ0585).

Tournefortia argentea L. f, heliotrope tree, beach heliotrope, tree heliotrope
Syns. *Messerschmidia argentea* (L. f.) M. Johnst.; *Argusia argentea* (L. f.) Heine

Marshallese: ***kiden***

Indigenous. Indian Ocean to Southeastern Polynesia. Common. In strand forest on ocean and lagoon shores, in taro pit areas, coconut plantations and in household gardens and as a street tree. One of the most important sources of traditional medicine (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0584, DPMJ0715, DPMJ0716).

BRASSICACEAE or **CRUCIFERAE** (Cabbage Family or Mustard Family)

Brassica chinensis L. var. **chinensis** Chinese cabbage, Chinese white cabbage, bok choy
Syn. *Brassica chinensis* Juslenius; *Brassica pekinensis* (Lour.) Rupr.

Recent introduction. Asia. Occasional. Found in extensive plantings at Laura Experimental Farm and in other vegetable farms at Laura. Previously reported on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999) (RRT 1999, 2000AB; NVV 1999).*

Brassica chinensis L.var. **parachinensis** (Bailey)Tsen & Lee
flowering white cabbage, choy sum
Syn. *Brassica parachinensis* Bailey

Recent introduction. Asia. Uncommon. Found in extensive plantings at Laura Experimental Farm at Laura (RRT 1999, 2000A).**

Brassica juncea (L.) Czern and Cossin mustard cabbage, Chinese or brown mustard
Syn. *Sinapis juncea* L.

Recent introduction. Asia. Occasional. Planted in household vegetable gardens and at the Laura Experimental Farm (RRT 1999, 2000A; NVV 2000).**

Brassica oleracea L. var. **capitata** L. English cabbage, head cabbage

Marshallese: ***kapej*** (a corruption of the English common name)

Recent introduction. Europe. Occasional. Food plant at Laura Experimental Farm and at Marshall Islands High School. Previously recorded on Kwajalein by F. S & O (1972) and on Enewetak by St. John (1960) (RRT 1991, 1999, 2000A; NVV 2000).*

Brassica oleracea L. var. **gongylodes** L. kohlrabi

Syn. *Brassica oleracea* L. *caulorapa* Pasq.

Recent introduction. Asia. Rare. Single plant seen in houseyard garden at Lojkar Resort (RRT 2000B) (DPMJ0243).**

Brassica x **hybridus** Saladeer hybrid Chinese cabbage

Recent introduction. Asia. Occasional. Food plant at Laura Experimental Farm and at Marshall Islands High School (RRT 1991, 2000AB).**

Rhaphanus sativus L. var. **sativus** radish, red radish

Recent introduction. East Asia. Rare; probably periodically extirpated. Food plant reported present on Majuro by F. S & O (1979); not seen growing by current authors, but probably periodically replanted with imported seed available at the major retailers (F, S & O 1979).

Rhaphanus sativus L.var. **longipinnatus** Bailey

daikon, white or Chinese/Japanese radish, loh bok

Recent introduction. East Asia. Rare. Food plant at Laura Experimental Farm in Laura and at Japanese Takeout Restaurant in Botkan (RRT 1991, 2000A, 2001).*

CACATACEAE (Cactus Family)*

Cereus sp. cereus cactus

Recent introduction. Tropical America. Rare. Small potted ornamental cactus. Identification tentative. Found as an indoor houseplant in Uliga. Similarly unidentified species of this genus previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) and on Kwajalein by Whistler & Steele (1999) (NVV 2000) (DPMJ0191a).*

Epiphyllum oxypetalum (DC.) Haw. gooseneck cactus
Syn. *Phyllocactus grandis* Lem.

Recent introduction. Mexico. Rare. Single young potted plant seen in houseyard garden in Rairõk. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) and on Kwajalein by Whistler & Steele (1999) (RRT 2000B) (DPMJ0307).*

Mammillaria sp. mammillaria cactus

Recent introduction. Mexico? Ornamental potted plant. Could possibly be *Mammillaria guelzowiana.* Found as an indoor house plant in Uliga (NVV 2000) (DPMJ0191b).**

Opuntia sp. prickly-pear cactus, beaver-tail cactus

Recent introduction. Tropical and subtropical America. Uncommon. Planted ornamental and potted plant. Similarly unidentified species of this genus previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962), and on Kwajalein by Whistler & Steele (1999) Can become invasive; has been declared noxious in Fiji and Samoa (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0370, DPMJ0520c).*

A number of other unidentified ornamental Cactaceae.*

CAESALPINIACEAE (Senna Family)

Bauhinia monandra Kurz pink bauhinia, orchid tree, pink butterfly tree

Recent introduction. Burma. Uncommon. Planted ornamental tree, reportedly introduced from Saipan, found on along ocean road in Delap; also seen at former President Amata Kabua's residence and a few other locations. *Bauhinia* sp. reported from Kwajalein by Whistler & Steele (1999) and could be the same species. Can become invasive (RRT 1991, 1999, 2000A, 2001; NVV 1999) (DPMJ0667).**

Caesalpinia bonduc Roxb. beach nicker, gray nickers, wait-a-bit

Marshallese: ***kãlõklõk*** ("thorns", "brambles", a name also applied to *Ximenia americana*, which is native to other Marshall Islands' atolls but not present on Majuro, *Cenchrus echinatus*, and *Xanthosoma sagittifolium*)

Indigenous. Pantropical. Uncommon. Large thorny shrub with yellow flowers in localized roadside coastal thicket in recently cleared area north of Laura seen in 1991, in a lagoon side coastal thicket just west of the airstrip in 1999, and a very dense thicket of many plants on the oceanside of the road west of the airstrip in 2000. Previously reported on Ujae and Jaluit by F. S & O (1979) and on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0244, DPMJ0245).*

Caesalpinia pulcherrima (L.) Swartz

pride of Barbados, dwarf poinciana, Barbados flower fence

Syn. *Poinciana pulcherrima* L.

Marshallese: ***jeimõta*** (reportedly named after the grandfather of the first President of the Marshall Islands, Amata Kabua)

Recent introduction. Tropical America. Occasional. Planted ornamental shrub in Rita, in Amata Kabua's garden and a number of other household gardens. Yellow, orange-red and pink cultivars are present. Previously reported from Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0633, DPMJ0634).*

Cassia x **nealii** Irwin & Barneby rainbow shower tree

Recent introduction. Horticultural origin. Occasional. A sterile hybrid of *C. fistula* L. and *C. javanica* L. Two mature trees planted in grounds of Capital Building and another in a private household garden in Woja (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0156).**

Delonix regia (Bojer) Raf. poinciana, flame tree, flamboyant

Recent introduction. Madagascar. Common. Planted ornamental tree in household gardens and around institutional buildings and commercial areas. Sabath (1977) reports that he only observed this tree in Uliga, but it is now found throughout the atoll; one tree planted near an abandoned structure on Calalin Islet. Can become invasive, forming dense monospecific stands (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Intsia bijuga (Colebr.) O. Ktze. ipil tree, island teak

Marshallese: ***kubõk***

Indigenous. Madagascar to Polynesia. Occasional. Few isolated trees in Laura and Woja. A number of small stands of saplings and mature trees found slightly inland from the north end of Eneko Islet and on Bok-botun in Aeañen (F, S & O 1979; FRF 1990; RRT 1999; NVV 2000).

Senna occidentalis (L.) Link coffee senna, arsenic bean
Syn. *Cassia occidentalis* L.

Recent introduction. Tropical America. Uncommon. Weed of waste places and roadsides; found near a waste area near a small dump and in a vacant lot in Delap (RRT 1991, 1999, 2000AB; NVV 2000).*

Senna surattensis (Burm. f.) Irwin & Barneby
glaucous cassia, sunshine tree, Singapore shower tree
Syn. *Cassia surattensis* Burm. f.

Recent introduction. Tropical Asia. Uncommon. Small tree found in Maria Fowler's household garden, in the center of the Capital complex, and in front of the Middle School Building. (RRT 2000AB, 2001; NVV 2000) (DPMJ0093, DPMJ0094).**

CANNABACEAE (Cannabis Family)**

Cannabis sativa L. Indian hemp, marijuana

Recent introduction. Tropical and subtropical Asia. Reported by Majuro police to be present and in cultivation in the early 1990s. Persons responsible for its cultivation were asked to leave the country or face criminal charges (NVV 1999).**

CAPPARIDCEAE (Caper Family)*

Cleome speciosa Volk. spider flower
Syn. *Gynandropsis speciosa* (Raf.) DC.

Recent introduction. Tropical America from Mexico to Peru. Occasional. Annual of household gardens in Rita, surviving without cultivation. Seeds imported for sale at Robert Reimer's Enterprise (RRT 1999; NVV 1999).**

Crateva religiosa Forster f. temple plant, garlic pear
Syn. *Crateva speciosa* Volk.

Recent introduction. Tropical Africa and Asia. Uncommon. Single small tree on the grounds of Capital Building and a few other trees planted in household gardens in Woja and Laura (RRT 1999, 2000AB; NVV 2000) (DPMJ0024, DPMJ0164, DPMJ0272).**

CAPRIFOLIACEAE (Honeysuckle Family)

Lonicera japonica Thunb. Japanese honeysuckle

Recent introduction. Eastern Asia and Japan. Rare. Planted ornamental in household garden at Good Earth Apartments. Can become invasive and has become a pest in parts in many states in the U.S, including Hawai'i, and on Christmas Island, Indian Ocean; sale is banned in New Zealand and in parts of the U.S. (NVV 2000; RRT 2000AB, 2001) (DPMJ0151b, DPMJ0356).**

Sambucus mexicana Presl. Ex. DC. Mexican elderberry

Recent introduction. Mexico. Rare, possibly extirpated. Recorded on both Majuro and Jaluit by F, S & O (1979), but reported as extirpated on Jaluit by Fosberg & Sachet (1962) and not reported by current authors on either atoll (F, S & O 1979).

CARICACEAE (Papaya Family)

Carica papaya L. papaya, papaw

Marshallese: ***keinabbu***

Recent introduction. Tropical America. Common. Planted fruit tree in household gardens, agricultural areas and around taro pits; planted in excavated pit plantations at Laura; occasional as an escape or volunteer in garden areas and on Calalin Islet (StJ 1951; MDS 1977; FRF 1990; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0680).

CASUARINACEAE (Casuarina Family)

Casuarina equisetifolia L casuarina, ironwood, Australian pine, she-oak
Syn. *Casuarina litorea* L.

Marshallese: ***pientri*** ("pinetree"); ***nidõl*** ("needle" on some atolls); ***bûlukam*** ("blue gum" on some atolls); ***mejinoki***

Recent introduction. Indian Ocean to Polynesia and Micronesia. Common. Occasional in household gardens, as a roadside tree and as planted windbreaks; naturalized in some areas. Some very large mature trees on the protected lagoon coast and slightly inland on Calalin Islet. Although often planted as a windbreak and to protect inland areas from salt spray, it can cause environmental damage by out competing *Scaevola taccada*. Listed as *Casuarina* sp. by Sabath (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0703).

CLUSIACEAE or **GUTTIFERAE** (Mangosteen Family)

Calophyllum inophyllum L. beauty leaf, Alexandrian laurel, beach mahogany

Marshallese: ***lukwej***; ***jijo***; ***ijo***

Aboriginally introduced. Some Marshallese believe that it might have been introduced during the German period. Tropical Africa to eastern. Polynesia and Micronesia. Common to locally abundant. A large stand of trees found along the lagoon coast between Ajeltake and Laura. Large hardwood shade tree in home gardens, along the lagoon shore of the DUD, growing on the protected lagoon areas of Aeañen (StJ 1951; MDS 1977; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0699, DPMJ0723).

Clusia rosea Jacquin autograph tree, Scotch attorney, pitch apple
Syn. *Clusia major* (Jacquin) L.

Recent introduction. West Indies. Rare. Three young trees planted on the lawn behind the Capital Building. Can become invasive and has become a problem in other tropical Pacific areas, including Hawai'i (RRT 2001; NVV 2001).**

COMBRETACEAE (Terminalia Family)

Lumnitzera littorea (Jack) Voigt red-flowered black mangrove
Syn. *Lumnitzera coccinea* Wight & Arn.

Marshallese: ***kimeme***; ***kimã*** (archaic name)

Indigenous, or possibly indigenous to at least on some atolls of the Marshall Islands, but of recent introduction to Majuro. Tropical Asia through Malaysia into Micronesia and Polynesia to the Marshall Islands, Kiribati and Tonga and Tuvalu in Polynesia. Several small, but flowering trees seen along small inner lagoon near a stand of *Bruguiera gymnorrhiza* at former President Amata Kabua's residence. These were introduced from Namdrik and the flowers used for making traditional garlands, hence the reason for keeping the trees small (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0712, DPMJ0713).*

Quisqualis indica L. Rangoon creeper

Recent introduction. Southeast Asia and Malaysia. Rare. A couple small plants found in household garden in Rairõk. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962). Can become invasive (RRT 2000B) (DPMJ0410, DPMJ0411).*

Terminalia catappa L. tropical almond, beach almond, Indian almond, Malabar almond

Marshallese: ***kotōl***

Aboriginal introduction. Tropical Asia and Australia to West Polynesia and Micronesia. Occasional. Medium to large semi-deciduous tree planted in household gardens. A number of large trees are found near the R & D Building and Pacific International Inc. Almond-like kernels used for food. Previously recorded on Kwajalein, Arno, Likiep and Jaluit by F. S & O (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0433, DPMJ0566, DPMJ0692, DPMJ0693).*

Terminalia samoensis Rech. beach almond, Samoan almond

Syns. *Terminalia littoralis* sensu auct. non Seem.; *Terminalia saffordii* Merr.

Marshallese: ***kukōñ*** (Ratak); ***ekkōñ*** (Railik)

Indigenous. Indonesia to Micronesia and Eastern Polynesia. Occasional. Found in a number of household gardens and along the streets throughout the DUD and in the coastal forest or slightly inland from the coastal forest of Aeañen (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0434).

CONVOLVULACEAE (Morning-Glory Family)

Evolvulus glomeratus Nees & Martius blue daze

Recent introduction. Tropical America. Uncommon. Blue-flowered potted plant in a few household gardens in Rita. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 2000A; NVV 2000) (DPMJ0018).*

Ipomoea aquatica Forsk. water spinach, swamp cabbage, ung ts'oi, kang kong

Syn. *Ipomoea repens* Poir.

Recent introduction. Pantropical. Uncommon. Food plant at Laura Experimental Farm, in a Filipino garden east of the airport and at Marshall Islands High School in 1991. Can become invasive and is on the U. S. list of noxious weeds (RRT 1991, 1999, 2000AB; NVV 2000).**

Ipomoea batatas (L.) Lam. sweet potato, kumara

Marshallese: ***piteto*** ("potato")

Recent introduction. Tropical America. Occasional. Food plant at Laura Experimental Farm and in a couple of home gardens in Laura; periodically grown at schools, such as Rita Elementary School and Marshall Islands High School, and in private home gardens in the DUD. Also grown in a Filipino garden and at the Laura Experimental Farm. St. John describes it as being rare in cultivation, having been introduced by the Germans. Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce sweet potato *I. tuberosa*, and so probably this species and not the wood rose (*Merremia tuberosa = I. tubersoa*) (StJ 1951; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0173).

Ipomoea fistulosa Mart. ex Choisy bush morning-glory

Recent introduction. Brazil. Rare, possibly extirpated. Planted ornamental shrub (RRT 1991, 1999).**

Ipomoea littoralis Bl. beach morning-glory

Syn. *Ipomoea gracilis* R. Br.

Marshallese: ***lojilñin kijdik*** ("rat's ear"; a name also used for certain fungi that are flat and spreading)

Indigenous or possibly weed of aboriginal introduction . Malaysia and the Pacific. Occasional. Creeping or twining vine in inner coastal strand vegetation, inland thickets, ruderal sites and along roadsides, mainly in Laura (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 2000AB, 2001; NVV 2000) (2K00408; DPMJ0333, DPMJ0549).

Ipomoea pes-caprae (L.) Sweet ssp. **brasiliense** (L.) v. Ooststr.
goat-foot beach morning-glory

Syn. *Ipomoea brasiliense* (L.) Sweet

Marshallese: ***topo***; ***marlap*** ("big-bush", general term)

Indigenous. Pantropical. Abundant. Vigorous creeping vine in coastal vegetation on ocean and lagoon shores and along roadsides, in ruderal sites and waste places (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0691, DPMJ0741).

Ipomoea quamoclit L. cypress vine

Recent introduction. Tropical America. Rare. Sprawling vine growing on the window screen of a private residence in Uliga, at the Chinese Embassy and a single young plant in private garden in Rita (NVV 2000).**

Ipomoea violacea L. wild moon flower; white morning-glory

Syns. *Ipomoea macrantha* R. & S., *Ipomoea tuba* (Schlecht.) G. Don

Marshallese: ***marpele***

Indigenous. Pantropical. Common. Somewhat woody creeping or climbing vine festooning inner coastal strand forest, in neglected coconut plantations and in ruderal sites; abundant in parts of Laura and Aeañen, but occasional in the inhabited areas of DUD (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0552).

Merremia peltata (L.) Merr. merremia

Recent introduction. Indian Ocean islands to the Society Islands in Polynesia and to Pohnpei and Kosrae in Micronesia. Occasional. Not recorded present in the Marshall Islands by F, S & O (1979) and not seen in 1991. Seen present in three locations in Laura in 1999 and 2000, climbing in secondary forest inland from the pastor's house in Laura, in secondary forest near the Laura Experimental Farm, and climbing a fence of an abandoned farm. An invasive vine that seems to have spread since 1999; could potentially cause ecological problems and thus should probably be eliminated before it spreads out of control. Identified on Majuro for the National Biodiversity Report by the RMI Biodiversity Team (2000), although location not specified. Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0363, DPMJ0522).

CORNACEAE (Dogwood Family)**

Griselinia littoralis (Raoul.) Raoul green jewel, broadleaf

Recent introduction. New Zealand. Rare. Small shrub with leathery variegated leaves growing in a container in household garden in Rairõk (RRT 2000B) (DPMJ0323).**

CRASSULACEAE (Orpine Family or Stonecrop Family)*

Kalanchoë blossfeldtiana v. Poelln. flaming Katy

Recent introduction. Madagascar. Occasional. Succulent potted plant found in a number of household gardens; imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants; several color varieties are present (RRT 1991, 2000AB, 2001; NVV 2000) (DPMJ0041).**

Kalanchoë daigremontianum Hamet & Per Mexican hat plant
Syn. *Bryophyllum daigremontianum* (Hamet & Perrier) Berger

Recent introduction. Madagascar. Uncommon. Ornamental potted plant (NVV 2000; RRT 2000AB, 2001) (DPMJ0103, DPMJ0119, DPMJ0111, DPMJ0145c, DPMJ0147d, DPMJ0344, DPMJ0483, DPMJ0600).**

Kalanchoë fedtschenkoi Hamet & Perrier lavender scallops

Recent introduction. Madagascar. Rare. Ornamental potted plant (NVV 2000; RRT 2000A).**

Kalanchoë gastonis-bonnieri Hamet & Perrier donkey ears

Recent introduction. Madagascar. Rare. Ornamental potted plant (NVV 2000; RRT 2000AB, 2001) (DPMJ0014).**

Kalanchoë pinnata (Lam.) Pers. air plant, miracle plant, life plant
Syns. *Bryophyllum calycium* Salisb.; *Bryophyllum pinnatum* (Lam.) Kurz

Marshallese: ***kibilia***

Recent introduction. Indian Ocean islands. Occasional. Planted ornamental and potted plant. Previously reported on Kwajalein, Arno, Likiep and Jaluit by F. S & O (1979). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Kalanchoë tomentosa Bak. panda plant, pussy ears; cocoon plant; velvet leaf kalanchoë

Recent introduction. Madagascar. Rare. Single plant seen in private garden in Rita (RRT 2000A; NVV 2000).**

Kalanchoë tubiflora (Harvey) Hamet
chandelier plant, mother-of-thousands, friendly neighbor
Syns. *Bryophyllum tubiflorum* Harvey; *Kalanchoë verticillata* Scott-Elliot

Recent introduction. Madagascar. Rare. Ornamental potted plant, found in nurse's room and the library at Marshall Islands High School and in an outdoor garden area in Rairõk. Previously reported on Kwajalein by Whistler & Steele (1999) (NVV 2000).*

CUCURBITACEAE (Melon Family or Gourd Family)

Benicasa hispida (Thunb.) Cogn. wax gourd, ash pumpkin, winter melon, tung kwa
Syns. *Benicasa cerifera* (Fisch.) Savi; *Cucurbita hispida* Thunb.; *Cucurbita cerifera* Fisch.

Recent introduction. Southeast Asia. Rare. Food plant at Laura Experimental Farm and poultry farm (RRT 2000A).**

Citrullus lanatus (Thunb.) Matsum. and Tan. var. **caffrorum** (Alef.) Fosb.
watermelon
Syn. *Citrullus vulgaris* Schrad. ex Eckl. and Zeyh.

Recent introduction. South Africa. Occasional. Food plant at Laura Experimental Farm and at Marshallese commercial garden in Laura, and periodically in private household gardens. Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that extensive attempts were made to introduce this plant (RRT 1991, 1999, 2000AB; NVV 1999).*

Coccinia grandis (L.) Voigt ivy gourd, scarlet gourd
Syn. *Coccinia cordifolia* (L.) Cogn.

Marshallese: ***kiuri awia*** ("wild cucumber" a name arbitrarily contrived during a weed workshop in connection with the South Pacific Commission)

Recent introduction. Tropical Africa to Australia. Rare. Single vine in household food garden near the dock in Uliga, but did not survive; subsequently seen climbing on the back fence of the Agricultural farm in Laura, where it was introduced experimentally; and later, growing on the fence of the R & D Building nursery and in a private garden in Botkan. A destructive invasive that has caused great ecological problems on Saipan. Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop (NVV 2000; RRT 2000B, 2001) (DPMJ0261, DPMJ0572).**

Cucumis melo L. var **cantalupensis** Naud — cantaloupe, rock melon

Recent introduction. Southwest Asia to Africa and the Mediterranean. Occasional. Food plant at Laura Experimental Farm and in Marshallese commercial garden in Laura and periodically in private household gardens; one plant also seen growing on Calalin Islet. Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce a melon, presumably this species (RRT 1991, 2000A; NVV 1999).*

Cucumis melo L. var **conomon** Makino — oriental pickling melon, ts'it kwa (Chinese)

Recent introduction. China. Rare. Food plant at Laura Experimental Farm and poultry farm. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) (RRT 2000A).*

Cucumis sativus L. — cucumber

Marshallese: ***kiuri*** (from Japanese)

Recent introduction. North India. Occasional. Annual food plant in Marshallese commercial garden and at Chinese experimental garden at Laura; a large private planting seen along Laura backroad in November 2001. Previously reported from Kwajalein and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000B, 2001; NVV 1999) (DPMJ0275, DPMJ0276, DPMJ0277, DPMJ0545, DPMJ0546).*

Cucurbita maxima Duch. — squash

Recent introduction. South America. Rare. Food plant at Laura Experimental Farm. Previously reported on Enewetak, Ujelang, Rongelap and Aur by F. S & O (1979) (RRT 1991).*

Cucurbita moschata (Duch. Ex Lam.) Duch. ex Poir. — winter squash

Recent introduction. Central America and Northern South America. Rare. Food plant at the Laura Experimental Farm in 2000. Previously reported on Jaluit by F. S & O (1979) (RRT 2000A).*

Cucurbita pepo L. pumpkin

Marshallese: ***baañke*** (a corruption of the English common name)

Recent introduction. Tropical America. Occasional. Food plant in household gardens and at Laura Experimental Farm, often adventive in waste places and gardens (StJ 1951; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0278).

Lagenaria siceraria L. bottle gourd

Recent introduction. Tropical Africa. Rare. Planted on Laura Experimental Farm. Previously reported on Aur by F. S & O (1979) (RRT 1991, 1999, 2000A).*

Luffa acutangula (L.) Roem. angled loofah, ridge gourd, silk gourd, sze kwa

Recent introduction. Tropical Asia. Uncommon. Food plant at Laura Experimental Farm, at poultry farm and in household gardens in the DUD (RRT 1999, 2000A; NVV 1999).**

Luffa cylindrica (L.) Roem. smooth loofah, wild vegetable sponge, sponge gourd

Recent introduction. Tropical Asia. Occasional. Food plant at Laura Experimental Farm and also present in a household garden; seen as an adventive in trees at Laura in 1999; found in 2000 at Natural Resources building and one very large plant growing on the fence at Elm Garage in 2000 and 2001 (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0357, DPMJ0358, DPMJ0561).**

Momordica charantia L. bitter gourd, balsam pear

Recent introduction. Paleotropics. Occasional. Climbing food plant household gardens, particularly in Filipino gardens. Both the small wild and the larger garden varieties found. Has become naturalized in some areas, and is invasive in other parts of the Pacific, such as Guam (RRT 1991, 1999, 2000AB; NVV 1999).**

CUSCUTACEAE (Cuscuta Family)**

Cuscuta campestris Yuncker golden dodder, field dodder

Recent introduction. Originally America, now widely dispersed in Old World. Rare. Found in a large patch growing in seaside roadside vegetation about 200 m north of the

Marshall Islands Club, the end of the road in Rita, at the CMI Marshall Islands Science Station in Arrok and in a roadside thicket opposite the Industrial Area just east of Majuro Bridge. Parasitic vine, with very small scale-like leaves and thin yellowish stems; slightly thinner and more delicate than the very similar *Cassytha filiformis.* Can become invasive and is on the U.S. Federal noxious weed list (RRT 2000B, 2001; NVV 2000) (DPMJ0280, DPMJ0281, DPMJ0282, DPMJ0283, DPMJ0700).**

ERICACEAE (Heath Family)**

Rhododendron sp. azalea

Recent introduction. Rare, possibly extirpated. Planted ornamental; not seen after 1991 (RRT 1991).**

EUPHORBIACEAE (Spurge Family)

Acalypha godseffiana Masters copper leaf, three-seeded mercury

Recent introduction. Origin uncertain, but possibly Malaysia and New Guinea. Rare. Planted ornamental and hedge plant. Previously reported on Likiep by F. S & O (1979) (NVV 2000; RRT 2000AB).*

Acalypha hispida Burm. f. cat's tail, chenille plant, red-hot poker, red-tassle plant

Recent introduction. Indonesia. Uncommon. Planted ornamental in household gardens; one seen along the main road in Rita. Previously reported on Likiep and Kwajalein by F. S & O (1979) but did not survive on Kwajalein according to Whistler & Steele (1999) (RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0216).*

Acalypha wilkesiana Muell.-Arg. Joseph's coat, copper leaf, beefsteak plant
Syns. *Acalypha amentacea* Roxb. ssp. *wilkesiana* (Muell.-Arg.) Fosb.; *Acalypha grandis* Benth.

Recent introduction. Melanesia. Occasional. Planted ornamental and hedge plant. Observed in cultivation in Laura by St. John. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants (StJ 1951; MDS 1977; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0623).

Acalypha wilkesiana Roxb. f. **circinata** Muell.-Arg. picottee acalypha
Syns. *Acalypha amentacea* Roxb. f. *circinata* (Muell.-Arg.) Fosb.; *Acalypha hamiltoniana*

Recent introduction. Pacific Islands. Uncommon. Planted ornamental, often as hedges (RRT 1991, 1999, 2000AB, 2001; NVV 1999).**

Breynia disticha Forst. f. leaf-flower of the Pacific Islands, snow bush
Syn. *Breynia. nivosa* (W.G. Sm.) Small

Recent introduction. Pacific Islands. Occasional. Planted ornamental in household gardens and potted plant when young; sometimes found in hedges. Previously reported on Kwajalein by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0508).*

Chamaesyce atoto (Forst. f) Croizat beach spurge
Syns. *Euphorbia atoto* Forst. f.; *Euphorbia chamissonis* (Kl. and Gke.) Boiss.

Marshallese: ***pãdãl*** ("push up soil", "of roots"; a name at times also applied to *Boerhavia tetrandra*); ***maldok***

Indigenous. Tropical Pacific. Uncommon. Spreading small shrub on ocean shore north of Laura; also seen on seaside in Lomajurok west of Peace Park near a *Colubrina asiatica* plant in an area where sea-borne seeds may have been deposited during high waves. Initially observed around Laura by St. John (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0251).

Chamaesyce hirta (L.) Millsp. garden spurge, asthma plant, hairy spurge, old blood
Syn. *Euphorbia hirta* L.

Recent introduction. Pantropical. Abundant. Weed in waste places and open areas; also seen near an abandoned structure on Calalin Islet. Previously reported on Enewetak, Utdrik, Kwajalein, Jemo, Likiep and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0252, DPMJ0587).*

Chamaesyce hypericifolia (L.) Millsp. graceful spurge
Syn. *Chamaesyce glomerifera* Millsp.; *Euphorbia glomerifera* (Millsp.) Wheeler

Marshallese: ***bwilbwilikkaj*** (a name sometimes also applied to *Adenostemma lanceolatum* and *Synedrella nodiflora*)

Recent introduction. Tropical America. Common. Garden and ruderal weed (F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Chamaesyce prostrata (Ait.) Small — prostrate spurge, red caustic creeper
Syn. *Euphorbia prostrata* Ait.

Marshallese: ***dãpijbok*** ("to hold onto the sand"; a name also used for *C. thymifolia*)

Recent introduction. Tropical America. Common. Weed along paths, roadsides, parking lots and in open waste places (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000B, 2001; NVV 1999) (DPMJ0253, DPMJ0254, DPMJ0504a).

Chamaesyce thymifolia (L.) Millesp. — thyme-leafed spurge
Syn. *Euphorbia thymifolia* L.

Marshallese: ***dãpijbok*** ("to hold onto the sand"; a name also used for *C. prostrata*); ***natto*** (a name also applied to *Boerhavia tetrandra*)

Recent introduction. India. Common to Abundant. Weed along roadsides, in ruderal sites and around buildings in Rita and in many other areas. Previously reported on Ujelang, Kwajalein and Jaluit by F. S & O 1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0092, DPMJ0119, DPMJ0255, DPMJ0504b).*

Cnidoscolus chayamansa McVaugh — chaya, tree spinach

Marshallese: ***pele*** (misapplication of "bele" or "pele" the Fijian and Polynesian names for *Abelmoschus manihot*, a spinach plant similar in appearance to *Cnidoscolus*)

Recent introduction. Mexico. Occasional. Food plant in household gardens and food gardens. Introduced as part of the European Community Pacific Regional Agricultural Project (PRAP) program for atolls (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0674).**

Codiaeum variegatum (L.) Bl. — croton
Syn. *Croton variegatum* L.

Marshallese: ***ut*** (general term for flower or hedge)

Recent introduction. Malaysia to Melanesia. Common. Planted ornamental, singly and as hedges in household gardens and around businesses. *C. variegatum* var. *aucubafolium* (DBMJ0007) found as a potted plant at Robert Reimers Hotel and a number of other locations; a wide range of extremely variable cultivars exists (StJ 1951; MDS 1977; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DBMJ0007, DPMJ0582).

Euphorbia antiquorem L. Malayan cactus spurge, Malayan spurge tree

Recent introduction. India and Southeast Asia. Uncommon. Ornamental potted plant at the College of the Marshall Islands Library and a few household gardens (RRT 1991, 2000AB; NVV 2000) (DPMJ0197).**

Euphorbia cotinifolia L. hierba mala

Recent introduction. West Indies. Uncommon. Ornamental potted plant and garden border (RRT 1991, 1999, 2000A; NVV 2000).**

Euphorbia cyathophora Murr.
Mexican fire plant, hypocrite plant, wild poinsettia, dwarf poinsettia
Syn: *Euphorbia heterophylla* L.

Marshallese: ***nukne*** (from a corruption of "New Guinea")

Recent introduction. Tropical America. Occasional. Roadside and waste place weed, including fields in Laura (StJ 1951; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0309, DPMJ0310, DPMJ0679).

Euphorbia lactea Haw. mottled candlestick, mottled spurge, milkstripe euphorbia

Recent introduction. India. Rare. A few plants seen in containers in a private household garden in Woja. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 2000B, 2001; NVV 2000) (DPMJ0311).*

Euphorbia milii Ch. des Moul. crown-of-thorns

Recent introduction. Madagascar. Occasional. Planted ornamental and potted plant. Previously reported on Jaluit by F. S & O (1979) and on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0312).*

Euphorbia pulcherrima Willd. ex Klotszch poinsettia
Syn. *Poinsettia pulcherrima* (Willd.) R. Grah.

Recent introduction. Mexico. Rare; possibly extirpated. Planted ornamental seasonally imported. Previously reported on Jaluit and Kwajalein by F. S & O (1979) but did not survive on either (Fosberg & Sachet 1962, Whistler & Steele 1999) (RRT 1999; NVV 1999).*

Euphorbia tirucalli L. pencil plant, naked lady, milk hedge

Recent introduction. East Africa and India. Occasional. Planted ornamental around houses. Previously reported on Kwajalein by Hebst (1988). The milky sap is highly poisonous and can cause blindness (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0313).*

Glochidion ramiflorum Forst. glochidion

Recent introduction, possibly from Chuuk or Pohnpei where it is listed as indigenous. New Guinea to Vanuatu and the Caroline Islands in Micronesia. Rare. Single tree about 7m high growing inland in an undeveloped lot across the street from Robert Reimer's residence in Rita. Damaged in October 2001 by a fire that burned a nearby abandoned structure. *Glochidion* is a highly variable genus that is characterized by adaptive varieties on high islands. As a result the nomenclature is confused and, although the species found in Majuro is most likely *G. ramiflorum*, it could be one of three other species also reported present in Chuuk and/or Pohnpei, which include *G. kanehirae* Hosok; and *G. ponapense* Hosok.; and *G. puberulum* Hosok (NVV 2000; RRT 2000B, 2001) (DPMJ0320, DPMJ0321, DPMJ0322).**

Jatropha integerrima Jacq. rose-colored jatropha
Syn. *Jatropha hastata* Jacq.

Recent introduction. Cuba. Occasional. Planted ornamental shrub or small tree in household gardens and around some businesses. Previously reported on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0516, DPMJ0627).*

Jatropha multifida L. coral plant
Syn. *Jatropha hastata* Jacq.

Recent introduction. Texas to Brazil. Rare. A single potted plant seen in Amata Kabua's garden. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 2000A; NVV 2000) (DPMJ0032).*

Manihot esculenta Crantz cassava, manioc, tapioca
Syn. *Manihot utilissima* Pohl

Marshallese: ***maniok*** (a corruption of one of its English common names)

Recent introduction. Tropical America. Occasional. Food plant at Laura Experimental Farm, Marshall Islands High School and in some household gardens, especially in gardens of contract workers from Fiji . Previously reported on Jaluit by F. S & O, and although those plants did not survive, according to Fosberg & Sachet (1962), observed by NVV during more recent visits; also reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Pedilanthus tithymaloides (L.) Poit. slipper flower, shoe spurge, red-bird cactus

Recent introduction. Caribbean. Occasional. Planted ornamental and potted plant. Previously reported on Kwajalein by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0044).*

Phyllanthus amarus Sch. & Th. sleeping plant, six-o'clock
Syn. *Phyllanthus niruri* L.

Marshallese: ***jiljino awa*** ("six-o'clock")

Recent introduction. Africa. Abundant. Weed of gardens, roadsides, farms, waste places and other ruderal sites; one of the most common weeds in Majuro; also common in disturbed sites on Calalin Islet. Leaves used in local medicine (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0570, DPMJ0590).

Ricinus communis L. castor bean

Recent introduction. Africa. Rare. A number of plants around the buildings of the CMI Marshall Islands Science Station in Arrak, apparently left by the Koreans who initially built the complex. Source of commercial castor oil, but unprocessed seeds highly poisonous. Previously reported on Enewetak, Ailinglaplap and Jaluit by F. S & O (1979) but did not survive at least on Jaluit (Fosberg & Sachet 1962). Can become invasive and has become a weed of ruderal sites in Hawai'i, Kiribati and other Pacific Islands and a noxious weed in South Africa (NVV 2000; RTT 2000A).*

FABACEAE (Pea Family)

Canavalia cathartica Thou. purple beach pea
Syn. *Canavalia microcarpa* (DC.) Piper

Marshallese: ***jiipkako*** (from English "chief cargo" due to the wallet-like shape of the seedpod); ***marlap*** ("big-bush", general term)

Indigenous. Pantropical. Occasional. Vine climbing on trees in neglected coconut plantation in Laura area and in lagoon vegetation of some of the less inhabited islets of Aeañen. Although not previously recorded on Majuro, this species was previous recorded for Enewetak, Rongelap, Ujelang, Ujae, Wotho, Lae, Kwajalein, Jemo, Likiep, Ailinglaplap, Arno and Jaluit by F. S & O (1972) (FRF 1990; RRT 1991, 1999, 2000A; NVV 1999) (DPMJ0131S)*

Canavalia rosea (Sw.) DC. sea bean

Syns. *Canavalia maritima* (Aubl.) Urb.; *Canavalia obtusafolia* (Lam.) DC.

Marshallese: ***marlap*** ("big bush", general term)

Indigenous. Pantropical. Occasional. Found in inner beach forest and abandoned coconut plantations in Laura; found along and just inland from coast on Calalin Islet; rare on the main islets of Majuro (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001).

Canavalia sericea A. Gray silky jackbean

Marshallese: ***marlap*** ("big bush", general term)

Indigenous. Fiji to eastern Polynesia and Micronesia. Rare, possibly extirpated. Reported on Majuro by St. John as a new record for Micronesia, with subsequent collections on Ailinglaplap and Wotje Atolls. At that time, the nearest known established location was Fiji. F. S & O (1979) also list it for Ulithi and Puluwat in the Caroline Islands. This species has not been observed by either of the current (StJ 1951; F, S & O 1979; FRF 1990).

Clitorea ternatea L. butterfly pea

Recent introduction. Tropical America or Pantropical. Uncommon. Growing in a hedge in a household garden in Laura, on fence near a home in Rita, at a Filipino residence next to the Natural Resources Building, and at the residence of former President Amata Kabua. Can become invasive (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0665).**

Crotalaria juncea L. Sunn hemp

Recent introduction. India. Rare; probably now extirpated. Single mature plant growing in a fenced area near the Land Grant Building at CMI. Planted experimentally, but never produced seed, and was extirpated with the construction of new buildings in late 1999 (RRT 1999; NVV 1999).**

Crotalaria pallida L. rattlepod

Syn. *Crotalaria. mucronata* Desv.

Recent introduction. Old World Tropics. Occasional. Weed of wasteplaces and ruderal sites; weed in schoolyard in Rita; locally common in waste places near the industrial area to the east of Majuro Bridge. Previously reported on Jaluit by F. S & O (1979) and although reported by have not survived by Fosberg & Sachet (1962), it either did actually survive or was introduced as it was observed there during recent visits by NVV (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0581).*

Desmodium incanum DC. Spanish clover

Syn. *Desmodium canum* (Gmel.) Sch. & Th.

Marshallese: ***lattil pako*** ("sharksucker", a name arbitrarily contrived during a weed workshop in connection with the South Pacific Commission)

Recent introduction. West Indies. Abundant. Weed in lawns, gardens, roadside and ruderal sites throughout atoll. Invasive weed that spreads by seeds that stick to clothing and other objects. Previously reported on Kwajalein by F. S & O (1979) and naturalized there by Whistler & Steele (1999). Has spread to other atolls visited by NVV. Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0559).*

Erythrina variegata L. var. **variegata** variegated coral tree, variegated dadap

Recent introduction. Pacific Islands. Rare; possibly now extirpated. Planted ornamental (RRT 1991, 1999).**

Erythrina variegata var. **orientalis** (L.) Merr. coral tree, dadap

Recent introduction. Indo-Pacific. Occasional. Planted tree, along lagoon coast in the vicinity of the dump and in household gardens. One large tree at former President Imata Kabua's residence is known to flower; others reportedly do not produce flowers. Sabath reports that this tree was part of the secondary forest along the old World War II runways and military areas on eastern Rairõk, which is still where the majority are to be found. Reported present on Kwajalein, Likiep and Jaluit by F, S & O (1979) (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 2000).

Glycine max (L.) Merr. soybean, soya bean

Syns. *Glycine soja* (L.) Sieb. & Zucc.; *Glycine hispida* (Moench.) Maxim.

Recent introduction. Southern Asia. Rare. Planted at Laura Experimental Farm in 1991 and at the Taiwanese experimental farm in 2000. Green pods and seeds cooked as a vegetable (RRT 1991; 2000A; NVV 2001).**

Inocarpus fagifer (Parkinson) Fosb. Polynesian chestnut, Tahitian chestnut

Syns. *Inocarpus edulis* J.R. and G. Forst.; *Inocarpus fagiferus* Fosberg ex Yuncker Parkinson

Marshallese: ***kûrak***

Recent introduction. Malaysia into Micronesia and as far west as French Polynesia.

Uncommon. One mature tree and a number of young trees seen in household gardens in Laura. Indigenous on high islands such as Pohnpei, but current trees seem to be recent introductions due to the age of the trees in Laura. During the Majuro Biodiversity Workshop (1998), said not to be a Marshall Islands tree but still a useful species worthy of mention (RRT 1999, 2000A, 2001; NVV 1999) (DPMJ0515).

Lablab purpureus (L.) Sweet

hyacinth bean, lablab bean, bonvist bean, Egyptian kidney bean

Syns. *Lablab niger* Medik.; *Dolichos lablab* L.; *Dolichos purpureus* L.

Recent introduction. Paleotropical. Occasional. Planted on a fence near the west end of the airport and in Filipino gardens in the DUD and Rairõk, and in a Chinese garden in Rita. Previously reported on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999). Can become invasive (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0346, DPMJ0347, DPMJ0563).*

Pachyrhizus tuberosus (Lam.) Spreng. West Indies yam bean, jicama

Recent introduction. Mexico and northern Central America. Rare. Planted in garden of the former President Amata Kabua, climbing on a fence and growing well, but somewhat chlorotic. Planted years previous and the edible tuberous root is periodically harvested for food (RRT 2001; NVV 2001) (DPMJ0636).**

Phaseolus vulgaris L. string bean, French bean, haricot bean

Marshallese: ***piin*** (a corruption of the English common name)

Recent introduction. Tropical America. Rare, probably at least periodically extirpated. Food plant at Laura Experimental Farm and planted annually in vegetable gardens. Previously reported on Kwajalein but did not survive (Whistler & Steele 1999) (RRT 1991; NVV 1999).*

Sophora tomentosa L. silverbush, yellow necklace pod

Marshallese: ***kille***

Indigenous. Indian Ocean to eastern Polynesia and Micronesia. Uncommon. Rare on beaches and occasionally planted in household gardens. One small tree on beach of Calalin Islet, a couple of other plants in household gardens in Delap and Rita, one planted at a private residence in Ajeltake, and a large mature shrub and other small bushes along beach and just inland from the lagoonside beach in Woja (StJ 1951; F, S & O 1979; FRF 1990; NVV 1999; RRT 2000AB).

Vigna marina (J. Burm.) Merr. yellow beach pea

Marshallese: ***marlap*** ("big bush", general term); ***markinenjojo*** ("bush for therapeutic bathing" in reference to its medicinal use)

Indigenous. Pantropical. Abundant. Found on beaches, in coastal forest on both ocean and lagoon coasts and in waste places and ruderal sites along roadways (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0440, DPMJ0513b, DPMJ0690).

Vigna unguiculata ssp. **sesqipedalis** (L.) Verdc. long bean, snake bean, asparagus bean
Syn. *Vigna sesquipedalis* (L.) Fruw.

Recent introduction. Tropical Africa. Occasional. Food plant at Laura Experimental Farm and in other vegetable gardens, sometimes in containers (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0441).**

GESNERIACEAE (Gloxinia Family)*

Chrysothemis pulchella (Donn ex Simms) Decaisne chrysothemis, dozakie

Recent introduction. Central America and Caribbean. Occasional. Planted ornamental and potted plant (RRT 1999, 2000AB; NVV 2000) (DPMJ0055, DPMJ0147a, DPMJ0256).**

Columnea microphylla Klotzsch and Hanst. goldfish plant, goldfish vine

Recent introduction. Central America. Uncommon. Potted plant at the University of the South Pacific Center in Delap and in a couple of other household gardens, one in Rairõk (RT2000AB, 2001; NVV 2000) (DPMJ0102, DPMJ0105, DPMJ0106, DPMJ0266, DPMJ0267, DPMJ0268, DPMJ0602).**

Episcia cupreata (Hook.) Hanst. flame violet, episcia

Recent introduction. Nicaragua. Occasional. Potted ornamental plant. Among unspecified species imported by Robert Reimers Enterprises in 1998 and 1999 as houseplants. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 2000AB, 2001; NVV 2000) (DPMJ0012, DPMJ0013, DPMJ0608). *

Saintpaulia ionantha Wendl. African violet

Recent introduction. Tropical Africa. Rare. Ornamental potted plant. Unspecified species imported by Robert Reimers Enterprises in 1998 and 1999 as houseplants (RRT 1991; NVV 2000).**

GOODENIACEAE (Naupaka Family)

Scaevola taccada (Gaertn.) Roxb. half-flower, saltbush

Syns. *Scaevola sericea* Vahl.; *Scaevola frutescens* (Mill.) Krause, Pflanzenr.

Marshallese: ***kõnnat*** (white-flowered form), ***kõlaime*** (form with purple-centered petals)

Indigenous. Tropical Asia to Hawai'i. Very abundant. A dominant component of the strand vegetation on both ocean and lagoon coasts; forms thickets that protect coastlines from wave erosion. Also found in waste places and planted along roads and causeways and in household gardens. Although almost all plants are the white-flowered form, there also exists a rare form with white flowers streaked with purple. This form is reported by Neal (1965) to exist in Hawai'i. There are two trees with purple-streaked flowers along the lagoon shore of the airport, one near the back entrance to the Capitol Building and one along the crossroad in Rita. Many Marshallese recognize the purple-centered petaled variety by the separate name of ***kõlaime*** (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0415, DPMJ0416, DPMJ0417, DPMJ0418, DPMJ0419; DPMJ0697, DPMJ0701).

HERNANDIACEAE (Hernandia Family)

Hernandia nymphaeifolia (Presl.) Kubr. jack-in-the box tree, lantern tree

Syns. *Hernandia sonora* L.; *Hernandia peltata* Meisn; *Hernandia ovigera* sensu auct. Non L.

Marshallese: ***piñpiñ***

Indigenous. Tropical Asia to Pacific Islands. Occasional to locally common. Tree along lagoon coasts and occasionally in household gardens; relatively common and a large grove on the lagoon side in Ajeltake; mature trees also present on the lagoon coast on Calalin Islet. Dark brown seeds used extensively as beads in necklaces and local handicrafts (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

LAMIACEAE or **LABIATAE** (Mint Family)

Mentha spicata L. mint, spearmint

Syn. *Mentha viridis* L.

Recent introduction. Europe. Rare. Growing unattended under air conditioning in Rairõk (NVV 2000) (DPMJ0187)**.

Ocimum basilicum L. basil, sweet basil

Recent introduction. Africa to Pacific Islands (Paleotropics). Uncommon. Planted in household gardens and pots. Leaves used in garlands and to scent coconut oil by Marshallese and Fijian residents. A variety known as lemon basil planted at one residence. Previously reported on Jaluit by F. S & O (1979) but did survive (Fosberg & Sachet 1962), and on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV 2000).*

Ocimum sanctum L. sacred basil, holy basil

Marshallese: ***katriiñ*** (from English, or possibly German, for "Catherine")

Aboriginal introduction. Pantropical. Uncommon. Planted ornamental, in the planter box of May C's Store in Delap and in private gardens. *Ocimum* sp. with the same Marshallese name was observed in cultivation in Laura by St. John. Fosberg & Sachet have this as aboriginally introduced plant on Jaluit. Flowers used in garlands and to scent coconut oil (StJ 1951; F, S & O 1979; RRT 1991; NVV 1999).

Plectranthus amboinicus (Lour.) Spreng.
Indian borage, Spanish thyme, Mexican oregano

Syns. *Coleus amboinicus* Lour.; *Coleus aromaticus* Benth.

Recent introduction. Africa and India to Indonesia. Rare. Very aromatic, densely pubescent, somewhat succulent, low sprawling perennial herb. Initially found in a planter box at Amata Kabua International Airport but was subsequently extirpated there, then found in household gardens, including one at Lojkar Resort. Can become invasive (NVV 1999; RRT 2000AB) (DPMJ0162, DPMJ0387).**

Salvia splendens Sello ex Schultes scarlet sage, bonfire salvia

Recent introduction. Brazil. Rare. Ornamental potted plant seen in nursery at Lojkar Resort and at one private residence (RRT 2000AB; NVV 2000).**

Solenostemon scutellarioides (L.) Codd painted nettle, coleus, variegated coleus

Syns. *Plectranthus scutellarioides* (L.) R. Br.; *Coleus scutellarioides* (L.) Benth.; *Coleus blumei* Benth.

Recent introduction. Malaysia. Rare. Ornamental potted plant in household garden in Rairõk. Previously reported on Kwajalein and Jaluit by F. S & O (1979) but did not survive on either (Fosberg & Sachet 1962; Whistler & Steele 1999). Can become invasive (RRT 1991, 2000B) (DPMJ0422).*

LAURACEAE (Laurel Family)

Cassytha filiformis L. laurel dodder; beach dodder; devil's twine

Marshallese: ***kaõnõn; kanõõn***

Indigenous. Pantropical. Abundant. Parasite on other plants, generally on natural vegetation; found in inner coastal strand vegetation, in ruderal sites and in downtown areas, including the Outrigger Marshall Islands Resort (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0248).

Persea americana Miller avocado

Recent introduction. Central America. Rare. Young tree about two feet tall, but not in good health, seen in a container in the garden at Rairõk Head Start which subsequently died. Although numerous attempts have been made to establish trees from seeds from imported fruit, no established trees have been reported. Previously reported on Kwajalein by F. S & O (1979) but did not survive. Although it can become invasive, it does not seem to do well in the Marshall Islands' environment (Whistler & Steele 1999) (NVV 2000).*

LECYTHIDACEAE (Brazilnut Family)

Barringtonia asiatica (L.) Kurz. fish-poison tree, barringtonia

Marshallese: ***wõp***

Indigenous. Indo-Pacific. Occasional. Planted in household gardens; one immature seedling also seen, possibly planted from a drift seed; one large tree along the main road just west of the Outrigger Marshall Islands Resort, and one large tree seen in the oceanside coastal forest on Calalin Islet. Previously reported by F, S & O (1979) on six other atolls and by Vander Velde on other atolls, in one case as a monospecific forest on Namu. Participants of the Majuro Biodiversity Workshop identified it as one of the more useful plants of the Marshall Islands (2000) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0554).

LEEACEAE (Lee Family)**

Leea guineensis G. Don West Indian holly
Syn. *Leea manillensis* Walpers

Recent introduction. Tropical Africa. Rare. Planted ornamental shrub with purplish tripinnate leaves in houseyard garden in Rairõk (RRT 2000B) (DPMJ0352).**

LOGANIACEAE (Strychnine Family)*

Polypremum procumbens L. juniperleaf, rust weed, wireweed

Recent introduction. America. Occasional. Prostrate spreading herb with needlelike leaves and small white flowers found in back lawn at the Royal Garden Hotel, the lawn by NTA and in ruderal areas of the DUD. Previously reported from Enewetak by Lamberson (1982), and as naturalized on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0501).*

LYTHRACEAE (Loosestrife Family)

Cuphea hyssopifolia HBK. Mexican heather, Hawaiian heather, false heather

Recent introduction. Mexico and Guatemala. Uncommon. Planted ornamental. Found in growing in driveway of residence in Rita, in a few other private gardens including the former President Amata Kabua's residence, and for a time, in the planter box at the main entrance of the airport. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0009, DPMJ0144a, DPMJ0153d, DPMJ0279, DPMJ0668).*

Lagerstroemia indica L. crepe myrtle, Chinese crepe myrtle

Recent introduction. South China. Uncommon. Planted ornamental in containers in household gardens; several mature shrubs in Rita; a large shrub at Robert Reimer's Enterprises in Uliga. Previously reported on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999) (NVV 2000; RRT 2000A, 2001).*

Pemphis acidula J.R. & G. Forst pemphis, ironwood

Marshallese: ***kōñe, kiej; kiejor***

Indigenous. Tropical East Africa to southeastern Polynesia and Micronesia. Common. Small groves on rocky outcrops, with a major concentrations bordering a small *Bruguiera gymnorrhiza* population on the lagoon near Amata Kabua's former residence, on the ocean shore of Jable, and along the raised coastal front on the lagoon side in Ajeltake (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0714).

MALPIGHIACEAE (Malpighia Family)

Malpighia coccigera L. Singapore holly, Florida holly, miniature holly

Recent introduction. West Indies. Rare. Planted ornamental in a container garden in Rita (NVV 2001; RRT 2000B) (DPMJ0029a).**

Tristellateia australasiae Rich. bagnit, shower of gold

Recent introduction. Malaysia and Australia. Occasional. Planted ornamental climber seen in a number of locations in Rita and elsewhere.(RRT 1991, 1999, 2000AB, 2001; NVV 1999).**

MALVACEAE (Mallow Family)

Abelmoschus esculentus (L.) Moench. okra
Syn. *Hibiscus esculentus* L.

Recent introduction. Northeast Africa. Rare. Several plants found in home garden in residence in Rita; also planted by Indian families from Fiji; planted at Taiwanese experimental garden and one plant seen in household garden at Lojkar Resort. Previously reported on Jaluit by F. S & O (1979) and although reported still present by Fosberg & Sachet (1962), not seen during 1999 visit (NVV 2000; RRT 2000A).*

Abelmoschus manihot (L.) Moench. bush hibiscus spinach, edible hibiscus, pele
Syn. *Hibiscus manihot* L.

Marshallese: ***pele*** (from "bele" or "pele" the Fijian and Polynesian names)

Recent introduction. Tropical Asia. Occasional. Food plant introduced by UNICEF Family Food Production Programme; found in home gardens of residences, particularly Fijian residences, throughout the atoll. Green leaves cooked as a very nutritious spinach-like vegetable. (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0214, DPMJ0471).**

Abelmoschus rugosus Wight & Arnott red musk mallow
Syn. *Hibiscus rugosus* (Wight & Arnott) Roxb.

Recent introduction. India. Rare. Seen in Maria Fowler's household garden in Delap, reportedly purchased from a seed catalog and also in Amata Kabua's garden (RRT 2000AB, 2001; NVV 2000) (DPMJ0085, DPMJ0086, DPMJ0614).**

Gossypium barbadense L. sea-island cotton, cotton

Marshallese: ***kotin*** (a corruption of the English common name)

Recent introduction. Tropical America. Presumably extirpated. Observed being cultivated in Laura by St. John (1951) but not observed by current authors. Listed by F. S & O (1979); also on Utdrik, Kwajalein, Jaluit and Arno, but did not survive at least on Kwajalein and Jaluit (Whistler & Steele 1999, Fosberg & Sachet 1962) (StJ 1951; F, S & O 1979; FRF 1990).

Hibiscus cannabinus L. kenaf, Deccan hemp, wild stockrose

Recent introduction. Old Word tropics and subtropics. Uncommon. Several plants in planter box at the main entrance of the airport and planted in household gardens (RRT 2000AB, 2001; NVV 2000) (DPMJ0328, DPMJ0728).**

Hibiscus mutabilis L. changeable rose mallow, changeable rose

Recent introduction. Southern China. Uncommon. Planted ornamental. Seen in a few household gardens, one at the north end of Rita. Previously planted on Arno, Jaluit, and Kwajalein, but did not survive at least in the latter two (Fosberg & Sachet 1962; Whistler & Steele 1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0628).*

Hibiscus rosa-sinensis L. common hibiscus, red hibiscus, China rose

Marshallese: ***rooj*** ("rose")

Recent introduction. Tropical Asia. Common. Planted ornamental around private homes and businesses. Occasional in rural garden areas (StJ 1951; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Hibiscus schizopetalus (Mast.) Hook. f. coral hibiscus, fringed hibiscus, dragon flower

Recent introduction. Tropical America. Rare. Single bush in household garden in Delap and another in Rita. Previously reported on Kwajalein by F, S & 0 (1979) (NVV 2000).*

Hibiscus syriacus L. blue hibiscus, rose of Sharon

Recent introduction. China. Rare. Several small bushes brought in from Hawai'i and planted at the former President Amata Kabua's residence (NVV 2000; RRT 2000A, 2001) (DPMJ0663).**

Hibiscus tiliaceus L. beach hibiscus, hibiscus tree

Syn: *Talipariti tiliaceum* (L.) Fryxell

Marshallese: ***lo***

Aboriginal introduction. Pantropical. Common. Occasional in household gardens, as a roadside tree, in tree groves and in areas near taro pits; more extensive stands found in thickets in swampy areas near Rairõk Elementary School, and in swampy areas of Laura (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0555, DPMJ0689).

Hibiscus x **hybridus** ornamental hybrid hibiscus

Marshallese: ***rooj*** ("rose")

Recent introduction. Horticultural origin. Common . Planted ornamentals around private homes and businesses. Many color and petal variations found (MDS 1977; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0329).

Lavatera trimestris tree mallow, annual mallow

Recent introduction. Mediterranean. Rare. Single mature flowering plant in Filipino doctor's garden east of the airport (RRT 2000AB; NVV 2000) (DPMJ0349, DPMJ0350, DPMJ0351).**

Malviscus penduliflorus Moc. & Sesse ex DC.

Turk's cap, sleeping hibiscus, firecracker hibiscus

Syns. *Malviscus arboreus* Cav.; *Malviscus conzatti* Greenm.; *Malviscus grandiflorus* Hort. non H.B.K.

Recent introduction. Tropical America. Uncommon. Planted ornamental shrub at Royal Garden Hotel and in a household garden in Rita. Previously reported on Kwajalein by Hebst (1988) but did not survive according to Whistler & Steele (1999) (RRT 1991, 1999, 2000A; NVV 1999).*

Sida fallax Walp. golden mallow; ilima (Hawai'ian)

Marshallese: ***kio*** ("yellow")

Indigenous. Indo-Pacific. Uncommon. Observed as present in Laura by St. John (1951) and reported present on Majuro by F. S & O (1979); not seen in 1991 or 1999 on the main islets of Majuro; about ten mature plants seen planted in a settlement on Calalin Islet in September 2000 and 2001; also reported to be present on Rongrong Islet north of Laura and in some household gardens in Rita and Botkan. Flowers used in gardens and said to give power to warriors in the past (StJ 1951; F, S & O 1979; FRF 1990; RRT 2000A; NVV 2000) (DPMJ0083, DPMJ0084, DPMJ0095).

Thespesia populnea (L.) Sol. ex Correa Thespian's tree, Pacific rosewood

Recent introduction. Paleotropics and the Pacific Islands. Uncommon. Single tree planted along the west border of the Royal Garden Hotel; single tree seen inland from the lagoon coast in Ajeltake; and number of young trees seen as part of a living fence just west of the Royal Garden Hotel. Previously reported on Kwajalein and Jaluit by F. S & O (1979); still present on Kwajalein (Whistler & Steele 1999), but did not survive on Jaluit (Fosberg & Sachet 1962) (RRT 1991, 1999, 2000AB; NVV 1999).*

MELIACEAE (Mahogany Family)*

Azadiracta indica A. Juss. nim, neem tree

Recent introduction. India and Southeast Asia to the East Indies. Rare. Reportedly successfully introduced by Jimmy Joseph to the Agricultural Farm; a single mature tree seen in the former President, Amata Kabua's garden. Can become invasive (NVV 2000, RRT 2001) (DPMJ0637).**

Lansium domesticum Corr. langsat

Recent introduction. Malaysia. Rare. Numerous small seedlings in the experimental garden of Jesse Napolitano at the College of the Marshall Islands, grown from seeds imported from the Philippines (NVV 2000).**

MIMOSACEAE (Mimosa Family)*

Acacia auriculiformis A. Cunn. Ex Benth. northern black wattle, earpod wattle

Recent introduction. New Guinea, Torres Strait Island and northern Australia. Rare. Single tree about 2 m tall planted in a household garden in Delap, but by early 2002, it was not doing well and may die. Has become an environmental pest in Florida but does not naturally reproduce well in Micronesia (RRT 2000A; NVV 2000) (2K00406; DPMJ0127S, DPMJ0128S).**

Adenanthera pavonina L.
red-bead tree, false wiliwili, coral bean tree, red sandalwoodtree

Recent introduction. Malaysia. Rare. Single mature tree found in garden of the old Sun Hotel in Rairõk. Has become invasive in other parts of the Pacific, including Kosrae (RRT 1999, 2000A; NVV 2000).**

Leucaena leucocephala (Lam.) de Wit leucaena, tangan tangan, leadtree
Syn. *Leucaena glauca* (L.) Benth.

Recent introduction. Tropical America. Occasional. Planted in household gardens, near industrial areas and possibly spontaneous in some areas; giant cultivars planted around Laura Experimental Farm. Present on Calalin Islet and spreading into disturbed sites. Previously reported on Utdrik, Kwajalein, Ailuk, Likiep and Jaluit by F. S & O (1979) Considered to be one of the "One Hundred of the World's Worst Invasive Alien Species" by the Global Invasive Species Database (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (PDMJ0734).*

MORACEAE (Mulberry Family)

Artocarpus altilis (Park.) Fosb. breadfruit

Syns. *Artocarpus incisus* (Thunb.) L. f.; *Artocarpus communis* Forst.

Marshallese: ***mã*** (general term for all breadfruit)

Aboriginal introduction. Malayo-Pacific. Abundant. Planted staple food tree in household gardens and in rural agricultural areas near taro pits; large old trees particularly common south of Delap to Laura in more rural areas; one tree planted on Calalin Islet. Very important staple food plant on the atolls. Marshallese names for breadfruit cultivars, which probably also include cultivars of *A. mariannensis* and hybrids, *include* ***botaktak, bukdol, mejenwe, kûbwedoul, kûtroro, mã kinono, mã jileklek, mãikwe, mãkwõle, maloke, mãroñ, mejidduull nenen*** and ***nõñnõñ*** (MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0724).

Artocarpus mariannensis Trec. Mariana Islands breadfruit

Marshallese: ***mã*** (general term), ***mejwaan*** ("false-eye"), ***metete***

Aboriginal introduction Micronesia. Occasional. Planted staple fruit tree in household gardens and near settled areas (StJ 1951; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Ficus benjamina L. weeping fig, weeping banyan, Benjamin tree

Recent introduction. Common. Tropical. Asia. Planted ornamental and shade tree. "Golden princess" variety and possibly other varieties imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants still exist. Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Ficus carica L common fig, edible fig

Marshallese: ***wõjke-piik*** ("fig tree")

Recent introduction. Probably originally native to Southwest Asia, but was spread in ancient times to the Mediterranean area. Uncommon. Several trees were planted experimentally at Laura Farms, but none remain. About three fruit bearing trees at Amata Kabua's residence. One tree planted in settlement on Calalin Islet. Previously recorded by F, S & O (1979) on Jaluit, but did not survive (Fosberg & Sachet 1962) (NVV 2000; RRT 2000AB, 2001) (DPMJ0038, DPMJ0638, DPMJ0639, DPMJ0640).*

Ficus elastica Roxb. Indian rubber tree, rubber plant

Marshallese: ***wõjke-roba*** ("fig tree")

Recent introduction. India. Uncommon. Planted ornamental tree in household gardens; one large tree in Amata Kabua's garden. Previously reported on Ailinglaplap and Jaluit by F. S & O (1979) and one at least one large old tree remains on the main street of Jabor, Jaluit as observed during 1999 visit. Can become invasive but only where the pollinating wasp is found (RRT 1991, 1999, 2000A, 2001; NVV 1999) (DPMJ0671).*

Ficus microcarpa L. f. Chinese banyan, laurel fig

Recent introduction. Tropical Asia and western Micronesia. Occasional. A mature tree along the road in front of the Resources and Development Building; other trees planted in garden west of the Airport near Rairõk, in a private garden in Woja and in a several other household gardens. Previously recorded on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0039, DPMJ0108, DPMJ0316, DPMJ0694).*

Ficus tinctoria Forst. f. var. **neo-ebudarum** (Summerh.) Fosb. dyer's fig, native fig

Marshallese: ***tõpdo*** (from the I-Kiribati "te bero")

Aboriginal introduction Southeast. Asia to Polynesia and Micronesia. Occasional. Planted food tree surrounding taro pits in Laura and in scattered private gardens throughout the atoll, including Aeañen. According to Fosberg 1990: "On Majuro said to have been brought from the Gilbert Is." (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0318, DPMJ0569).

MORINGACEAE (Moringa Family)*

Moringa oleifera Lam. horseradish tree, drumstick tree

Recent introduction. India. Occasional. Food plant some food gardens at Laura, including former President Kabua's family garden and numerous other private gardens on the atoll. One of the few more recent agricultural introductions that seems to thrive in the atoll environment. Previously recorded on Kwajalein by Hebst (1988). Has begun to become naturalized on Guam and potentially could become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0365).*

MYRTACEAE (Myrtle Family)*

Psidium guajava L. guava

Recent introduction. Tropical America. Uncommon. Food tree in some food gardens at Laura, including former President Amata Kabua's garden. Previously recorded on Kwajalein by F. S & O (1979). Can become invasive (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Syzygium aqueum (Burm. f.) Merr. & Perry water apple
Syn. *Eugenia aquea* Burm f.

Marshallese: ***abōl*** (a corruption of the English "apple")

Recent introduction. Southern India. Uncommon. Tree seen in a private household garden in Woja bearing many bright pink-red top-like fruit (RRT 2000B, 2001; NVV 2000) (DPMJ0431).**

Syzygium malaccense (L.) Merr. and Perry Malay apple, mountain apple
Syn. *Eugenia malaccensis* L.

Marshallese: ***abōl*** (a corruption of the English "apple")

Recent introduction. Southeast Asia. Occasional. A number of mature and immature trees found in household gardens and in agricultural developments in Laura and in DUD; one bearing tree seen on Calalin Islet. Reported by the Namdrik Biodiversity Workshop and recorded by the RMI National Biodiversity Team (2000). Some of these immature trees may in fact be *S. aqueum* rather than *S. malaccense (*RRT 1999, 2000AB, 2001; NVV 2000).*

NYCTAGINACEAE (Four-O'clock Family)

Boerhavia tetrandra Forst. f.
Syns: *Boerhavia diffusa* var. *tetrandra*(Forst.)Heimerl; *Boerhavia repens* sensu Catala, Guillaumin, non L.

Marshallese: ***dãbijdekã,*** ("to hold on to a rock"; a name that is also applied to *Peperomia ponapensis,* which occurs on other atolls, but not on Majuro, and to other small ground cover plants); ***natto*** (a name also applied to *Chamaesyce thymifolia*); ***pãdãl*** ("push up soil", "of roots"; a name also applied to *Chamaesyce atoto*); ***marmilliñ*** (name used by Herbst 1988 but not known from any other source)

Indigenous. Central Pacific atolls. Rare and ephemeral. Listed on 18 atolls by F. S. & O. 1979, but not on Majuro. However, in Fosberg (1990), those same 18 atolls are listed, with an additional 3, including Majuro. Small patch found amidst other native herbs on Bok-botun in Aeañen in October 2001 by NVV (FRF 1990; NVV 2001) (DPMJ0742).

Bougainvillea x **buttiana** Holttum & Standl· hybrid bougainvillea

Syn. mistakenly identified as *Bougainvillea spectabilis* Willd.

Marshallese: ***kõtõmãnlimpok*** (sometimes shortened to just ***limpok***; from a Pohnpeian word meaning "reminder of love"); ***ikdeelel*** ("desire something," a name used by Herbst 1988, with spelling updated, but not know from any other source; perhaps used because being similar in meaning to the Pohnpeian)

Recent introduction. Horticultural origin. Common. Planted ornamental in household gardens. According to Whistler (2000), it is commonly misidentified as the Brazilian species, *B. spectabilis* Willd., and is apparently a hybrid of two other species, one of which is possibly *B. spectabilis* (StJ 1951; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0004, DPMJ0666).

Bougainvillea glabra Choisy lesser bougainvillea, red bougainvillea

Marshallese: ***kõtõmãnlimpok*** (sometimes shortened to just ***limpok***; from a Pohnpeian word meaning "reminder of love")

Recent introduction. Tropical America. Occasional. Planted ornamental with small white flowers and magenta bracts. Previously reported on Utdrik, Likiep, Arno and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Mirabilis jalapa L. four-o'clock, marvel of Peru, false jalap

Marshallese: ***emãn-awa*** ("four o'clock")

Recent introduction. Mexico. Common. Planted ornamental in household gardens; sometimes surviving without cultivation as a protected adventive, because of its attractive flowers which come in a variety of colors (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999).

Pisonia grandis R. Brown great lettuce tree, great birdcatcher tree, pisonia

Syn. *Pisonia alba* Span.

Marshallese: ***kañal***

Indigenous. Indo-Pacific. Occasional to locally abundant. Soft-wooded tree found in inland forest on uninhabited atoll islets of Aeañen; particularly common inland in abandoned and unused coconut plantations on Calalin Islet; also found in a few household gardens in Laura, and a single medium sized tree planted along the lagoon in Boktan and a smaller one along the back road of Delap. The dominant tree species of the traditionally taboo (***mo***) island of Iroij and commonly the dominant inland climax forest tree species on undisturbed and uninhabited atolls; also renown as the most important seabird rookery species on most Pacific Islands (F, S & O 1979; FRF 1990; RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0037b).

OLEACEAE (Olive Family)*

Jasminum laurifolium Roxb. angle-wing jasmine

Syns. *Jasminum nitidum* Skan.; *Jasminum laurifolium* f. *nitidum* Skan.

Recent introduction. Rare. Planted ornamental in a houseyard garden in Rita (NVV 2000; RRT 2000B) (DPMJ0201).**

Jasminum sambac (L.) Ait. Indian jasmine

Recent introduction. India. Uncommon. Planted ornamental. Found in Filipino household garden just east of the airport. Previously reported on Jaluit by F. S & O (1979) and on Kwajalein by Whistler & Steele (1999) (RTT 1999, 2000AB, 2001; NVV 2000) (DPMJ0341, DPMJ0342).*

ONAGRACEAE (Evening Primrose Family)

Ludwigia octovalvis (Jacq.) Raven swamp primrose, willow primrose

Syn. *Jussiaea suffruticosa* L.

Marshallese: ***utilolõb*** ('flower at the grave', a name also applied to *L. hyssopifolia*, which is present in some other Marshall Islands' atolls but not on Majuro)

Recent introduction. Pantropical. Occasional to locally common. Weed in swampy areas and taro pits in Laura, at Robert Reimer's Hotel, and in ruderal areas in Delap (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0166, DPMJ0538, DPMJ0729).

OXALIDACEAE (Wood Sorrel Family)**

Averrhoa bilimbi L. bilimbi

Recent introduction. Malaya to India. Rare. Mature fruit tree in household east of Royal Garden Hotel and another seen in Rairõk, both reportedly introduced by the same person (RRT 1991, 1999, 2000AB, 2001; NVV 2000).**

Averrhoa carambola L. carambola

Recent introduction. Malaysia and Southeast Asia. Rare. Small fruit tree in private household garden in Woja (RRT 1991, 2000B; NVV 2000) (DPMJ0240).**

Oxalis corniculata L. yellow wood sorrel

Recent introduction. Cosmopolitan weed, origin unknown. Rare, possibly extirpated. Weed at Japanese Takeout Restaurant, observed in 1991 but not seen again. *Oxalis* sp. subsequently reported on Kwajalein by Whistler & Steele (1999) (RRT 1991).**

PASSIFLORACEAE (Passion Flower Family)*

Passiflora edulis Sims passionfruit

Recent introduction. Tropical America. Rare. Single plant seen in household garden east of the Royal Garden Hotel; one very large vine seen climbing in weedy vegetation in Amata Kabua's garden, just west of the main house. Previously reported on Jaluit and Kwajalein by F. S & O (1979), where those from the earlier records did not survive, but it was evidently reintroduced into Kwajalein (Fosberg & Sachet 1962; Whistler & Steele 1999). Although it has become a pest species in other areas, does not seem to do well in the Marshall Islands' environment (RRT 1999, 2001; NVV 2001) (DPMJ0677, DPMJ0678).*

PIPERACEAE (Pepper Family)*

Peperomia obtusifolia (L.) A. Dietr. Jade plant, pepperface, baby rubber plant

Recent introduction. Tropical America. Rare. Potted plant. Variegated cultivar also seen in 1999. Previously reported on Likiep by F. S & O (1979) and subsequently on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0168a).*

Peperomia pellucida (L.) HBK. Shiny bush, pepper elder, rat's ear, peperomia

Syns. *Peperomia pellucidum* L.; *Peperomia lineata* Miq. ex Yuncker

Recent introduction. Tropical America. Rare; possibly now extirpated. Found in moist area of limestone rocks near Gibson's Supermarket growing with *Pilea microphylla*; not seen again. Can be eaten as a cooked vegetable or in salads. Previously recorded on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962). Can become invasive (RRT 1999).*

Piper betle L. betel pepper

Recent introduction. India to Malaysia. Rare. Vine climbing on a log in household garden in Rairõk. Reportedly introduced from Palau. Leaves chewed with betelnut in western Micronesia, Melanesia and Asia (RRT 2000B) (DPMJ0385).**

PLUMBAGINACEAE (Leadwort Family or Plumbago Family)*

Plumbago auriculata Lam. Cape plumbago, Cape leadwort, blue plumbago

Syn. *Plumbago capensis* Thunb.

Recent introduction. South Africa. Rare. Seen as a potted plant in one houseyard garden in Rita. Previously reported on Kwajalein by Whistler & Steele (1999) (NVV 2000; RRT 2000A) (DPMJ0051).*

POLYGONACEAE (Buckwheat Family)

Antigonon leptopus H. & A. Mexican creeper, chain-of-love, Mexican love vine

Marshallese: ***to- in-iokwe*** ("chain-of-love" a name arbitrarily contrived during a weed workshop in connection with the South Pacific Commission)

Recent introduction. Mexico. Rare. Planted ornamental vine in planter box and climbing on a trellis in a yard outside of MIKA's store in Delap. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) and Kwajalein, where it also did not survive, by Whistler & Steele (1999). A potentially destructive invasive which has caused tremendous damage on Guam but is often planted because of its bright attractive flowers. Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop (NVV 2001; RRT 2001) (DPMJ0606, DPMJ0735, DPMJ0736).*

Coccoloba uvifera (L.) Jacq. sea grape

Recent introduction. Tropical America. Uncommon. Planted ornamental tree; a couple trees in the garden area of Robert Reimers Hotel and another poorly maintained plant in residential area, ocean road, in Rita; another tree in household garden in Laura. Previously reported on Jaluit and Kwajalein by F. S & O (1979) but did not survive on either atoll (Fosberg & Sachet 1962; Whistler & Steele 1999) (RRT 1991, 2000AB, 2001; NVV 2000).*

PORTULACACEAE (Purslane Family)

Portulaca australis Endl. portulaca

Syns. *Portulaca samoensis* v. Poelln.; *Portulaca pilosa* sensu auct. non L.

Marshallese: ***kûrañ*** ("shocked", "startled", "stunned", a name also applied to *P. oleracea,* although perhaps only the wild varieties)

Indigenous. Pantropical? Uncommon. Seen in disturbed sites slightly inland from the seaside coast in Laura and near the wall at Peace Park (F, S & O 1979; FRF 1990; RRT 1999, 2000B, 2001; NVV 1999) (DPMJ0394, DPMJ0395, DPMJ0502).

Portulaca grandiflora Hook. portulaca, rose moss

Recent introduction. Brazil. Occasional. Ornamental potted succulent plant with linear to awl-shaped leaves. An ornamental cultivar of *Portulaca oleracea*, which has more flattened oblanceolate to elliptic leaves has, according to Whistler, been widely misidentified as *P. grandiflora* (see below) (RRT 1991, 1999, 2000AB; NVV 1999).**

Portulaca oleracea L.

sun plant, wildfire, eleven o'clock (cultivated); pigweed, purslane (wild)

Marshallese: ***kûrañ*** ("shocked", "startled", "stunned", a name also applied to *P. australis*)

Recent introduction. Europe. Common. According to Whistler there are two types of *P. oleracea*, one the common weedy species, probably *P. oleracea* var. *granulato-stellulata* v. Poelln., and another ornamental variety ("Wildfire"), which is represented by numerous cultivars with five-parted red, yellow, white or mauve flowers, that has been widely misidentified as *P. grandifolia*. The yellow-flowered wild variety is a weed of gardens and waste places, especially in sandy soils; it is common on abandoned plots in vegetable gardens and at the Experimental Farm in Laura. The cultivated ornamental variety is found in household gardens, usually as a potted plant (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0396, DPMJ0397).

PUNICACEAE (Pomegranate Family)*

Punica granatum L. ornamental flowering pomegranate

Recent introduction. Middle East? Rare. Ornamental potted plant, sterile, non-fruiting flowering variety planted at a couple of private residences in Rita. Previously recorded on Jaluit by F. S & O (1979) but it was most likely the fruit-bearing variety, and did not survive (Fosberg & Sachet 1962) (NVV 2000; RRT 2000B, 2001) (DPMJ0167b, DPMJ0408).*

RHAMNACEAE (Buckthorn Family)**

Colubrina asiatica (L.) Brongn. soapbush, hoop withe

Syns. *Ceanothus asiaticus* L.; *Ceanothus capsularis* Forst. f.

Indigenous, but of recent arrival. Paleotropical. Rare. A single mature plant about 2 m high seen in Lomajurok in an open field about 10 m from the oceanside of the island, just inland from an area with a large concentration of seaborne seeds and other jetsam. The plant was about 2.5 m high in November 2001, but unhealthy and covered with the parasitic vine, *Cassytha filiformis*. A common Indo-Pacific coastal plant not recorded previously from the Marshall Islands but may periodically grow only to be extirpated by *Cassytha filiformis* and other native vines (RRT 2000AB, 2001; NVV 2000) (DPMJ0263, DPMJ0264, DPMJ0265, DPMJ0503).**

Ziziphus maurtiana Lam. Indian jujube

Recent introduction. India and Southeast Asia to the East Indies. Rare. Reportedly successfully introduced by Jimmy Joseph to the Agricultural Farm. Has become moderately invasive in Fiji (NVV 1999).**

RHIZOPHORACEAE (Mangrove Family)

Bruguiera gymnorrhiza (L.) Lam. f. black , oriental or brown mangrove

Marshallese: ***joñ***

Indigenous, at least on some atolls, although its range has been greatly extended by intentional plantings since aboriginal times. Indo-Pacific. Occasional. A number of mature trees are found in an interior depression in the center of Delap, which had been partly filled with household garbage; there is a small stand in a protected area on the lagoon side near Amata Kabua's residence; larger stands of mature trees exist slightly inland from the lagoon in

Ajeltake and about 200 m inland from the ocean coast in a swampy depression in Laura. There are reportedly also trees present on Rongrong Islet to the north of Laura (StJ 1951; MDS 1977; F, S & O 1979; RRT 1991, 1999, 2000; NVV 1999) (DPMJ0710, DPMJ0711).

ROSACEAE (Rose Family)*

Rhaphiolepis umbellata (Thunb.) Makino round-leaf hawthorn, Yeddo hawthorn

Recent introduction. Japan. Rare. Two shrubs with leathery, shiny, nearly round dark green leaves in houseyard garden in Rairõk (RRT 2000B) (DPMJ0315, DPMJ0317).**

Rosa x **damascena** Mill. damask rose

Marshallese: ***rooj*** (a corruption of the English common name); ***utrooj*** ('rose bush')

Recent introduction. Asia? Occasional. Planted ornamental in private household gardens. Previously recorded on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0412).*

Rosa cultivars rose

Marshallese: ***rooj*** (a corruption of the English common name); ***utrooj*** ('rose bush')

Recent introduction. Asia. Occasional. Potted plants and ornamentals planted in household gardens (RRT 1991, 1999, 2000AB, 2001; NVV 1999).**

RUBIACEAE (Coffee Family)

Dentella repens J. & G. Forst. dentella

Recent introduction. Pantropical. Rare, possibly now extirpated. Creeping weed. Seen growing on the construction site of the Eastern Gateway Hotel. Subsequently not seen (F, S & O 1979; RRT 1991).

Gardenia augusta (L.) Merr. gardenia
Syns. *Gardenia florida* L.; *Gardenia jasminoides* Ellis

Recent introduction. China. Occasional. Planted ornamental; seen in former President Amata Kabua's garden. Previously reported on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999) (RRT 1991, 1999, 2000AB; NVV 1999).*

Gardenia taitensis DC. Tahitian gardenia, tiare Tahiti

Recent introduction. Pacific Islands. Occasional. Planted ornamental in houseyard gardens. Subsequently reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0319, DPMJ0620, DPMJ0625).**

Guettarda speciosa L.

Marshallese: ***utilomar*** ("flower of the bush"); ***ut*** (general term for flower or bush); ***utin-ãkõj*** (a term generally not used)

Indigenous. Tropical Asia to Pacific Islands. Common. In the coastal strand forest, household gardens, abandoned coconut plantations and around taro pits in Laura. Although not official, it is considered by many people to be the national flower of the RMI; the fragrant, night-blooming flowers are popular for making garlands (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0707, DPMJ0708, DPMJ0709).

Hamelia patens Jacq. scarlet bush, firebush

Recent introduction. Tropical America. Rare. Planted potted plant in household garden in Delap (NVV 2000; RRT 2000A) (DPMJ0188)**

Hedyotis biflora (L.) Lam. two-flowered hedyotis

Syns. *Oldenlandia biflora* L.; *Oldenlandia paniculata* L

Marshallese: ***kinwõj***

Indigenous or perhaps aboriginally introduced as a weed. Tropical Asia and Indian Ocean to western Polynesia and Micronesia. Uncommon. Found growing in disturbed sites near coast and as a weed in houseyard gardens and waste places; seems to being slowing replaced by introduced weedy species (StJ 1951; F, S & O 1979; FRF 1990; RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0484).

Hedyotis corymbosa (L.) Lamb. Old World diamondflower

Syn. *Oldenlandia corymbosa* L.

Recent introduction. Africa. Common. Weed in gardens, in potted plants, along roadways and ruderal areas. Previously reported on Kwajalein and Jaluit by F. S & O (1979) (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0153a, DPMJ0180b, DPMJ0324, DPMJ0325, DPMJ0477, DPMJ0592)*

Ixora casei Hance flame of the forest, Case's ixora, Caroline Island ixora, great red ixora
Syn. *Ixora carolinensis* (Val.) Hoosokawa var. *typica* Fosberg; *Ixora longifolia* Sm.

Marshallese: ***kajdo*** (although this name originally referred to this species, it is now sometimes used in reference to other *Ixora* spp.)

Aboriginal introduction. Caroline Islands. Occasional. Planted ornamental bush or small tree in household gardens. Probably an introduction from Pohnpei or another Micronesian island where it is a native endemic species (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0088, DPMJ0621, DPMJ0622).

Ixora chinensis Lam. Chinese ixora

Recent introduction. China and East Indies. Occasional. Planted ornamental around houses and businesses (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0334).**

Ixora coccinea L. red ixora, flame of the woods, flame flower
Syn. *Ixora fraseri* Hort ex Gentil

Recent introduction. Southeast Asia. Occasional. Planted ornamental. Previously reported on Aur and Jaluit by F. S & O (1979) but did not survive at least the latter (Fosberg & Sachet 1962) (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0533).*

Ixora finlaysoniana Lam. white ixora, fragrant ixora

Recent introduction. Thailand and Southeast Asia. Occasional. Planted ornamental (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0040, DPMJ036, DPMJ037).**

Ixora lutea Hutchinson yellow ixora
Syn. *Ixora coccinea* L. var. *lutea* Corner

Recent introduction. Southeast Asia. Occasional. Planted ornamental (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0338).**

Ixora siamensis Wallich ex G. Don pink ixora, Siamese ixora

Recent introduction. Southeast Asia. Uncommon. Planted ornamental (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0146c, DPMJ0339, DPMJ0340, DPMJ0657).**

Ixora x hybrid hybrid ixora

Recent introduction. Horticultural origin. Uncommon. Several well-established plants in gardens in DUD and at the Outrigger Marshall Islands Resort. Bright red flowers fewer in number than other *Ixora*, with individual flowers having frilly petals rather than the typical cruciform petals (NVV 1999; RRT 2000AB, 2001) (DPMJ0335).**

Morinda citrifolia L. var. **citrifolia** beach mulberry, Indian mulberry

Marshallese: ***nen***; ***kalenen***

Aboriginal introduction. Tropical Asia and Australia to Southeast. Polynesia. Common. Cultivated and growing wild in household gardens, in neglected coconut plantations, as an understorey species in secondary forest, around taro pits, and in inner coastal forest. A larger cultivar from Polynesia has been introduced recently and is now planted around some homes in Rita and Rairõk. A small cottage industry has developed recently for the processing and local sale of ***nen*** juice locally as a medicinal drink and in the production of a new soap (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0364, DPMJ0696).

Nertera granadensis (L. f.) Druce coral-bead plant, baby tears, pin cushion
Syns. *Gomozia granadensis* L. f. ; *Nertera depressa* Banks. and Sol.

Recent introduction. New Guinea, New Zealand, Cape Horn and South and Central America, often montane. Rare. Mat-forming groundcover with tiny broad oval leaves found planted in a pot in houseyard garden in north Rita in September 2000; not seen in flower or fruit. (RRT 2000A; NVV 2000) (DPMJ0059).**

Pentas lanceolata (Forsk.) K. Schum. pentas, Lady Fletcher, Egyptian star cluster
Syn. *Ophiorrhiza lanceolata* Forsk.

Recent introduction. Tropical Africa and Arabian Peninsula. Uncommon. Planted ornamental and potted plant; both the light purple and red cultivars seen present. Previously reported on Kwajalein by F. S & O (1979) but did not survive (Whistler & Steele 1999) (RRT 1991, 1999 2000AB, 2001; NVV 2000) (DPMJ0738).*

Spermacoce assurgens R. & P. woodland false buttonweed
Syn. *Borreria laevis* (Lam.) Griseb.

Recent introduction. Tropical America. Common. Weed in waste places and vegetable gardens. Previously reported as naturalized on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0591).*

Spermacoce bartlingiana (DC) Fosb. buttonweed

Recent introduction. Southern Asia. Occasional. Weed in waste places (RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0423, DPMJ0424, DPMJ0500, DPMJ0674).**

RUTACEAE (Rue Family)

Citrus aurantiifolia (Christm.) Swingle lime

Marshallese: ***laim*** (a corruption of the English common name)

Recent introduction. India. Common. Planted fruit tree in household gardens and near settlements and taro pits. The only citrus species which seems to do well in the atoll environment (StJ 1951; MDS 1977; F, S & O 1979; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0726).

Citrus limon (L.) Burm. f. lemon

Recent introduction. East Asia. Rare. Planted fruit tree in Majuro Mayor Kabua's garden at Laura. Previously reported on Jaluit by F. S & O (1979). Kratz (1986) in his translation of Chamisso's account of the first contact of Europeans with the people of the Marshall Islands, reports that attempts were made to introduce a lemon tree, presumably this species (RRT 1991, 2000AB).*

Citrus limon (L.) Burm. f. x **Citrus medica** rough lemon
Syns. *Citrus medica* L. var. *limon* L.; *Citrus hystrix* DC.

Recent introduction. Tropical Asia. Rare. Plant seen in two household gardens of Fijian contract workers. The nomenclature of the rough lemon is somewhat unclear and the species is very similar and may be the same as the kaffir lime or Mauritius papeda (*Citrus hystrix* DC.), which is common in Southeast Asia (RRT 2000A).*

Citrus mitis Blanco calamondin orange, kalamondin

Recent introduction. East Asia. Rare, now possibly extirpated. Planted fruit tree in household garden in Rita; reportedly introduced from Pohnpei. Subsequently not observed. (RRT 1991).**

Citrus sinensis (L.) Osbeck orange, sweet orange

Syn. *Citrus aurantium* var. *sinensis* L.

Marshallese: ***oran*** (a corruption of the English common name)

Recent introduction. Southern Asia. Rare. Single tree planted at the former President Amata Kabua's residence. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) (RRT 2000A; NVV 2000).*

Euodia hortensis J.R. & G. Forst. island musk

Recent introduction. Melanesia. Uncommon. Small ornamental shrub with somewhat fragrant or fetid smelling leaves. Ornamental and cultural plant in a number of household gardens of Fijian and Rotuman contract workers from Fiji. Leaves and flowers used in garlands and to scent coconut oil by Fijians (RRT 2000AB; NVV 2000).**

Murraya koenigii (L.) Spreng. curry leaf, Indian bay leaf, tej patti, karipilai

Recent introduction. India and Southeastern Asia. Rare. A single nature plant seen in the lawn area between the main road and the residence of the former President Amata Kabua's residence and another in a household garden just behind Gibson's Supermarket in Delap (RRT 2000AB; NVV 2000) (DPMJ0365).**

Murraya paniculata (L.) Jack

mock orange, orange jessamine, orange jasmine, satinwood

Syn. *Murraya exotica* L.

Recent introduction. Southeast Asia to Australia. Rare. Ornamental potted plant in front of Ajidrik Hotel in Uliga. Previously reported on Kwajalein by F. S & O but did not survive (Whistler & Steele 1999). Can become invasive and favors limestone soil (NVV 2000; RRT 2000A)*

SAPINDACEAE (Soapberry Family or Litchi Family)

Allophylus timoriensis (DC.) Bl.

Syns. *Schmidelia timoriensis* DC.; *Allophylus litoralis* Bl.

Marshallese: ***kûtaak***

Indigenous. Malaysia to eastern Polynesia and Micronesia. Uncommon. A member of the inner coastal strand forest. St. John observed this species in Laura village, where trees are still present. Single trees were located behind Marshalls Broadcasting Company in Uliga, in Jenrok by Retty Reimer's, Amata Kabua's garden, at the U. S. Embassy, and a few large trees in household gardens in rural Ajeltake. Also found in the inner coastal strand forest and portions of the inland forest on Calalin Islet (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (2K00409; DPMJ0142S, DPMJ0143S, DPMJ0225, DPMJ0617).

Litchi chinensis Sonn. litchi, lychee, leechee nut
Syn. *Nephelium litchi* Cambess

Recent introduction. Southern China. Rare. A few seedlings growing in a container at Maria Fowler's garden; sprouted from seeds of imported fruit (NVV 2001).**

Manikara zapota (L.) van Royen sapodilla
Syn. *Achras zapota* L.

Recent introduction. Mexico and Central America. Uncommon. Planted fruit trees in a couple household gardens. Introduced by the Agricultural Department as a promising fruit tree. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV2000).*

SCROPHULARIACEAE (Snapdragon Family or Figwort Family)*

Angelonia biflora Benth. angelonia, monkey face
Syn. *Angelonia gardneri* Hook.

Marshallese: ***jab meloklok*** ("don't forget")

Recent introduction. South America. Rare. Planted ornamental in household garden in Rairõk (RRT 2000B) (DPMJ0235).**

Angelonia salicariifolia Humb. & Bonpl. angelonia,monkey face,grandmother's bonnets
Syn. *Angelonia angustifolia* Benth.

Marshallese: ***jab meloklok*** ("don't forget")

Recent introduction. Tropical America. Occasional. Planted ornamental. Previously reported on Kwajalein, Arno and Jaluit by F. S & O (1999) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0236).*

Bacopa monnieri (L.) Pennell smooth water hyssop
Syn. *Bacopa monniera* (L.) Pennell

Indigenous, or possibly of recent introduction as a garden plant. Pantropical. Rare. Ground cover around the teachers' housing of Coop School in Delap, very close to the ocean. This area is periodically inundated by high waves, which could have washed seeds ashore. Indigenous to some Pacific Islands, including the Marquesas and Hawai'i, but in Micronesia, only previously known from Guam and Kiribati (NVV 2002) (DPMJN010602).**

Lindernia procumbens (Krock.) Philcox procumbent false pimpernel

Recent introduction. Morava River floodplain, Poland. Endangered in its native habitat, a pestiferous weed resistant to pesticides elsewhere in the world. Uncommon to locally common. Few small yellow-flowered procumbent plants found in lawn area near taro pit in Laura and in a ruderal areas in Rita (NVV 1999; RRT 2000B) (DPMJ0211, DPMJ0212, DPMJ0353).**

Russelia equisetiformis Schlect. and Cham. firecracker flower, coral plant

Marshallese: ***albokbõroro*** ("to bud, flower or about to bloom" and "pregnant, budding"); ***kwõdeak*** ("whiskers")

Recent introduction. Mexico. Occasional. Planted ornamental in several private gardens in Rita, Laura, at the U. S. Embassy and the residence of the former President Amata Kabua. Previously reported on Utdik, Kwajalein, Likiep, Ailinglaplap and Ebon by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Scoparia dulcis L.. sweetbroom, broomweed, bitterbroom, riceweed, licoriceweed

Recent introduction. Tropical America. Rare. Small weed of marshy and disturbed areas. Few plants found in wet area by the bridge. Previously reported on Kwajalein by F. S & O (1979) but not found by Whistler & Steele (1999) (NVV 2001) (DPMJN122701).*

SIMAROUBACEAE (Quassia Family)*

Soulamea amara Lam. bitter tree

Marshallese: ***kabwijlõñ*** (Railik), ***keinwa*** (Ratak)

Indigenous, to at least on some atolls of the Marshall Islands, but of recent introduction to Majuro. Rare. Indo-Pacific as far east as Solomon Islands and Vanuatu in Melanesia and to the Caroline Islands and Marshall Islands in Micronesia. Reported to have been found in the past in Laura and on the isolated islands of Aeañen. Single tree growing in a container, with its roots breaking though, in household garden in Delap. Reported present on ten other islands in the Marshall Islands, but not on Majuro by F. S & O 1979, and again on 13 other islands but again not Majuro by Fosberg (1990) (NVV 2000; RRT 2000AB, 2001) (DPMJ0087, DPMJ0096, DPMJ0152, DPMJ0610, DPMJ0611, DPMJ0612, DPMJ0613).*

SOLANACEAE (Nightshade Family)*

Brugmansia x **candida** Pers. angel's trumpet
Syn. *Datura candida* (Pers.) Stapf.

Recent introduction. Tropical America. Uncommon. Several mature shrubs seen in household gardens in Rita; two smaller plants seen on Small Island. All parts of the plant are poisonous (NVV 2000; RRT 2000A) (DPMJ0035).**

Capsicum annuum L. var. **acuminatum** (L.) Fingerh. cayenne pepper, long red pepper

Recent introduction. Tropical America. Rare. Food plant planted at farms in Laura. Previously reported on Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000B) (DPMJ0247).*

Capsicum annuum L. var. **grossum** (L.) Sendtn.
bell pepper, sweet pepper, sweet capsicum
Marshallese: ***pepa*** (a corruption of the English common name)

Recent introduction. Tropical America. Occasional. Food plant planted at farms in Laura and periodically in household food gardens. Previously reported on Kwajalein by Whistler & Steele (1999) (RRT 1991, 1999, 2000AB; NVV 1999).*

Capsicum annuum L. varieties chili pepper cultivars

Recent introduction. Tropical America. Rare. Various annual or biennial chili pepper cultivars, including jalapeño and "Serrano" periodically planted. Previously reported on Jaluit by F. S & O (1979) (RRT 2000B, 2001).*

Capsicum frutescens L. tabasco, bird chili, perennial chili

Recent introduction. Tropical America. Uncommon. Planted spice in household gardens, often in containers. Previously reported on Arno by F. S & O (1979) and on Kwajalein by Hebst (1988) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0473).*

Cestrum nocturnum L. night flowering cestrum, lady of the night, queen of the night

Marshallese: ***joñoul ruo awa*** ("twelve o'clock", in reference to its nocturnal blossoms that are fragrant at night)

Recent introduction. West Indies. Uncommon. Planted ornamental. In private gardens in DUD and in household gardens Jenrok, Rita, Ajeltake and another in a private household garden in Woja. Previously reported on Likiep by F, S & O (1979). Has become invasive on Tahiti and began to show invasive qualities on Guam but later became only a localized problem (RRT 1991, 1999, 2000AB, 2001; NVV 2000) (DPMJ0250).*

Nicotiana tabacum L. tobacco

Recent introduction. Tropical America. Rare, probably extirpated. Brought in experimentally a few years ago to see if could be grown, but failed to survive. Previously reported on Jaluit by F. S & O but did not survive (Fosberg & Sachet 1962) (per. comm. with importer; NVV 2000).*

Physalis angulata L. cape gooseberry, bladderberry, ground cherry

Marshallese: ***kaõrõr*** (grate ones teeth)

Recent introduction. Tropical America. Occasional. Weed of wasteplaces and ruderal sites, in recently abandoned fields at Laura Experimental Farm and in hydroponic plots at K & P Farm in Laura; found in one small population near an unfinished structure on Calalin Islet. Previously reported on Bikini, Ujae, Kwajalein, Jemo, Arno, and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0381, DPMJ0672, DPMJ0514, DPMJ0672, DPMJ0676).*

Solanum lycopersicum L. var. **lycopersicum** tomato
Syn. *Lycopersicon esculentum* Mill.

Marshallese: ***tõmato*** (a corruption of the English common name)

Recent introduction. Tropical America. Occasional. Food plant in commercial and experimental food farms in Laura; occasionally in household gardens. Previously reported on Enewetak, Kwajalein, Ailinglaplap and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999).*

Solanum melongena L. egg plant, aubergine

Recent introduction. Southern Asia. Occasional. Food plant at farms in Laura, at Marshall Islands High School in 1991, at the Taiwanese experimental garden, and periodically planted in household gardens. Previously reported on Jaluit by F. S & O (1979) and while those specimens may not have survived, observed replanted for food on Jaluit during 1999 visit as is undoubtedly done many other atolls, including Kwajalein (Whistler & Steele 1999) (RRT 1991, 1999, 2000AB; NVV 1999).*

Solanum tuberosum L. potato, Irish potato

Recent introduction. Andes Mountains. Rare. Single young plant seen in Chinese garden in Rita, probably grown from a potato skin cutting (RRT 2000B) (DPMJ0421).**

SURIANACEAE (Bay Cedar Family)*

Suriana maritima L. bay cedar

Marshallese: ***ñeñe*** (Ratak); ***kalañe*** (Railik)

Indigenous to the Marshall Islands, particularly more northern , drier atolls, but of recent introduction to Majuro. Pantropical. Rare. One mature tree planted near the tennis court at the residence of the late President Amata Kabua with a number of seedlings underneath. Although several plants were imported for medicinal purposes from one of the islets of Kwajalein, only one survived (NVV 2001; RRT 2001) (DPMJ0616, DPMJ0721, DPMJ0722)*

TILIACEAE (Linden Family)

Triumfetta procumbens Forst. f. prostate beach burr

Marshallese: ***atat***

Indigenous. Paleotropics. Occasional. Growing in sandy areas on the lagoon coastal strip in the Delap area and in sandy inland area in Laura. Locally common in open sites and on the east end of Calalin Islet near the ocean. Traditionally used to produce fiber and dye, the fiber being used in fine mats; plant also used medicinally (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB; NVV 1999).

TURNERACEAE (Turnera Family)

Turnera ulmifolia L. yellow alder; sage rose, Marilopez, West Indian holly

Marshallese: ***nõr in jiboñ*** ('blooming in the morning', a name arbitrarily contrived during a weed workshop in connection with the South Pacific Commission)

Recent introduction. Mexico and the Caribbean to Northern South America. Common to locally abundant. Introduced in the mid-1990s and planted in household gardens; has escaped an become adventive in Fiji, Kiribati and other countries; spreading rapidly throughout Majuro as a cultivated ornamental because of its bright yellow flowers. Also spreading to outer islets; a single plant found at an abandoned compound on Calalin Islet. Identified on Majuro by the RMI Biodiversity Team and included in 2000 report, but location not specified. Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop in 2001 (NVV 1999, RRT 1999, 2000AB, 2001) (DPMJ0025, DPMJ0437, DPMJ0438).

URTICACEAE (Nettle Family)

Laportea ruderalis (Forst. f.) Chew
Syn. *Fleurya ruderalis* (Forst. f.) Gaud. ex Wedd.

Marshallese: ***neen kõtkõt*** ("leg of the ruddy turnstone", a shorebird, due to the reddish color of the stems)

Indigenous. Malayo-Pacific. Occasional. Growing in shady and moist disturbed sites in household gardens and coconut plantations in rural areas; under *Pisonia grandis* on Iroij Island. Common and locally dominant in open sites and openings in the tree cover on Calalin Islet (StJ 1951; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0080).

Pilea cardieri Gagn. and Guill. aluminum (aluminium) plant

Recent introduction. Vietnam. Rare, possibly extirpated. Potted plant (RRT 1991).**

Pilea depressa (Sw.) Bl. baby's tears

Recent introduction. Caribbean. Occasional. Single hanging potted plant at Lanai Night Club and a few other plants in private gardens in Rairõk and Woja (RRT 2000AB) (DPMJ0145b, DPMJ0382, DPMJ0383).**

Pilea microphylla (L.) Liebm. artillery plant, artillery fern

Marshallese: ***loktõktõk*** ("wrinkly"); ***mõlowi*** ("moisture" in reference to growing in damp areas)

Recent introduction. Tropical America. Common. Weed in potted plants, under planted ornamentals and in other moist ruderal sites; common in areas near hydroponic gardens. Locally common, often with *Phyllanthus amarus*, on Calalin Islet. Previously reported on Kwajalein, Ailinglaplap and Jaluit by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0178, DPMJ0481, DPMJ0550, DPMJ0652).*

Pilea nummularifolia (Sw.) Wedd. creeping Charlie

Recent introduction. Tropical America. Uncommon. Ornamental groundcover and potted plant at Good Earth Apartments and private gardens (NVV 1999; RRT 2000AB) (DPMJ0384).*

Pilea serpyllacea (Kunth) Liebm. artillery plant, artillery fern

Recent introduction. Northern South America. Rare. Ornamental potted plant (NVV 2000) (DPMJ0001).**

Pipturus argenteus (Forst. f.) Wedd. var. **argenteus** silver pipturus

Marshallese: ***armwe***

Indigenous. Malaysia to Polynesia and Micronesia. Occasional. Uncommon. Shrub or small tree in disturbed sites; occasionally in household gardens; one tree planted at the U. S. Embassy. A single small tree seen near ocean road in Rita, small groves in Laura, and locally common in inland disturbed forest on Calalin Islet. Fiber produces strong fish line useful, in the past, for catching tuna; leaves used as pig feed (St J. 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1999, 2000AB, 2001; NVV 2000) (DPMJ0078, DPMJ0385, DPMJ0512).

VERBENACEAE (Verbena Family)

Clerodendrum buchananii (Roxb.) Walp.
scarlet clerodendrum, red clerodendrum, Java glorybower

Syns. *Clerodendrum fallax* Lindl.; *Clerodendrum speciosissimum* Van Geert ex Morren

Recent introduction. Java. Occasional. Planted ornamental in private gardens; also found as an adventive in a thicket to the south of the Laura back road. Can become invasive (RRT 1991, 1999, 2000AB; NVV 2000) (DPMJ0258, DPMJ0260).**

Clerodendrum inerme L. var. **oceanicum** A. Gray beach privet

Marshallese: ***wûlej***

Indigenous. Indomalaysia, Australia and the Pacific Islands. Occasional. In coastal vegetation and as a planted ornamental or hedge plant in household gardens (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0257).

Clerodendrum paniculatum L. pagoda flower

Recent introduction. Malaysia to China. Uncommon. In household gardens in Rita. Can become invasive (NVV 1999; RRT 2000A) (DPMJ0259).**

Clerodendrum quadriloculare (Blanco) Merr. Philippine glorybower

Marshallese: ***tirooj in belle*** ("foreign false eranthemum" a name arbitrarily contrived during a weed workshop in connection with the South Pacific Commission)

Recent introduction. Philippines. Occasional. Large ornamental shrub with leaves purplish on the lower surface and beautiful long, white *Ixora*-like flowers. Subsequently reported on Kwajalein by Whistler & Steele (1999). Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0557). **

Clerodendrum thomsonae Balf. bleeding heart

Recent introduction. West Africa. Uncommon. Planted ornamental climbing potted plant. Imported by Robert Reimers Enterprises in 1998 and/or 1999 as houseplants (RRT 1991, 1999, 2000AB; NVV 1999) (DPMJ0153b).**

Holmskioldia sanguinea Retz. cup-and-saucer plant, parasol flower

Recent introduction. Himalayas. Rare, possibly extirpated. One potted plant observed in Rita in 1998 but it was not observed later. It either was moved to another location or it did not seem to survive. Identified on Majuro by the RMI National Biodiversity Team (2000), although location was not stated (NVV 1999).

Lantana camara L. lantana, shrub verbena

Marshallese: ***lantõna*** (a corruption of the English common name)

Recent introduction. Tropical America. Occasional. Planted ornamental; possibly adventive in inland areas of Laura. The bright colored var. *aculeata* (L.) Mold is the more commonly observed, but the white and yellow var. *nivea* (Vent.) Bailey also present; one plant near the entrance of the Outrigger Marshall Islands Resort and others at private residences in Rita and Ajeltake. Previously reported on Ailinglaplap and Jaluit by F. S & O (1979) but did not survive in Jaluit (Fosberg & Sachet 1962); and subsequently on Kwajalein by Whistler & Steele (1999). Named as one of the top-ten invasives for the Marshall Islands during a South Pacific Commission workshop. Considered to be one of the "One Hundred of the World's Worst Invasive Alien Species" by the Global Invasive Species Database (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0348, DPMJ0154).*

Phyla nodiflora (L.) E. Greene turkey tangle, mat grass, false thyme
Syns. *Lippia nodiflora* (L.) Michx.; *Verbena nodiflora* L.

Recent introduction. Warm temperate America. Common. Low ground cover with rounded serrated leaves and small white or lavender flowers in back yard at the Royal Garden Hotel and in ruderal areas throughout the DUD. Reported present on Enewetak by Lamberson (1982) and naturalized on Kwajalein by Whistler & Steele (1999) (RRT 1999, 2000AB, 2001; NVV 1999) (DPMJ0100, DPMJ0593, DPMJ0597).*

Premna serratifolia L. false elderberry
Syns. *Premna obtusifolia* R. Br.; *Premna taitensis* Schauer

Marshallese: ***kaar***

Indigenous. Indo-Pacific. Common. Tree or shrub in coastal vegetation, common pioneer in abandoned coconut plantations and secondary vegetation and in household gardens as single tree or living fence; occasional in disturbed sites on Calalin Islet (StJ 1951; MDS 1977; F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0398, DPMJ0541, DPMJ0695).

Stachytarpheta jamaicensis (L.) Vahl. Jamaica vervain, blue rat's tail

Recent introduction. Tropical America. Common. Blue-flowered weed of roadsides, waste places, fallow vegetable plots and other ruderal sites. Although it can become invasive and has become a problem in Niue and French Polynesia, has not yet caused problems in Micronesia (F, S & O 1979; FRF 1990; RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0426, DPMJ0580, DPMJ0586a).

Vitex trifolia L. var. **subtrisecta** (Kuntze) Mold. blue vitex, mosquito bush

Marshallese: ***utkanamnam*** ("flower-to-cause-mosquito-mosquito", in reference to its use as mosquito repellent)

Recent introduction. East Africa to the Pacific Islands. Very abundant. Small aromatic tree or shrub widely planted as a manicured hedge, with reported mosquito-repellent properties; occasional as a planted ornamental and naturalized in some areas. Reportedly introduced from Pohnpei or from Kwajalein, where it is planted as a hedge. Previously reported on Kwajalein by F. S & O (1979) (RRT 1991, 1999, 2000AB, 2001; NVV 1999) (DPMJ0442, DPMJ0560).*

ADDENDUM

These five species were recorded after January 2002, thus after the completion of the main list and not included in the total of 563. Four are new records to the country and the other, new to Majuro. None represents a new family.

POLYPODIACEAE (Common Fern Family or Polypody Fern Family)

Adiatum tenerum Swartz brittle maidenhair fern, fan maidenhair fern

Recent introduction. Florida, Caribbean and Central America. Rare. Small patch found in November 2002, under the raised foundation of a house in Delap. Has become naturalized in Guam (NVV 2002) (DPMJN111602).**

AMARYLLIDACEAE (Amaryllis Lily Family)

Hymenocallis latifolia (Miller) M. J. Roemer broadleafed spider lily

Recent introduction. Southeastern United States. Rare. A few plants in a household garden in Rita. Flowers similar to *H. pedalis* but has leaves that are notably wider. Said to have purchased several years earlier from Robert Reimers Enterprises (NVV 2002) (DPMJN1127a, DPMJN1127b)**

POACEAE or **GRAMINAE** (Grass Family)

Eragrostis pectinacea (Michx.) Nees tufted lovegrass

Recent introduction. North America. Rare. Small patch found in December 2002 near Pacific Basin Wholesale in Delap. Identification not certain and so it could possibly be another closely related species (NVV 2002) (DPMJN122102).**

FABACEAE (Pea Family)

Pithecellobium dulce (Roxb.) Benth. Manila tamarind

Recent introduction. Mexico to Venezuela. Rare. Single large tree about 4 meters in height behind a house in Uliga. Brought in as a seedling from Hawai'i as a novelty and has never produced any fruit. Previously reported on Jaluit by F. S & O (1979) but did not survive (Fosberg & Sachet 1962) Has become naturalized on Guam and Hawai'i (NVV 2002) (DPMJN090502).*

SCROPHULARIACEAE (Snapdragon Family or Figwort Family)

Buchnera americana L. American bluehearts
Syns. *Buchnera floridana* Gandog.; *Buchnera breviflora* Pennell

Recent introduction. Eastern United States. Rare. Delicate lavender colored wildflower found just past reservoir, near airport in November 2002. Several small patches found and it may be showing invasive qualities. Has long been naturalized on Guam (NVV2002) (DPMJN112102)**

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ATOLL RESEARCH BULLETIN

NO. 504

STUDY OF AN ORIGINAL LOBSTER FISHERY IN NEW CALEDONIA (CRUSTACEA: PALINURIDAE & SCYLLARIDAE)

BY

EMMANUEL COUTURES AND CLAUDE CHAUVET

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
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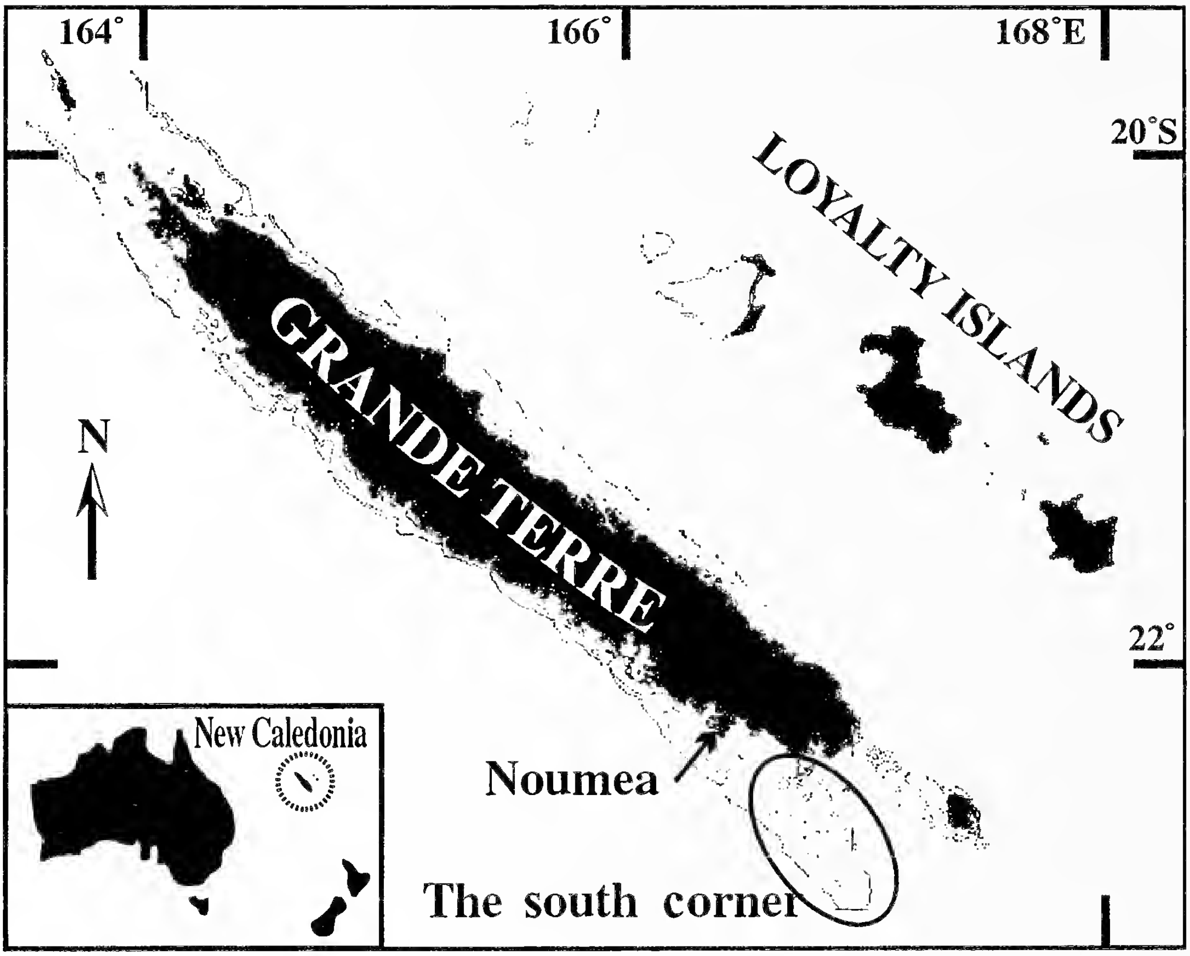

Figure 1. Location of New Caledonia and sampling area.

STUDY OF AN ORIGINAL LOBSTER FISHERY IN NEW CALEDONIA (CRUSTACEA: PALINURIDAE & SCYLLARIDAE)

BY

EMMANUEL COUTURES[1, 2] and CLAUDE CHAUVET[1]

ABSTRACT

A lobster fishermen team using two fishing techniques was studied in New Caledonia. The day-fishing technique is used to catch pronghorn spiny lobsters (*Panulirus penicillatus*) and Caledonian mitten lobsters (*Parribacus caledonicus*) while walking on the reef flat at low tide near the breakers directly to their den. The night-fishing technique allows catching three species and one subspecies of palinurids (*Panulirus penicillatus*, *P. longipes bispinosus* and some *P. ornatus*) and two scyllarid species (*Scyllarides squammosus* and some *Parribacus caledonicus*) by diving with a water torch over the reefs. Analysis of fishermen's efficiency shows that one of them always catches more than others. Catch analysis among the lunar phase indicates that night catches are not influenced by the moonlight with the exception of *Parribacus caledonicus*.

INTRODUCTION

In New Caledonia (Fig. 1), three species and one subspecies of *Panulirus* spp. and two species of slipper lobsters are commonly found in the lagoon (Table 1), i.e., from the shoreline to the barrier reef surf line (Richer de Forges and Laboute, 1995; Coutures, 2000). Adults of these species are associated with different habitat features in the lagoon (Fig. 2). As lobster densities are greater on the barrier reef, professional fishermen mainly prospect this area. The main fishing method in New Caledonia is night diving with a waterproof torch, catching lobsters by hand while they forage on the reef flat. However, some fishermen also catch lobsters by walking on the reef flats during the day at low tide.

The present contribution compares catches qualitatively and quantitatively using both fishing methods in the southwest lagoon of New Caledonia.

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Table 1. The common species of Palinuridae (spiny lobster) and Scyllaridae (slipper lobster) in New Caledonian shallow water.

Family	Species	
PALINURIDAE	*Panulirus penicillatus* (Olivier, 1791)	Pronghorn spiny lobster
	P. longipes bispinosus Borradaile, 1899	Longlegged spiny lobster
	P. ornatus (Fabricius, 1798)	Ornate spiny lobster
	P. versicolor (Lateille, 1804)	Painted spiny lobster
SCYLLARIDAE	*Scyllarides squammosus* (H. Milne-Edwards, 1837)	Blunt slipper lobster
	Parribacus caledonicus Holthuis, 1960	Caledonian mitten lobster

METHODS

New Caledonia is situated between 20°-22°30´S and 164°-167°E (Fig. 1) and is surrounded by a 23,400 km^2 lagoon, delimited by 1,600 km of an almost continuous barrier reef.

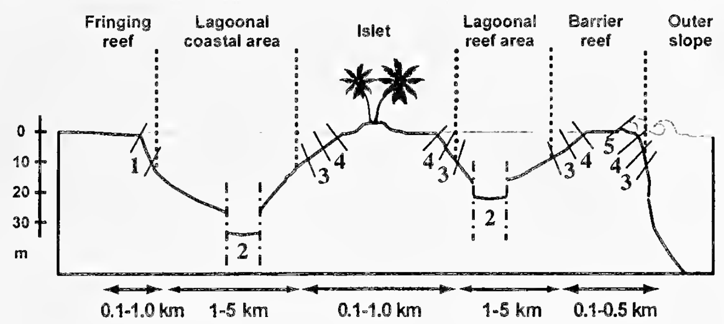
A professional fishermen team based in Noumea was monitored. Their favorite fishing areas are situated in the south corner of New Caledonia (Fig. 2). Each fishing trip lasts six days and a new part of the south corner barrier reef is being prospected every day. The team is composed of four or five fishermen who fish during daytime at low tide and at night by diving. At the end of the outing, each fisherman's catch was weighed according to three groups: spiny lobsters (*Panulirus* spp.), blunt slipper lobsters (*Scyllarides squammosus*) and Caledonian mitten lobsters (*Parribacus caledonicus*). These data were recorded with dates and fishing sites obtained by Global Positioning System (GPS).

In order to study fishing methods and determine catch per unit effort (cpue) index, we joined the fishermen during five campaigns in 1995. This sampling was also used to evaluate the proportion of each species of spiny lobster in catches.

A cpue was defined as the catches (in kg) of a fisherman in a day or night knowing that a day of fishing lasts two hours whereas during the night they fish on average three hours. Average cpue by day vs night was compared from data recorded by the captain between April 1994 and July 1995. As catches are nominatives, fishermen's efficiency was compared by *t*-paired tests.

Several authors (Prescott, 1980, 1988; Pitcher, 1992) indicate that most species of spiny lobster are relatively inactive during the light phase of the moon. Thus, variations of cpue among lunar cycles were analysed by Kruskal-Wallis tests and Multiple

Comparison Between Treatment (MCBT) as a posteriori test when appropriate (Dagnelie, 1980; Siegel and Castellan, 1989).



1 **Fringing reef:**
Panulirus versicolor; P. longipes bispinosus
2 **Lagoonal bottom and scattered coral patches:**
Panulirus ornatus; Scyllarides squammosus
3 **Weak hydrodynamism, fragil corals:**
Panulirus versicolor; Scyllarides squammosus
4 **Medium hydrodynamism, tough corals:**
Panulirus longipes bispinosus; Scyllarides squammosus
5 **Strong hydrodynamism, corals and encrusting algae:**
Panulirus penicillatus; Parribacus caledonicus

Figure 2. The habitats of common Palinuridae and Scyllaridae in the southwestern lagoon of New Caledonia. Adapted from George (1974) and Dandonneau *et al.* (1981).

RESULTS

Fishing technique

Whereas the diving fishing method by night is well known, catching lobsters by day is an original technique. Fishermen walk on the reef flat at low tide when the swell is not too strong. They crisscross the area situated near the swash zone and search animals in their holes. Two species are caught: the pronghorn spiny lobster (*Panulirus penicillatus*) and the Caledonian mitten lobster (*Parribacus caledonicus*). The first lives under the breakers in immersed cavities dug in large dead coral patches. Their capture is difficult because it is hard to recognize open corals that contain lobsters. In addition power and agility are needed to extract them from holes. The Caledonian mitten lobsters live at about 20 m from the breakers in cavities (called nests) with small openings. This species is gregarious and a nest can contain 40 individuals. These animals are generally hung upside down under the dome and are easily caught.

During the night fishermen dive near the breakers, over the inner slope of the barrier reef and sometimes also over lagoonal reefs. Thus, they can catch different species of lobsters. Figure 3 shows the proportion of each spiny lobster species caught by night.

Table 2 shows average cpue by day and by night of the three groups: spiny lobster, blunt slipper lobster (*Scyllarides squammosus*) and Caledonian mitten lobster (*Parribacus caledonicus*).

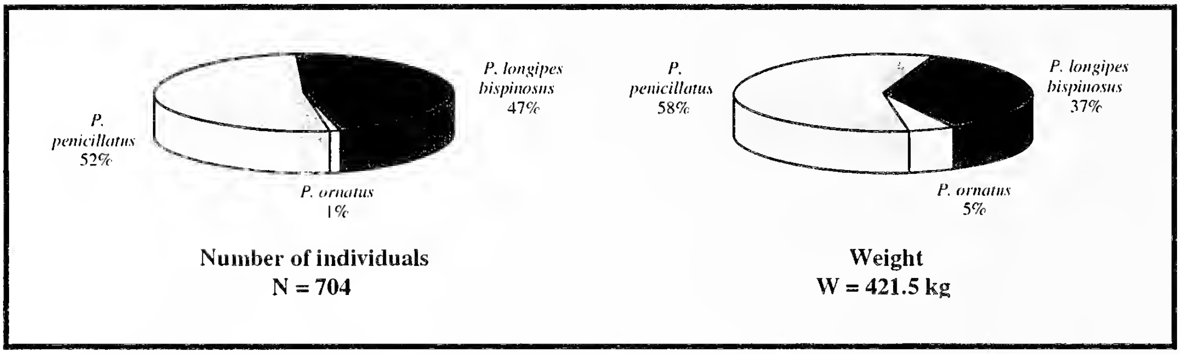


Figure 3. Ratio of different *Panulirus* species and subspecies in night catches.

Table 2. Average Catch Per Unit Effort (cpue) in kg/fisherman/day or night of Caledonian mitten lobsters (*Parribacus caledonicus*), blunt slipper lobsters (*Scyllarides squammosus*) and spiny lobsters (*Panulirus* spp.). SD = standard deviation.

	Species	Average CPUE	SD	Min.	Max.
DAY N = 278	*P. caledonicus*	5.20	4.72	0	17.00
	Panulirus spp.	2.81	2.78	0	11.60
NIGHT N = 154	*P. caledonicus*	0.54	0.76	0	4.33
	Panulirus spp.	7.24	7.42	0	58.75
	S. squammosus	1.32	1.95	0	10.55

Catch Analysis

From nominative records, one fisherman often appeared more efficient than the others. Catches (cpue) of this fisherman were compared to the mean cpue of other fishermen for each outing. Results indicate that this fisherman is more efficient (+ 60%, in average) in catching all species, whatever the technique (Table 3). In order not to introduce bias, catches of this fisherman were not taken in account for the following analysis.

After using a Kruskal & Wallis test, no differences were shown between cpue of *S. squammosus* and *Panulirus* spp. among lunar cycles. Catches of *P. caledonicus* are statistically different during the lunar phase, and MCBT a-posteriori test indicates that catches during the full moon are lower than those during a new moon and the first quarter (Table 4).

DISCUSSION

This study has supplied quantitative and qualitative data on lobster fishery in coral-reef environments. The original day-fishing technique allows catching plenty of Caledonian slipper lobsters. This species is easily sold in local markets and its value is equal to the prices of other lobsters (20/25 US$ per kg). In fact, this technique is additional to night fishing because it allows diversification of catches (and potential markets), and the doubling of activity when fishermen leave for several days. However, this technique is not applicable everywhere in New Caledonia. Some reefs contain too many holes or there are not enough exposed at low tide to fish near breakers. Moreover, reefs too exposed cannot be fished or only rarely.

Table 3. *t*-paired test between cpue's of the more efficient fisherman (in bold) and the average cpue of other fishermen (in brackets). SD = standard deviation; DF = degree freedom; *t* = student value; p = probability value.

	Species	Average cpue	SD	Min.	Max.	DF	t	p
DAY	*P. caledonicus*	**4.36** (2.76)	*4.59 (3.00)*	**0** (0)	**26.30** (13.90)	**132**	5.161	<.0001
	Panulirus spp.	**5.71** (3.75)	*8.85 (5.07)*	**0** (0)	**68.50** (48.70)	**132**	3.776	0.0002
NIGHT	*P. caledonicus*	**0.79** (0.46)	*1.13 (0.77)*	**0** (0)	**5.20** (4.75)	**116**	3.828	0.0002
	Panulirus spp.	**9.84** (5.71)	*8.83 (4.99)*	**0** (0)	**40.50** (29.75)	**116**	7.101	<.0001
	S. squammosus	**2.16** (1.30)	*3.14 (1.87)*	**0** (0)	**14.40** (8.60)	**116**	4.006	0.0001

Table 4. Comparisons by Kruskal-Wallis (K-W) test and Multiple Comparisons Between Treatments (MCBT) between average night cpue (in bold) among the lunar phase. Standard deviation in italics.

	Average cpue				K-W	
Species	NM	FQ	FM	LQ	p	MCBT
P. caledonicus	**0.63** *0.80*	**1.05** *1.25*	**0.28** *0.43*	**0.61** *0.75*	0.002	FM<NM-FQ
Panulirus spp.	**7.20** *1.20*	**8.05** *8.61*	**7.34** *9.28*	**6.55** *5.20*	0.969	---
S. squammosus	**0.96** *6.20*	**1.86** *1.96*	**0.84** *2.70*	**0.93** *1.39*	0.367	---

Whether by day or by night, fisherman's efficiencies are not equal. This is important in terms of management when fishery analyses are carried out from landing records. These records are rarely filled out with the numbers and names of fishermen, fishing sites, and catches per species and per fisherman. Thus, it is not easy to compare fishing teams, and average cpues can vary a lot.

Except for *Parribacus caledonicus*, our results do not show catch differences among the lunar phases, but catches are not very important at night. In other words, catching lobsters does not vary according to moonlight. This result is in contradiction with the literature and with the general thinking of fishermen. In fact, lobster activity is certainly low around the full moon, and animals stay near the entrances to their dens (Prescott, 1988) but this behavior does not influence their catch. However, Hoogesteger (1960, *in* Prescott, 1988) showed for a *Panulirus penicillatus* fishery in Christmas Island (Kiribati) little change between catches made during dark nights and those made during moonlight phases.

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ATOLL RESEARCH BULLETIN

NO. 505

FERAL CATS IN PARADISE: FOCUS ON COCUS

BY

DAVID ALGAR, G. JOHN ANGUS, ROB I. BRAZELL,
CHRISTINA GILBERT, AND DAVID J. TONKIN

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FERAL CATS IN PARADISE: FOCUS ON COCOS

BY

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ABSTRACT

The Department of Conservation and Land Management was approached by the Shire Council of the Cocos (Keeling) Islands to provide a long-term solution to the feral cat problem on the islands. Researchers in the Department have developed a number of techniques and strategies to control feral cats. The project on the islands provided the opportunity to assess these procedures on a closed population in a wet tropical climate.

A control program resulted in the removal of approximately 90% of the feral/stray cats on the islands. It is anticipated that Shire officers that were trained in trapping techniques during the control program will remove the remaining individuals.

INTRODUCTION

The Cocos (Keeling) Islands were initially settled by Alexander Hare in 1826 and subsequently by the Clunies Ross family in 1827. These families brought with them a number of coconut plantation workers, predominantly of Malay origin. Today, 460 Cocos-Malay people live in the kampong (village) on Home Island while 150 people mostly from mainland Australia live on West Island. Pondoks (weekender shacks) used by the Home Islanders are present on the lagoon shore of South Island and on a number of the smaller islands.

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The early settlers first introduced cats to the southern atoll and throughout the islands' history cats have arrived as domestic pets. Over the last two decades, the number of stray/feral cats present has concerned the community and a number of short-term control programs have been implemented (Garnett, 1992; Reid, 2000). These control campaigns have only reduced cat numbers over a limited period and the problem has persisted. A recent policy adopted by the Shire Council has restricted the importation of cats to sterilized animals only. The presence of feral/stray cats potentially poses health problems to the human population as cats are hosts and reservoirs for a number of diseases and parasites. The presence of feral/stray cats in residential areas has also presented a significant nuisance problem with cats calling and fighting through the night and urinating and defecating around the houses. The Cocos-Malay people were also concerned that cats were predators of their domestic chickens around the kampong and pondoks where chickens are allowed to range free.

Successful control of stray and feral cats would also benefit the proposed reintroduction of the endangered buff-banded rail (*Rallus philippensis andrewsi*) to several islands within the group (Garnett, 1993; Parks Australia, 1999; Garnett and Crowley, 2000; Reid, 2000). This species was once widespread on all the Cocos (Keeling) Islands but is now restricted to the cat-free North Keeling Island. The last record for this species, other than on North Keeling Island, was an individual killed by a cat on West Island in 1991 (Garnett, 1993).

Members of the Shire Council on behalf of the Island Community made an approach to the Department of Conservation and Land Management to provide a long-term solution to the cat problem on the islands. Feral cats are present on Home and West Islands and possibly occupy some or all of the chain of islands between the two.

Until recently, limited research has been conducted in Australia on control strategies for feral cats. The research and operational programs being conducted by the Department are providing innovative techniques and successful strategies for controlling feral cats. The program on the Cocos (Keeling) Islands offered the opportunity to expand the range of environmental conditions under which the current control techniques have been assessed. Two broad climatic regimes under which the techniques have not been tested are the wetter temperate and tropical climates. The Cocos (Keeling) Islands offered the opportunity to assess current procedures on a closed population in a wet tropical climate with rats and chickens as the principal prey species.

METHODOLOGY

Site Description

The Cocos (Keeling) Islands are a remote Australian External Territory located in the Indian Ocean. They lie 2,768 km northwest of Perth, 3,658 km almost due west of Darwin, 900 km west of Christmas Island and 1,000 km southwest of Java Head. The islands are two coral atolls only several meters above sea level which have developed on top of old volcanic seamounts. The inhabited southern atoll is 14 km long and 10 km across and comprises 26 islands. Some islands are linked together (or separated by very shallow water) at low tide, while others are in deeper water and are accessible only by boat. The uninhabited northern atoll 26 km to the north comprises a single island, North Keeling Island, an area of 1.3 km^2 that is a seabird rookery of world-wide significance.

The islands of the southern atoll are located at latitude 12^0 12'S and longitude 96^0 54'E. Climate is oceanic-equatorial and humid with a mean annual rainfall of approximately 2000 mm, high humidity (65-84%), and uniform temperatures year round (mean daily temperature: 25.8 –27.5^0 C) (Falkland, 1994). The southeast trade winds dominate for most of the year but with periods of doldrums during the tropical cyclone season (November-April).

The total land area of all the islands of the southern atoll is 14 km^2. The reef islands of the Cocos (Keeling) Islands are described in detail by Woodroffe and McLean (1994) and summarized below. The smaller islands are less than a hundred meters wide, some are virtually vegetated sandbanks, and all are made up of coral clinker and sand thrown up from the surrounding reef. All the islands are flat, their highest points being sand hills on the ocean side. The sizes of the main islands in the group are indicated in Table 1 (from Woodroffe and McLean, 1994).

Table 1. The sizes of the main islands of the southern atoll

Island	Perimeter (km)	Area (km^2)
Pulu Panjang (West Is.)	38.5	6.23
Pulu Atas (South Is.)	28.5	3.63
Pulu Luar (Horsbourgh Is.)	4.4	1.04
Pulu Selma (Home Is.)	6.7	0.95
Pulu Tikus (Direction Is.)	3.4	0.34
Pulu Pandan	3.9	0.24
Pulu Wak Bangka	2.4	0.22
Pulu Siput	2.2	0.10
Pulu Ampang	1.8	0.06
Pulu Kembang	1.6	0.04
Pulu Labu	1.3	0.04
Pulu Blekok	1.1	0.03
Pulu Blan	0.8	0.03
Pulu Blan Madar	0.7	0.03
Pulu Wa-idas	0.7	0.02
Pulu Kelapa Satu	0.5	0.02
Pulu Beras (Prison Is.)	0.4	0.02
Pulu Maria	0.7	0.01

The majority of islands in the atoll have a conglomerate platform on the ocean side, although there are extensive sandy/shingle areas on South and Horsburgh Islands. The ocean side of West Island is predominantly sand. The lagoon side of the islands is either sandy beaches or intertidal sands with variable areas of coral shingle. On a number of islands sandy spits extend into the lagoon.

The vegetation on the southern atoll is dominated by groves of coconut palms. This coconut woodland has ceased to be cleared and has become largely overgrown and penetrable with difficulty. The understory is mostly coconut seedlings with some shrubs, grasses or other perennials or a dense mat of decaying palm fronds and coconuts. These woodlands are fringed on the lagoon shore by shrub land of *Pemphis acidula* and on the ocean shores by cabbage bush (*Scaevola taccada*) and clumps of octopus bush (*Argusia argentea*) (Williams, 1994; Woodroffe and McLean, 1994).

There are no native mammal species on the atoll; however, a number of species have been introduced. Two species of introduced rats, the brown rat (*Rattus norvegicus*) and black rat (*R. rattus*), are present on the islands (Wood Jones, 1909). Rats arrived on the Cocos before the settlers. Rats that survived the shipwreck of the Mauritius in 1825 colonized an island the Cocos Malay call Pulu Tikus (Rat Island, now known as Direction Island) (Wood Jones, 1909; Bunce, 1988). Subsequent shipwrecks and dispersal of rats have enabled the animals to spread to all the islands in the southern atoll. Two bird species have also been introduced and become established on the southern atoll (Carter, 1994). "Feral chicken", domestic chicken that have become semi-wild, occur on most if not all islands in the southern group. The green junglefowl (*Gallus varius*) of Java was also introduced to West Island.

The Control Program

The first stage in providing a long-term solution to the cat problem on the islands was to sterilize domestic pets and thus prevent young animals entering the overall cat population. Prior to implementing the control program, the Shire of Cocos contracted a veterinary surgeon to sterilize those domestic cats that the owners wished to retain. The sterilized cats were sprayed with a red marker to enable identification and release of pets should they be captured during the trapping program. The sex, age and the owners of sterilized cats were recorded.

A public awareness and education program was conducted upon our arrival outlining the program and method of operation. Talks were given to children in primary and high schools and a presentation was provided to shire councillors. Once the control campaign had been initiated, there was an ongoing commitment to inform the shire and members of the general public of the program's progress.

The control program commenced on November 5, 2000 and was conducted over a 40-day period. The majority of cats were reported to be on the inhabited Home and West Islands and therefore these two islands were the focus of the control program. The other 24 islands in the southern atoll were systematically examined for evidence of cat activity. The extensive searches conducted revealed that South Island was the only other island in the group that cats occupied. The cat population on this island was localized and relatively small, probably less than 10 animals.

Department researchers have developed a series of techniques that have proven highly successful in controlling feral cats. A bait has been developed to control feral cats. It is similar to a chipolata sausage, approximately 25 g wet-weight, and is composed of minced kangaroo meat, chicken fat and flavor enhancers that are highly attractive to feral cats. Toxic baits contain the poison 1080 (sodium monofluoroacetate).

A trapping technique, using lures that mimic signals employed in communication between cats, has also been developed. Cats are very inquisitive about other cats in their areas; their communication traits are principally reliant on audio and olfactory stimuli. The trapping technique uses padded leg-hold traps, Victor 'Soft Catch'® traps No. 3 (Woodstream Corp., Lititz, Pa., USA.), a Felid Attracting Phonic (FAP) that produces a sound of a cat call, and a blended mixture of feces and urine (pongo). Each trap site consists of a channel slightly wider than the width of one trap which is cleared into a bush to create a one-way (blind) trap set. Two traps, one in front of the other, are positioned at the entrance of the blind set at each trap site. Cats are lured to a trap set initially by the audio signal produced by the FAP. The FAP consists of a 36 x 25 mm printed circuit board with a microprocessor data-driven voice read only memory (ROM). As cats approach the trap sets they are further enticed into the traps by the smell of pongo. These techniques, along with cage traps baited with fish or nontoxic sausage baits and shooting with a 0.22 caliber rifle or 12-gauge shotgun, provided the options during the control program. A number of cats were also captured by hand; these animals were usually kittens (under 500 g in weight) in the kampong.

The use of individual techniques varied for each island because of their size and the extent of human inhabitation. On Home Island a toxic baiting program could not be conducted because of legislative regulations and health and safety protocols. Cage trapping was the principal control measure used on the island. Initially the traps were provided to individual households and the villagers trapped the cats for us. The enthusiastic response to this program enabled traps to be located across the majority of houses in the kampong. Between 20-25 traps were employed daily in the kampong. Following the removal of the majority of cats from the kampong, the cage traps were strategically located across the rest of the island. Shooting of cats was employed in areas distant from the kampong. To remove those cats that were wary of entering cage traps, a number of leg-hold traps were strategically set in areas where cats were observed. Setting these traps in the village was conducted with the consent of the householder and all inhabitants of that house were shown its location. Leg-hold traps were also set outside the kampong. The leg-hold traps were either baited with pongo or a food lure and the traps were set at dusk and removed at dawn.

The much larger West Island with a smaller, localized residential area and South Island inhabited only on the weekends provided the opportunity to assess baiting options as a measure of cat control. Preliminary trials with nontoxic baits placed on the ground resulted in all baits being removed overnight by nontarget species. Land crabs (*Cardisoma carnifex*) which dominate the forest floor, hermit crabs *(Coenobita perlata)* along the coastal areas and chickens were responsible for removing the baits. A subsequent trial using 30 cm wooden skewers to elevate the baits above the ground prevented land crabs from taking baits but over three-quarters of the baits were still taken by hermit crabs and chickens. Further trials were abandoned and the option of using baits to control cats was dismissed. Later in the control program, it was discovered that attaching several baits to a string tied to a stake angled into the ground overcame the problem. The baits were suspended approximately 30 cm above the ground and were not taken by nontarget species but were highly attractive to cats. Unfortunately at this stage we did not have sufficient equipment to use this technique in a baiting program but it did provide a very successful method for trapping cats towards the end of the control program.

West Island with its smaller localized residential area also enabled a greater flexibility in the use of control options. Cage trapping was conducted around the houses and leg-hold traps were located outside the residential area across the island. Leg-hold traps with the FAP/pongo lure were positioned at 500 m intervals along all road accesses on the island. The network of roads on the island provided 20 km of accesses along which 46 traps were located. All traps were left in position for a minimum of 20 days. A further 10 trap sets employing the suspended sausage lures were strategically located to remove those cats wary of the FAP/pongo lures.

Controlling cats on South Island was abandoned following the preliminary bait trials. South Island could only be accessed easily at certain points at high tide, which posed immense difficulty in being able to examine traps on a daily basis. The time involved in travelling to and from the island also meant that more critical efforts on the other islands could not be undertaken. Our focus was concentrated on Home and West Islands where the cat populations were much greater and posed more significant problems to the people.

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Captured cats were humanely dispatched according to approved ethical procedures and the carcasses disposed of according to local government guidelines. For each individual animal, sex was determined, weight recorded and a broad estimation of age (as either kitten, subadult or adult) was determined according to their weight. The pregnancy status and litter size of females was recorded by examining the uterine tissue for the presence of fetuses or placental scarring from the previous litter. Stomach contents were examined to provide information on principal prey species. Samples of brain, muscle, spleen, blood and feces were collected from the first 10 cats on both Home and West Islands for analysis of communicable diseases and parasite presence and also for determination of the genetic origins of the cats.

RESULTS

A total of 29 cats were neutered during the sterilization program. Three of these animals were later requested to be destroyed by their owners. A survey of cat owners conducted while on the island indicated that a further 17 pet cats had been sterilized previously. Another five cats removed during the control program had also been sterilized at some stage but had become stray or feral. Records of the sterilized animals are given in Table 2.

Table 2. The sex, age and location of sterilised cats

	Male		Female	
	Adult	Subadult	Adult	Subadult
Home Is. (Nov. 2000)	5	4	9	8
(previously)	3	-	1	-
West Is. (Nov. 2000)	-	2	1	-
(previously)	4	-	9	-
Total	12	6	20	8

The intensive searches for evidence of cat activity on each of the islands in the atoll indicated that they only inhabited Home, West and South Islands.

A total of 230 cats were removed during this exercise, 43 animals from West Island and 187 from Home Island. Female cats pregnant at the time of removal contained an additional 108 kittens *in utero* that potentially would have survived to enter the cat population. The number of animals removed using the various techniques is given in Table 3.

Table 3. The number of cats removed using the various techniques on West and Home Islands

Technique	West Island	Home Island
Cage trap	11	127
Leg-hold trap with FAP and Pongo lure	15	0
Leg-hold trap with food lure	12	12
Leg-hold trap with Pongo only	Not used	6
Shot	5	14
By Hand	Not used	28

The male-to-female sex ratio of these animals was 0.93. The population age structure for the two islands is presented in Table 4. The age of individuals was arbitrarily assigned according to weight. The lowest weight recorded for a pregnant female was 1.6 kg and this was used as the minimum adult weight for female cats. The weight/age classes for females were 0-0.5 kg for kittens, 0.6-1.5 kg for subadults and 1.6+ kg for adults; males were 0-0.5 kg for kittens, 0.6-2.0 kg for subadults and 2.1+ kg for adults.

Table 4. Population age structure of culled cats

	Male			Female		
	Kitten	Sub adult	Adult	Kitten	Sub adult	Adult
Home Island	21	19	51	21	11	58
West Island	-	5	12	1	7	18
Total	21	24	63	22	18	76

The average weight for adult male cats was 3.38 $\pm$ 0.07 kg ($\mu \pm$ s.e.) with a maximum weight of 4.80 kg. The average weight for adult female cats was 2.69 $\pm$ 0.06 kg ($\mu \pm$ s.e.) with a maximum weight of 3.75 kg. Counts of fetuses *in utero* and placental scars indicated that the average litter size was 2.85 $\pm$ 0.19 kittens ($\mu \pm$ s.e.) with a maximum litter size of six kittens.

Analysis of the stomach contents for individual animals indicated that the majority of cats on Home Island were feeding on household scraps and food put out for the chickens. Grasshopper remains were found in only two cats and one cat had eaten a rat. In contrast, the principal dietary items on West Island were rats and grasshoppers. There was no evidence that cats were predators of chickens, or any other bird species, despite the abundance of young domestic and feral chickens on the two islands.

Analysis of the parasite presence in the cats sampled indicated a high degree of hookworm. Ninety percent of the samples contained this parasite.

DISCUSSION

The control program on the Cocos (Keeling) Islands has served as an important example of how investment in research can lead to practical and valuable outcomes to the benefit of the broader community. Evidence suggested that there were probably a maximum of 10 feral/stray cats remaining on each of Home, West and South Islands at the conclusion of the control program. The program, therefore, resulted in the removal of approximately 90% of feral/stray cats. The success of this operation was due, to a large extent, to the enthusiastic response and participation by the entire community. The public education programs and liaison with the community addressed potential community concerns and resulted in significant public co-operation to the benefit of the project.

The abundance of cats on the three islands was significantly different and this can be attributed to the availability of food and suitable shelter. On Home Island an abundant food supply was present comprising food scraps scavenged within the kampong and around the tip and also food provided for the villager's chickens. Areas that provided adequate shelter and sites to raise kittens, particularly under the houses in the kampong away from the disturbance of land crabs, were numerous. On West Island, despite its larger size, cat abundance was significantly less than on Home Island. Rats and grasshoppers dominated the diet of cats on West Island. Kittens and young cats were generally only found around the residential area and rubbish tips where they were able to scavenge food scraps. Land crabs were much more abundant on West Island and areas of shelter and sites to raise kittens were limited. Lower food availability and limited sites for shelter would have significantly reduced survivorship, particularly of kittens and young cats. The small number of cats on South Island were located in the vicinity of the pondoks that were frequently occupied and had free-range chickens. These areas would have provided household food scraps and food supplied for the chickens. The absence of cats on other islands in the atoll would have been due to the islands being too small to support a cat population because of limited food and shelter.

One of the major reasons for conducting this control program was the community's concern of potential health risks due to the presence of feral/stray cats. Cats are hosts and reservoirs for a number of diseases and parasites including *toxoplasmosis* which can cause spontaneous abortion and birth defects. Analysis of the cat population sampled indicated a high incidence of hookworm infection. Hookworm larvae can burrow into human skin causing a disease called *cutaneous larval migrans*, also known as "ground itch" (Hotez and Pritchard, 1995).

Predation by cats, rats, and humans, competition with feral chickens, and habitat change have been suggested as the factors responsible for the local extinction of the buff-banded rail on the southern atoll of the Cocos (Keeling) Islands (Garnett, 1992, 1993; Garnett and Crowley, 2000; Reid, 2000). If proposed reintroductions are to be successful, effective control of cats is essential (op. cit.). The campaign conducted thus far, and that outlined for completion, will provide the level of control required.

The trapping techniques previously used in more arid and semiarid environments proved equally as effective under the wetter, tropical conditions on Cocos. The refinement to bait placement, developed while on Cocos, by suspending baits, prevented nontarget animals from removing the baits while maintaining their attractiveness to cats. This new approach to baiting provides a relatively simple means to control cats where nontarget species pose a problem and is likely to be invaluable elsewhere where control is required. This baiting technique will now be used to remove those feral/stray cats remaining on West and South Islands. Instruction in trapping techniques was provided to shire officers nominated to continue the program after our departure. These officers are continuing the trapping program on Home Island to remove the remaining feral/stray cats. These methods, the sterilization program for domestic pets, and the existing procedure of quarantining ships and pleasure yachts will provide the long-term solution to the cat problem on the Cocos (Keeling) Islands.

The success of the control program on the atoll follows a previous eradication program of cats from Hermite Island in the Montebellos group, Western Australia (Algar and Burbidge, 2000: Algar *et al*., in press). This year, a cat eradication campaign was also successfully conducted on Faure Island, an area of 58 km^2 within the eastern gulf of Shark Bay, Western Australia.

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ATOLL RESEARCH BULLETIN

NO. 506

DISTRIBUTION AND DIVERSITY OF MARINE FLORA IN CORAL REEF ECOSYSTEMS OF KADMAT ISLAND IN LAKSHADWEEP ARCHIPELAGO, ARABIAN SEA, INDIA

BY

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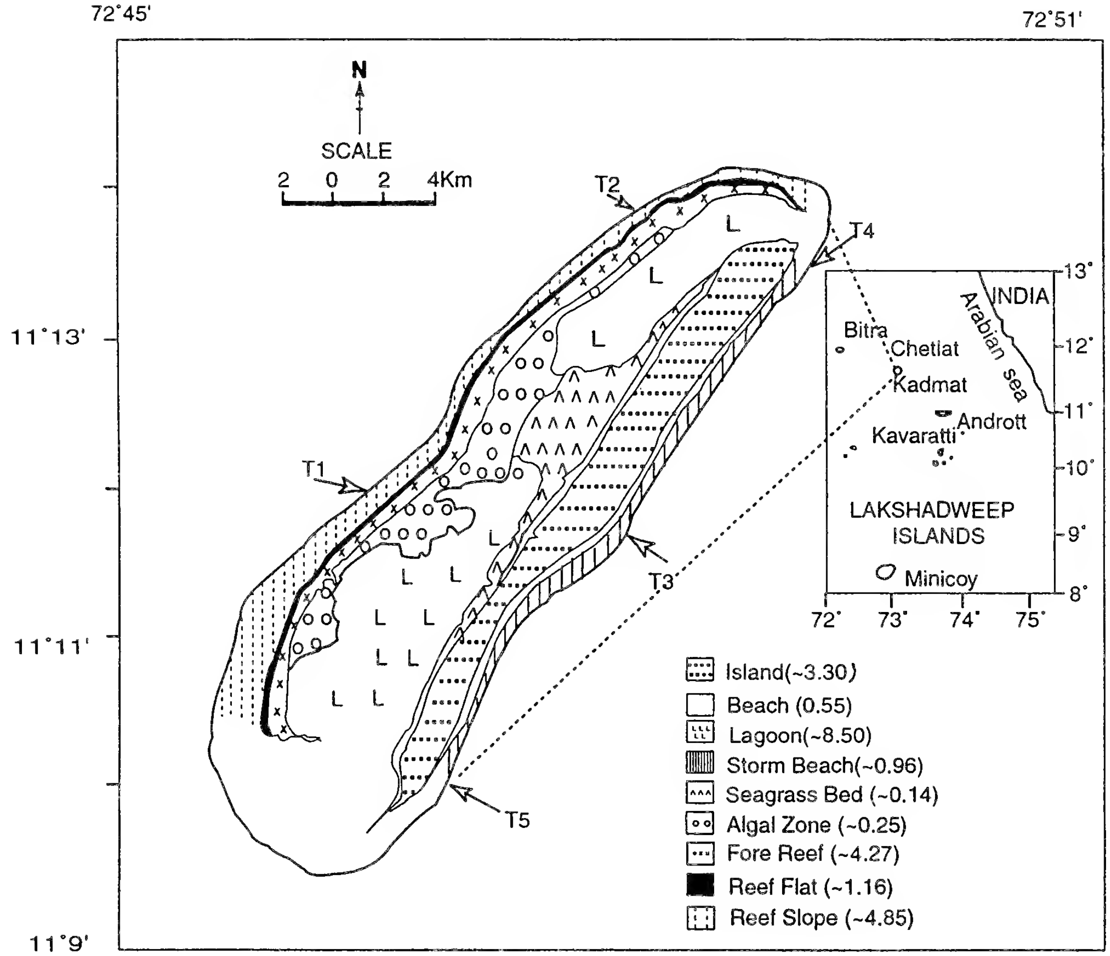

Figure1. Physical data and morphological features of coral reef from Kadmat Island (the numbers in parenthesis refer to an area in km^2).

DISTRIBUTION AND DIVERSITY OF MARINE FLORA IN CORAL REEF ECOSYSTEMS OF KADMAT ISLAND IN LAKSHADWEEP ARCHIPELAGO, ARABIAN SEA, INDIA.

BY

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ABSTRACT

The coral reef of Kadmat Island of Lakshadweep was assessed for its biological components along with relevant hydrological characteristics. Corals were represented by 12 species, the most dominant being *Acropora* and *Porites*. The distribution of coral was mainly confined to the reef slope and fore reef; however, the cover was very poor except for a few patches on the fore reef towards northwest (< 10%). The lagoon and reef flats were almost devoid of corals.

The low counts ($0\text{-}80 \times 10^3$ cells l^{-1}) and poor composition (11 spp.) of phytoplanktons could be due to oligotrophic waters around the island. The high contents of dissolved oxygen (DO) might be due to photosynthetic activities of macrophytes in the lagoon. Seagrass meadow occupied only 0.14 km^2 area of the lagoon leaving 98% of it barren. It was more prominent in the mid- and landward region of the lagoon due to fine and well-sorted thick sediment. Seagrass flora was comprised of two species and was dominated by *Cymodocea rotundata.* Biomass was estimated to be more (26-30.5g m^{-2} dry weight) during premonsoon season. The marine algae were represented by 23 spp. and mainly occurred in the seagrass beds but contributed negligibly to the biomass. *Acanthophora spicifera*, *Padina boergesenii* and *Jania capillaceae* were common during premonsoon season.

Sand-dune flora was represented by 39 spp. of which 16 spp. were perennial. The most dominant forms were *Spinifix littoreas* and *Ipomea pes-caprae*. The sand-dune region is under constant threat of reclamation for cultivation of vegetables and dwellings. Poor composition, particularly of corals, indicated that the reefs around Kadmat Island were converting into algal or detrital reefs.

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INTRODUCTION

Major oceanic reefs in India are confined to Lakshadweep (Arabian Sea) and Andaman and Nicobar (Bay of Bengal) groups of islands. Oceanic islands generally represent a multitiered ecosystem typically comprised of wetland habitats such as corals, seagrasses, seaweeds, mangroves and sand-dune vegetation. These wetland habitats from Lakshadweep, being unique and rich in biodiversity and productivity, are of great ecological and socioeconomic importance (Bakus *et al.*, 1993). However, because of their vulnerability to anthropogenic and natural destruction, they have been considered "Marine Critical Habitats" and hence are of global concern. These coastal habitats have also been categorized as "Ecologically Sensitive Regions" under the Coastal Regulation Zone (CRZ – I) Act (Anon., 1990). However, such regions in general and particularly at the oceanic islands are heavily pressurized, mainly due to overexploitation, deteriorating the overall reef ecosystem. Degradation of particular habitat is mainly associated with poor or total lack of management policies.

It is essential to adopt sustainable management of marine habitats at oceanic islands due to limited land resources. The existing data and information relevant to such habitats, particularly from the Lakshadweep group of islands, are inadequate for an understanding of the environmental and biological characteristics. The present investigation provides data on the structural aspects of various reef components, with emphasis on marine flora, from Kadmat Island in the Lakshadweep group. The data and recommendations would be of great help in rejuvenating the reef environment and formulating strategies for the sustainable utilization of the coral-reef resources.

DESCRIPTION OF THE STUDY AREA

Lakshadweep comprises a group of 36 islands situated between 8^0 and 10^0 13' N and 71^0 and 74^0 E in the Arabian Sea. Kadmat island (Fig.1) is located between 11 ^{0} 10' 52"- 11 ^{0} 15' 20" N and 72 ^{0} 45' 41"- 72 ^{0} 47' 29" E. It stretches ~ 8 km from north to south with width ranging from ~ 50 to ~400 m and measuring 3.12 km^2. The lagoon is on the leeward (western) side with its depth in the range of 2 – 3 m. The storm beach along the eastern side has an average width of ~100 m. A coralline algal ridge occurs along the breaking zone of the storm beach.

Climatology

The climatological data (average of 30 years from 1951-1980) pertaining to Amini Divi Island (Anon., 1999), in close vicinity to the study site, are depicted in Figure 2. The atmospheric temperature fluctuates between a minimum of 23.5^{0}C during January to a maximum of 33.3^{0}C during April-May. The average total precipitation has been estimated to be 1500 mm, 98% of which occurs during the period of April to November with the maximum rainfall during June-October. The humidity ranges from 79 – 87% with the maximum during the monsoon period (June to October). The monthly mean wind speed varies from 6 - 29.6 km h^{-1} (Fig. 2).

Geomorphology, Geology, Soil and Topography

The island is a submarine platform with a coral reef in the form of an atoll. It is crescent-shaped having a north-south orientation. The western margin of the lagoon is a submarine bank marked by a narrow reef below. The geology is marked by an upper 1-2 m-thick layer of disintegrated coral, below which is a compact porous crust of conglomerate stone and soil composed mostly of coral sand. Topography is a flat 1-2 m above sea level. Erosion occurs mostly along the shore towards the northeast and northwest.

METHODS

Information on various features of the study site was collected using aerial photographs of 1973 (scale 1:25000) and Indian Remote Sensing (IRS) data of October 1998 (scale 1:2,50,000). The final map was prepared by comparing photo and satellite data-interpreted results with ground truth observations on various features of the reef and island (Fig. 1).

The samplings and observations for physicochemical characteristics of water, floral constituents and sediment characteristics were made along the five fixed transects T1–T5 (Fig. 3) laid down from -10 m on the reef slope up to ~150–200 m above high-tide line on the island. The length of the transect varied from ~ 1-3.5 km depending upon the topography or the contour. The samplings were taken during the postmonsoon (November 1998) and premonsoon (May 1999) season. The collections and observations were made from the depth of -10 m and -5 m on the reef slope and from -1.5 and -2.5 m in the lagoon, and from exposed flats of reef and storm beach (Fig. 3). The subtidal samplings and observations were made by snorkeling and diving. The sediment samples from the subtidal regions were collected by graduated acrylic core while those from sand-dune regions were hand picked. The thickness of sediment (in the lagoon) was measured by pushing a graduated acrylic core to a maximum possible depth in the substratum. Analysis of the organic contents and the granulometric analysis of the sediments were done by following the methods of EL Wakeel and Riley (1957) and Folk (1968), respectively. Water samples were analyzed for various physicochemical parameters such as salinity, dissolved oxygen (DO), NO_3 - N, NO_2 - N, PO_4 - P, by using standard oceanographic techniques (Strickland and Parsons, 1972). Temperature and pH of the water samples were measured using a precision mercury thermometer and a pH meter (Systronics Graph 'D' 327).

For phytoplankton composition analysis, the subsurface water samples were preserved immediately after collection with five drops of Lugol's solution. Phytoplankton were identified using relevant literature (Heurck, 1986; Allen and Cupp, 1935; Subramanian, 1946; Dodge, 1985; and Hallergraeff, 1988). For quantitative analysis, 1 ml of preserved phytoplankton sample was transferred to Sedgewick rafter counting chamber. The cells were counted from three replicate subsamples.

Specimens of marine macrophytes, including seaweeds, seagrasses and sand-dune flora, were collected and preserved in 5% formalin as well as in the form of herbaria for further taxonomic identifications. The preserved specimens were identified using standard literature (Taylor, 1969 a, b; Abbott and Hollenberge, 1976; Tseng, 1983; Hooker, 1897; Cooke, 1960; Gamble, 1967; Hartog, 1970; Silva *et. al.*, 1996). Quantitative data, such as percentages, frequency of occurrence (FO), biomass of seaweeds and seagrasses (total and individual species), were collected using 1 m^2 quadrant technique (Jagtap, 1996, 1998).

The entire mass of vegetation, collected from the randomly chosen five quadrants at each station, was taken on board the Coastal Research Vessel (CRV), "Sagar Paschimi", washed to remove adhering debris, blotted dry and dried in the oven at 60^0 C to a constant weight. Species weighing >5 g (wet weight) were considered for estimating biomass and species weighing <5 g (wet weight) were discarded for biomass estimation as per Anon (1998). The qualitative and quantitative sampling for sand-dune vegetation was carried out on the berm and backshore regions on each transect at every 50 m intervals on the land. The biomass (wet weight) of major flora was estimated by removing the entire crop from three quadrants of 1 m^2 each and weighing it after removing adhered sand. The density of major species was measured by counting the actual numbers of individual and total plants in three 100 m^2 quadrants.

RESULTS AND DISCUSSION

The study region could be classified broadly into six major zones (Fig. 4). The lagoon occupies maximum area (~8.5 km^2) followed by reef slope (~4.85 km^2) and fore reef (~4.3 km^2). Because of large variability in the biotic components from various habitats of the reef, the data were pooled for separate zones of the reef such as reef slope, reef flats, storm beach, fore reef, lagoon, intertidal and sand dunes. The corals were mainly confined to the reef slope and fore reef, while the reef flat was almost devoid of corals. The fore reef towards northeast was observed to support a growth of young colonies of scleractinians, the species of *Pocillopora* and *Porites*. The substratum over the reef slope, reef flat, fore reef and storm beach flat was composed mainly of coral boulders and coral sands. The lagoon is generally sandy, except for occasional coral debris and boulders, towards the extreme northwest and southwest. The sandy substratum was comprised of coralline sand increasing landward.

The surface-water temperatures over the reef slope were slightly lower compared to the same in the lagoon (Table 1), which may be attributed to the greater depths and the high-energy zone compared to the shallow and low-energy region in the lagoon. The salinity values ranging from 34.17 to 35.08 PSU did not vary much in the lagoon and over the reef slope. In general, the nutrient concentrations were observed to be low (Table 1); however, the waters over the reef slope were relatively richer in nutrients compared to lagoon water. The nutrient values were slightly higher during November which may be due to the upwelling processes commonly occurring in the

Arabian Sea during October-November (De Souza *et al.*, 1996). The low nutrient concentrations in the lagoon could be attributed to their utilization by macrophytes, particularly seagrasses and seaweeds, and low retention by loose and unstable sediments (Sankaranarayanan, 1973).

The Lakshadweep waters have been reported to be generally of oligotrophic nature. However, areas that are oligotrophic at certain times can be eutrophic at other times (Bhattathiri and Devassy, 1979). The relatively high (8.2–8.8) pH values in the lagoon compared to water over the reef slope (7.5–8.7) might be due to respiratory processes by benthic flora in the lagoon influencing the biogeochemical processes of these waters (Sankaranarayanan, 1973). Similarly, the higher concentrations of dissolved oxygen (Table 1) in the lagoon water could also be attributed to photosynthetic processes by marine algae and seagrasses. In spite of low concentrations of phytoplankton, oxygen-enriched waters (4.11 - 6.57 ml l^{-1}) around Kadmat Island could only be attributed to the photosynthetic productivity of submerged flora (Odum, 1956; Qasim and Bhattathiri, 1971; Kaladharan *et al.,* 1998).

The phytoplankton counts of 0 to 80 x 10^3 cells l^{-1} over the reef slope and in the lagoon, respectively, indicate poor densities as also was reported earlier (Bhattathiri and Devassy, 1979) from Lakshadweep waters. Phytoplankton was represented by 11 species but *Trichodesmium* sp. was abundant (Bhattathiri and Devassy, 1979). A maximum of six species were observed from the lagoon and three from over the reef waters during November (Table 2). The poor qualitative and quantitative distribution of phytoplankton from the waters around Kadmat Island could mainly be due to the oligotrophic nature of its waters.

The prominent biological feature of any reef is its coral composition, which determines the health of the reef environment. The corals from the study site were mainly confined to the reef slope and fore reef and were represented by only 12 species. The most dominant forms belonged to the genera *Acropora* and *Porites* (Anon., 2000a). Occasional young colonies of *Pocillopora* grew on the reef flat and storm beach. The lagoon region, except the fore reef, was totally devoid of corals. The distribution was patchy with hardly 5% live coral colonies on the reef slope and fore reef. However, towards northeast and northwest, as well as southeast, occasional patches having an average of 10% live colonies were observed. Large numbers of coral colonies, particularly *Acropora* and *Porites,* were observed to be bleached indicating impact of certain stress. A similar phenomenon was observed in the case of corals along the central west coast during the same period (Anon, 2000b). Considering an earlier record of 104 spp. of corals from Lakshadweep region (Pillai and Jasmine, 1990), the distribution and number of coral species observed during the present study were extremely poor indicating severe deterioration of the coral reefs. The large-scale natural death and the bleaching phenomenon of the corals all over the tropics have been related to global warming causing a rise in seawater temperature by 1-2^0 C during the summer of 1998 (Huppert and Stone, 1998). The reef slope towards the northeast and east was totally devoid of live scleractinians except for a few colonies of *alcyonarians.*

The degradation of coral reefs due to various natural and anthropogenic causes results in the formation of algal reefs. The dead coral debris and boulders largely contribute to the sediments in the lagoon and island building processes. Similarly, they provide natural substrate for the growth of macrophytes, particularly seaweeds and seagrasses of great ecological importance and including a few species of commercial potential (Odum, 1971; Ott, 1980; Siddiqui, 1980; Ogden, 1988; Mann, 1988; More and Hudson, 1989; Jagtap, 1998). The seagrass beds from the study region were confined to the lagoon towards the northeast. However, ~98% of the total lagoon area, particularly towards the west and southwest, was totally devoid of corals, as well as macrophytes, except for the stray occurrence of a few algae. The storm beach, measuring about 0.96 km^2 towards the east of the island, also had scanty coral and macrophyte growth.

The coral-reef regions in general, and particularly in Lakshadweep Archipelagos, have been observed to be very productive and harbor large numbers of marine algae and dense seagrass beds (Hacket, 1977; Jagtap, 1987, 1996, 1998; Untawale and Jagtap, 1989; Bakus, 1993; Rodrigues et al., 1997; Jagtap and Untawale, 1999). However, the seaweed flora around Kadmat Island was represented by small numbers (23 spp.) and negligible quantities except for a few forms such as *Padina borgesenii, Acanthophora spicifera* and *Hypnea valentiae* during March (Table 3). Marine algae were mostly confined to the peripheral stretches along the reef flat towards the reef slope and fore reef, in association with the seagrass beds, and on the narrow patches of sand stones at the lower intertidal region along the shore. The intertidal and submerged reef regions harbored very limited algae such as *Turbinaria ornata* and *Halimeda* spp. The economically important species, such as *Gelidiella acerosa* and *Sargassum* spp., occurred on the reef flat of storm beach towards high-tide and low-tide mark respectively, while species of *Gracilaria* and *Hypnea* were restricted to the lagoon.

The poor representation of algal flora in the region could be attributed to their seasonal occurrence. Maximum species diversity and abundance of marine algae along the Indian coast generally occur during the postmonsoon (October-January) period. Species richness, diversity and percent cover of algae from Lakshadweep reefs have been reported to be three times lower during the premonsoon season compared to the postmonsoon months (Rodrigues, *et al.*, 1997). The total absence of algae from the reef region could also be attributed to intensive grazing by herbivores (Millon, 1982; Hay, 1985). Intensive herbivory is reported to consume 50–100% plant production over the coral reefs (Hatcher and Larkum, 1983; Carpenter, 1986). Coral reefs from Lakshadweep islands have been reported to be rich in herbivores among which reef fishes and sea urchins form the dominant grazers (Bakus *et al.*, 1993; Rodrigues *et al.*, 1997).

Major seagrass beds from India are mainly restricted to the lagoon regions from Lakshadweep, Andaman and Nicobar group of islands and the southeast coast of India (Jagtap, 1991). The seagrass flora comprised of 15 spp., of which 7 spp. occur in the Lakshadweep group of islands (Jagtap, 1987,1991, 1998). Varieties of marine algae grow in the seagrass beds as well as in epiphytic forms on seagrass blades and rhizomes (Jagtap, 1996, 1998). The seagrass bed from the Kadmat lagoon was observed to be patchy as were stretches along the shore. Dense meadow occurs towards the northwest region of the lagoon covering ~0.14 km^2 and exhibited marked zonation. Mostly sparse and small patches of *Thalassia hemprichii* occurred in the shallow sandy regions towards the fore reef, while the mid-lagoon deeper region (1.5–2.5 m) harbored mixed dense beds of *Thalassia hemprichii* and *Cymodocea rotundata*. The shallow region (0.5–1.5 m) towards land supports intensive growth of *Cymodocea rotundata*.

A similar kind of distribution trend has been reported from the other islands on Laccadive archipelagos (Jagtap and Untawale, 1993; Jagtap, 1998). The seagrass flora of Kadmat comprised of two spp and higher biomass (17–26 g m^{-2} dry weight) were recorded from the mixed zone in the mid-lagoonal area (Table 4). The drifted biomass of 195 g m^{-2} dry weight was recorded during March when the biomass of the standing crop was higher (26 g m^{-2} dry weight). The frequency of occurrence also increased from 20% to 70% during March, indicating the maximum abundance and biomass, and happens during premonsoon period because of higher wind speed (Fig. 2) causing disturbances in the sea state including lagoon waters. Earlier, (Jagtap and Inamdar, 1991) five species of seagrasses were recorded from the lagoons of Kadmat. It has been observed that the creeping kind and small-sized seagrasses, such as *Halophila* spp., commonly grow as pioneer species and form a suitable substratum for other larger-sized seagrasses to follow during the succession process (Birch and Birch, 1984; Jagtap, 1998). The absence of such species from Kadmat lagoon during this study might be due to out-competition by the existing species during succession. A considerable amount of seagrass biomass contributes towards the detrital food chain (Mann, 1988; Valiela et al., 1985). The organic carbon in the sediments, particularly from the seagrass beds, varied from 0.11 – 0.42% (Table 4). The benthic faunal population from the seagrass beds has been reported to be higher due to high organic carbon in the sediments (Ansari *et al*, 1991).

Coral reefs play a significant role in nutrient recycling and creating sedimentary environment (Macintyre *et al*., 1987; Ogden, 1988), which is most suitable for the establishment of seagrasses. Colonization and abundance of seagrass depend upon the nature of substratum and its thickness, the source, routes, and rates of sediment transport and its accumulation (Ziemann, 1972; Burrel and Setubel, 1977). The substratum in the lagoon of Kadmat was mostly sandy (94.8–97.95%) admixtured with trace amounts of silt and clay (Table 4). However, the sediment texture in non-seagrass regions in the lagoon was either compact or coarse, while in the seagrass beds and in the immediate vicinity it was comprised of well sorted fine sand with more thickness. The sediments from the lagoons of Lakshadweep islands are comprised of moderate-to-very well sorted sediments towards shore (Jagtap, 1998). Dense growth and abundance of *T. hemprichii* and *C. rotundata* in the mid- and landward region of the lagoon may be due to sufficient thickness of the substratum and well sorted and fine sediments which favor the seagrass establishment and growth (Ziemann, 1972).

The absence or poor growth of seagrasses towards fore reef, west and northwest regions of the lagoon could mainly be attributed to the compact nature, less thickness, and relatively unstable and coarse texture of the sediments, as reported elsewhere (Jagtap, 1998). Seagrass establishment enhances the sedimentation by decreasing speed of water movement and trapping sediments (Wood *et al*., 1969). Encrusting flora on seagrass blades, particularly diatoms, and epiphytic coralline algae, particularly *Melobesia* sp., form an additional source of lagoon sediments (Humm, 1964; Stockman *et al*., 1967) besides sedentary corals and coralline algae. It has been found that the epiphytic forms in a peak growth of seagrass contribute 7-52% of total seagrass biomass, mainly contributed by rhodophycean members (Jagtap, 1996, 1998). The calcareous algae, particularly *Halimeda* spp that are commonly associated with coral reefs and seagrass meadows, have been estimated to contribute almost 60% of lagoon sediments (Siddique, 1980) forming suitable substratum for seagrasses to establish.

The perennial sand-dune vegetation was observed to be more predominant along the southeast, southwest, northeast and northwest shores of Kadmat Island. The maximum of 39 spp. was recorded during the postmonsoon (November) period, of which 23 spp. were annual and 16 spp. were perennial (Table 5). The dominant perennial species were *Spinifix littoreas*, *Ipomea pes-caprae*, *Bidens biternata* and *Vernonia cinuea*. *Pemphis acidula* and *Scaveola sericea* were observed along the southwest and southeast regions just behind the fore-shore dunes. The average biomass of *S. littoreas* and *I. pes-caprae* in the northeast and southeast regions of the island were estimated to be 500 and 290 g m^{-2} (wet weight), respectively. So far, two species of *Pemphis* have been recorded from the Lakshadweep group of islands (Sivadas *et al.*, 1983; Jagtap, 1998). Species of *Pemphis* and *Scaveola* have been commonly reported from the islands of Maldives and Laccadive archipelagos and act as pioneer species on the newly formed islands (Hackett, 1977; Jagtap and Untawale, 1999). However, the pioneer sand-dune flora from Lakshadweep appears to be *Spinifix* and *Ipomea*.

The southernmost stabilized atoll of Maldives has been reported to be very dense in *Pemphis* and *Scaveola* forest in the backshore zones (Jagtap and Untawale, 1999). Sand-dune flora is of great importance in accumulating and binding the sediments and governing their movement. Lakshadweep islands are 1.5-2 m above sea level and mainly composed of sandstone and sand. Therefore, the natural sand-dune flora is of great importance to the island from the point of shore stabilization. However, sand-dune habitats around the island have been largely reclaimed for agricultural and urbanization purposes. The entire tourist complex towards the south has been developed by reclaiming sand-dune areas. Species such as *Scaveola, Pemphis* and *Thespesia* could form a potential source of fuel, as well as shore stabilizers, if managed on a sustainable basis.

The present studies revealed that the major biotic components of the reef around Kadmat Island are extremely poor compared with those of other islands of Lakshadweep (Untawale and Jagtap, 1984; Jagtap, 1987, 1991, 1996, 1998; Subharamaiah *et al.*, 1979; Kaliaperumal *et al.*, 1989; Pillai and Jasmine, 1990; Bakus *et al.*, 1993; Rodrigues *et al.*, 1997). Even the existing sand-dune flora from the island is patchy and under constant threat from anthropogenic removal, particularly for vegetable cultivation and construction. The absence and poor cover of corals from the various reef zones clearly indicate that they are turning into dead and detrital reefs. Offshore coral reefs protect islands from eroding by minimizing the impact of wave energy. Some Maldivian atolls, including the inhabited island of Kilisfaruhurra, have been submerged due to green-house effect and sea-level rise (Dixit, 1994). The healthy coral reefs may keep pace with sea-level rise and the continuing land-building process. Similarly, sand-dune flora, as well as seagrass meadows with their associate flora, help in stabilizing the shore besides enhancing the productivity of the reef ecosystem.

Considering constant global warming causing sea-level rise (Hoffmann, 1983), small island development programs, particularly those of the Lakshadweep group of islands which are in an emerging process, should be the top priority under the Coastal Zone Development Program (CZDP) for the "10^{th} five-year plan" of the country. The following suggestions could be of help in formulating CZDP for improving the health, sustainable utilization and protection of Lakshadweep reef ecosystems.

- Establishment of a community program for rejuvenating deteriorated reef by transplantation of corals.
- Cultivation and culture of commercially valuable marine organisms would provide job opportunities and additional income for the islanders. The cultivation of seaweeds, such as *Gracilaria edulis* and *Hypnea* spp, and raft and cage culture of fishes and prawns in the shallow water and lagoons and over the seagrass beds would be of great commercial importance. Similarly, the reef regions are the best grounds for growing commercially potential species of holothurians.
- Cultivation of seagrasses in the lagoon by transplantation may help in increasing productivity and in stabilizing the shore.
- Protection of the existing sand-dune regions and plantation of sand-dune flora, particularly species of *Pemphis, Scaveola* and *Thespesia,* on the berm and backshore zones. This would provide natural fuel, help arrest erosion and enhance stabilization process of the island.
- Long-term monitoring of reef environment would help in Natural Resource Accounting (NRA) of the region, which in turn would help in indicating improvement or decline in the quality of the environment.
- Coral reefs form potential sites for tourist industries because of their recreational, scenic and cultural importance. Recreational tourism has already been initiated at a few of the Lakshadweep islands including Kadmat. Overdevelopment and poor planning of small islands in the tropical ocean, particularly for tourism, have resulted in a major decline in the reef biota (Zea *et al.*, 1998). Therefore, very careful long-term planning should be considered for tourism development, particularly for small emerging islands of Lakshdweep.

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Table 1. Hydrological Characteristic Over the Coral Reef Region Around Kadmat Island

Parameters	Reef slope		Lagoon	
	November 1998	March 1999	November 1998	March 1999
Water Temperature (^0C)	28 - 28.5	28.5 - 29	28 - 28.5	29.5 - 30
Salinity (PSU)	34.17 - 34.86	34.99 - 35.08	34.32 - 34.86	34.32 - 34.37
Nitrite (μ mol l^{-1})	0.02 - 0.05	0.002 - 0.007	0.01 - 0.04	0 - 0.005
Nitrate (μ mol l^{-1})	0.72 - 1.36	0.12 - 0.33	0.076 - 0.14	0.03 - 0.22
Phosphate (μ mol l^{-1})	0.085 - 0.125	0.085 - 0.345	ND	ND - 0.02
pH	7.5 - 8.7	8.1 - 8.3	8.6 - 8.8	8.2 - 8.4
Dissolved Oxygen (ml l^{-1})	4.11- 4.84	4.17 - 4.93	-	4.29 - 6.57
Phytoplankton count (no x 10^3 cells l^{-1})	0 - 13	0 - 80	3 - 48	0 - 10

*ND – Not Detectable

Table 2. Distribution of Phytoplankton Species (no x 10^3 cells l^{-1}) in the Reef Slope and Lagoon Water of Kadmat Island

	Reef slope		Lagoon	
	November 1998	March 1999	November 1998	March 1999
Bacillariophyceae				
Achnanthes longipes C. Ag.	-	-	3	-
Asterionella japonica Cleve	3	-	6	-
Diploneis weissfloggi (A.Schmidt) Cleve	-	-	3	-
Gyrosigma sp.	-	-	3	-
Lephocylindrus danicus Cleve	10	-	-	-
Navicula hennedyii W. Smith	-	-	3	-
Pinnularia sp.	3	-	3	-
Thalossionema nitzschioides Grunow	-	-	-	1
Dinoflagellata				
Prorocentrum gracile Schutt	-	-	-	2
P. micans Ehrenberg	-	-	-	1
Cyanophyceae				
Trichodesmium sp.	-	80	30	-

Table 3. Algal Species Observed from Kadmat Island, Lakshadweep During Post-monsoon and Pre-monsoon Period

	Lagoon		Intertidal	
	November 1998	March 1999	November 1998	March 1999
Chlorophyta				
Boergesenia forbesii (Harvey) Feldmann	+	+	+	+
Cladophora sp.	-	+	+	+
Enteromorpha compressa (Linn.) Nees	+	-	+	+
E. intestinalis (Linn.) Nees	+	-	+	+
Halimeda gracilis Harvey ex J. Agardh	+++	+++	+	+
Halimeda sp.	++	++	+	+
Ulva lactuca Linn.	+	-	+	+
Phaeophyta				
Dictyota bartayresiana Lamouroux	+	+	+	+
Padina boergesenii Allender & Kraft	++	++	++	+++
Sargassum duplicatum J. Agardh	+	+	+	+
Turbinaria ornata (Turner) J. Agardh	++	++	+	+
Rhodophyta				
Acanthophora spicifera (Vahl.) Boergesen	+	+	+	+++
Ceratodictyon spongiosum Zanardini	+	-	+	+
Ceramium sp.	+	-	+	+
Gelidiella acerosa (Forsskal) Feldmann et Hamel	++	++	+	+
Gracilaria edulis (J. Ag.) Silva	++	++	+	+
G. variabilis (Grev.) Schmitz	+	-	+	+
Hypnea pannosa J. Agardh	+	+	+	+
H. valentiae (Turner) Montagne	+	+	+	+
Jania capillaceae Harvey	+	+	++	+++
Laurencia papillosa (C. Agardh) Greville	+	+	+	+
Laurencia sp.	-	+	-	++
Polysiphonia sp.	+	-	+	-

+++ Dominant ++ Common + Less common - absent

Table 4. Structure of Seagrass Meadow from Kadmat Island, Lakshadweep

	November 1998			March 1999		
	LFR	MLA	LAL	LFR	MLA	LAL
Depth (m)	1 - 1.5	1.5 - 2.5	0 - 0.5	1 - 1.5	1.5 - 2.5	0 – 0.5
Substratum	S+ CD	S	S	S + CD	S	S
Thickness of substratum (cm)	>2.5	5 - 10	>10	>2.5	5 - 10	>10
Sand % (range)	97.1 - 97.95	97.8 - 98	94.8 - 97.6	-	-	-
Silt % (range)	0.23 - 2.8	1.67 - 1.82	2.02 - 2.48	-	-	-
Clay % (range)	0.1 - 2.03	0.32 - 0.42	0.41 - 2.74	-	-	-
Organic Carbon (%)	0.11 - 0.27	0.21 - 0.23	0.36 - 0.42	1.08 - 1.4	1.52 - 1.96	0.92 – 1
Nature of seagrass beds	SP	LP	BS	SP	LP	BS
Quantitative Aspect of Seagrasses						
Number of seagrass species	1	2	1	1	2	2
Thalassia hemprichii (Ehrenb.)						
% FO	+	+	A	+	++	A
Biomass (gm^{-2} dry wt.)	N	5	NA	N	7.5	NA
Cymodocea rotundata (Ehrenb.) Hempr. Ex. Aschers						
% FO	A	+	++	-	++	+++
Biomass (gm^{-2} dry wt.)	NA	15	17	-	23	26
Total biomass (gm^{-2} dry wt.)	NA	20	17	N	30.5	26
Average total drifted biomass (gm^{-2} dry wt.)	NA	NA	N	NA	NA	195

Legends: N = Negligible, NA = Not Applicable, SP = Small patches, LP = Large patches, BS = Broken stretches, S = Sandy, CD = Coral debris, A = Absent, + = Frequency of occurrence 10 – 20%, ++ = Frequency of occurrence 50– 70%, +++ = Frequency of occurrence >70%, LFR – Lagoon towards fore reef, MLA – Mid-lagoon region, LAL – Lagoon towards land

Table 5. Sand-Dune Flora from Kadmat Island (Lakshadweep)

	November 1998	March 1999
Acalypha indica, Linn.	+++	-
Aerua lanata, Juss.	+++	-
Bidens biternata (Lour.) Merr. & Sherff	+++	+++
Boerhavia diffusa, Linn.	+++	-
Bonneria sp.	+	-
Corchorus aestuans Hb. Madr.	+++	-
Crotalaria pallida, Klotz.	+++	-
Cucumis sp.	++	-
Dactyloctenium aegytiacum, Willd.	++	++
Desmodium triflorum, DC.	+	+
Eclipta alba Haask.	++	++
Eragrostis pilosa, Beauv.	++	++
Euphorbia hirta, Linn.	++	-
Fimbristylis polytrichoides, Vahl.	++	++
Hyptis suaveolens, Poit.	++	-
Indigofera linnaei, Ali	++	-
Indigofera tinctoria, Linn.	+++	-
Ipomea pes-caprae, (Linn.) Sweet.	+++	+++
Ischaemum sp.	+	-
Lapartea interrupta (Linn.) Chew.	+++	-
Launaea fallax (Jaub. & Spach) Kuntze.	++	++
Micrococca mercurialis, Benth.	+++	-
Oldenlandia herbacea, Roxb.	+	+
Oplisemenus burmannil, Beauv.	+++	-

Pemphis acidula, Forst.	+++	+
Phyllanthus niruri, Linn.	++	-
Portulaca tyberosa, Roxb.	+	-
Pouzolzia zeylanica, Benn.	+	-
Pycreus sp.	++	-
Scaevola sericea Vahl.	+	+
Sida cordata, (Burm. f.) Borssum	+++	-
Spinifex littoreus Merrill	+++	+++
Synedrella nodiflora, Gaertn.	+	-
Tephrosia pumila, Pers.	+++	-
Tephrosia strigosa (Dalz.) Santapau & Maheshwari	+++	-
Tephrosia sp.	+	+
Thespesia populnea, Soland.	+	+
Tridax procumbens, Linn.	+++	++
Vernonia cinerea (Linn.) Less	+++	+++

Legends: +++ = Dominant (Frequency of occurrence >50%)
++ = Common (Frequency of occurrence 30 – 50%)
+ = Less common (Frequency of occurrence <30%)
- = Absent

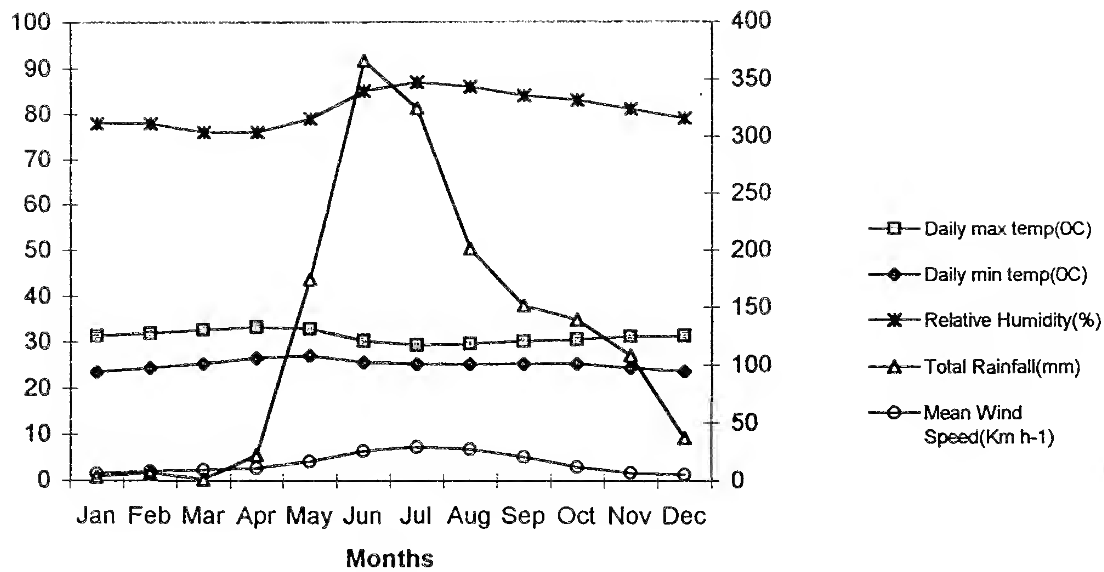


Figure 2. Climatological data (average from 1950–1980) for Amini Divi Island in the vicinity of Kadmat Island.

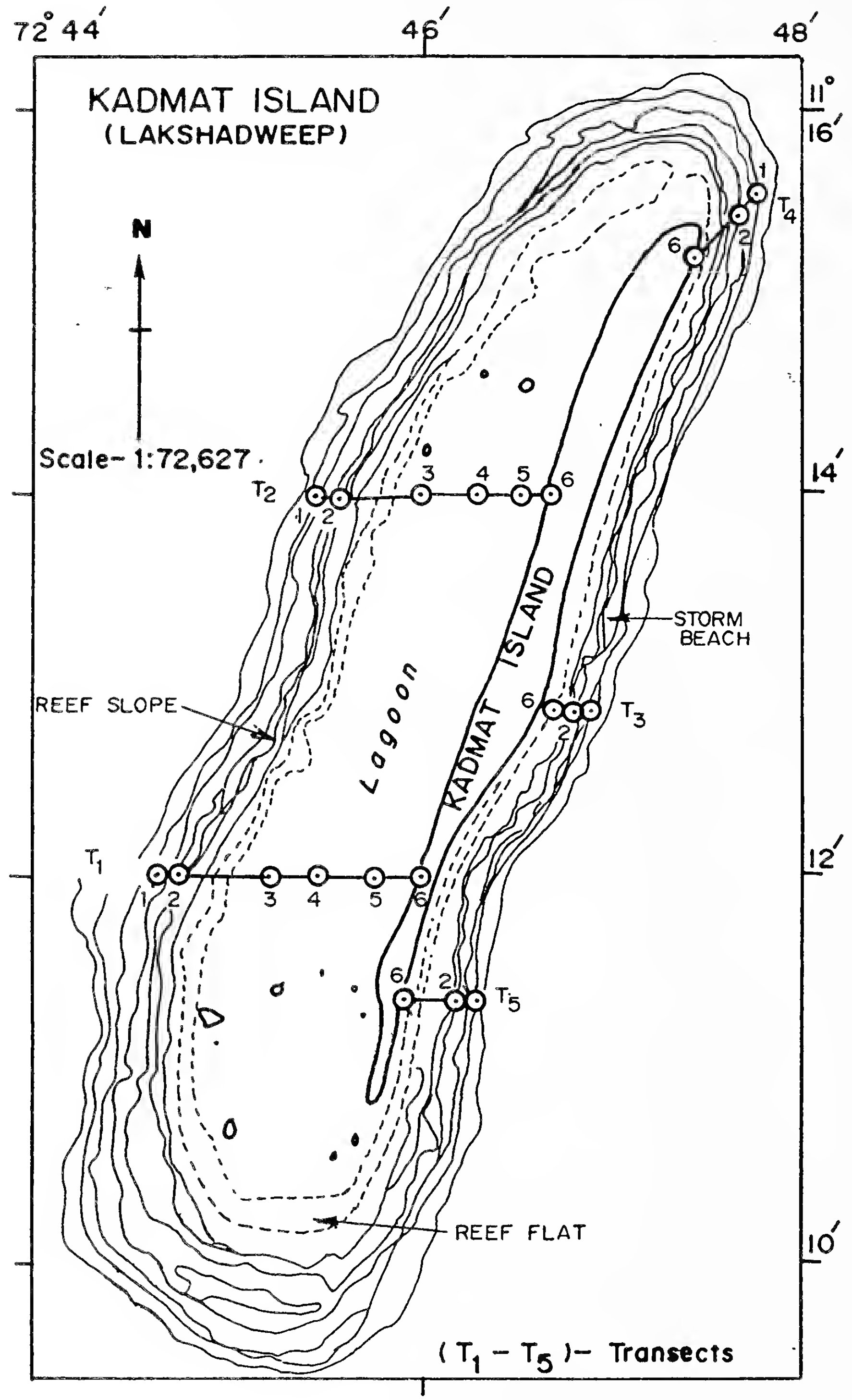


Figure 3. Geographical positions of sampling locations around Kadmat Island (Lakshadweep).

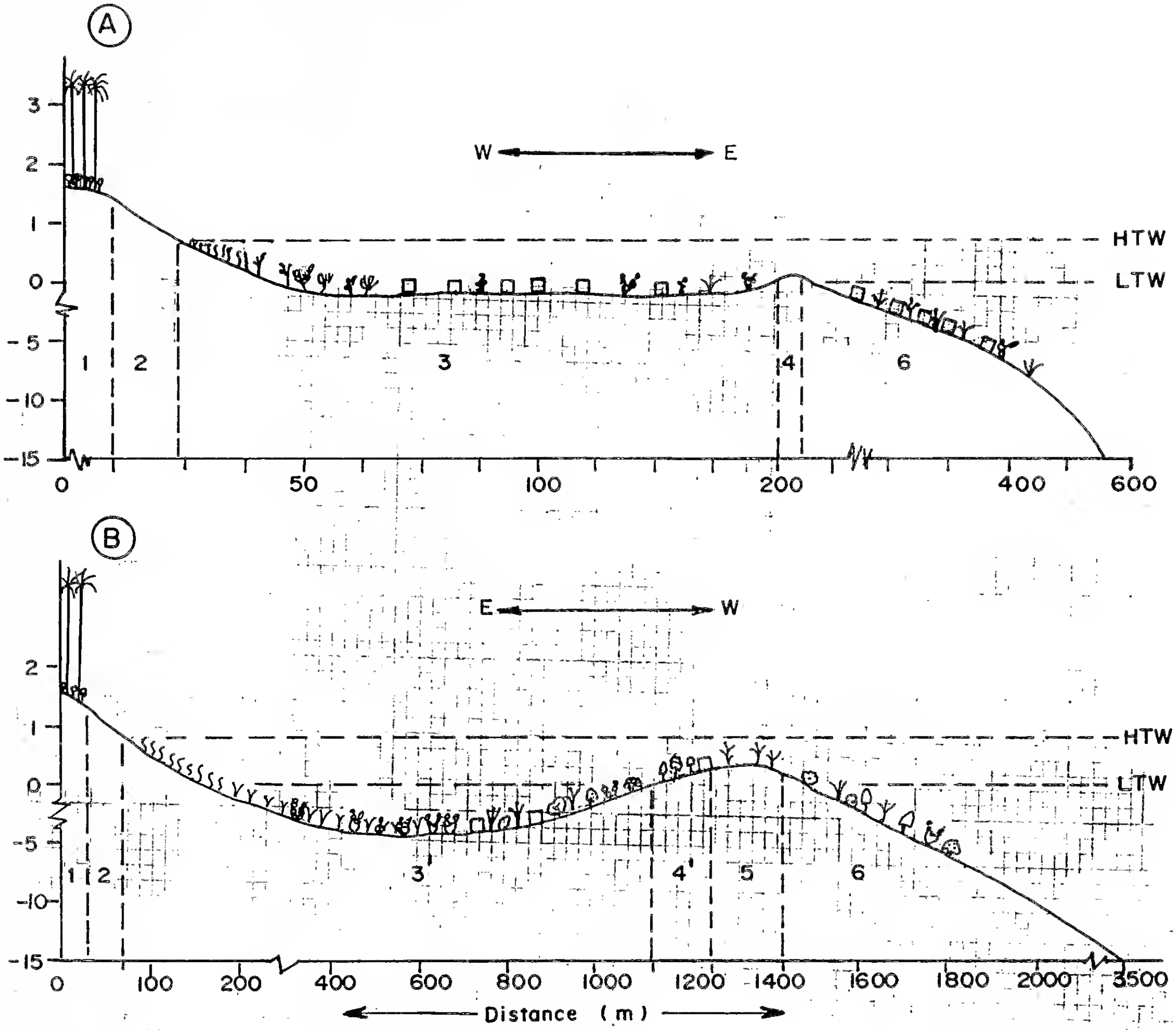
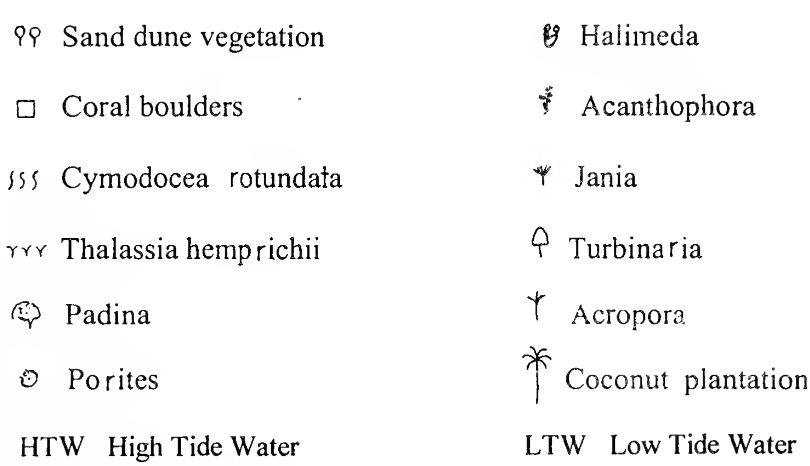


Figure 4A & B. Schematic representation of biotic habitats in the various zones of coral reef of Kadmat Island of Lakshadweep.

1. Island 2. Beach 3. Storm Beach 3'. Lagoon 4.Algal ridge 4'. Fore reef 5. Reef flat 6. Reef slope



ATOLL RESEARCH BULLETIN

NO. 507

CORAL SPECIES DIVERSITY AND ENVIRONMENTAL FACTORS IN THE ARABIAN GULF AND THE GULF OF OMAN: A COMPARISON TO THE INDO-PACIFIC REGION

BY

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ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
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Figure 1. Map of the Arabian Gulf and Gulf of Oman

CORAL SPECIES DIVERSITY AND ENVIRONMENTAL FACTORS IN THE ARABIAN GULF AND THE GULF OF OMAN: A COMPARISON TO THE INDO-PACIFIC REGION

BY

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ABSTRACT

The reef corals of the Arabian Gulf and the Gulf of Oman comprise a substantially reduced subset of the Indo-Pacific coral fauna. Only about 10% of the species that occur in the Indo-Pacific are found in the Gulf region and community species compositions are substantially altered from assemblages that normally dominate Indo-Pacific reefs. For example, the highly diverse family Acroporidae is under-represented in the Gulf region while the families Dendrophylliidae, Faviidae and Siderastreidae are over-represented. Some of this regional uniqueness may be due to geographic isolation but it probably is primarily a result of physical and environmental conditions that are among the most extreme and stressful in the world and act to limit the diversity of corals that o ccur i n t he region. S eawater t emperatures i n t he A rabian Gulf h ave h istorically ranged up to 25°C at coral study sites, approximately 6°C above and below the temperatures traditionally considered limiting to coral survival. Short-term temperature fluctuations in the Gulf of Oman due to upwelling can range up to 8°C in a day without visible effect on resident corals. Salinities survived by Gulf corals range up to 50 parts per thousand (ppt), about 15 ppt higher than normal ocean salinity in the Indo-Pacific. Other factors, such as relatively high turbidity and competition with macroalgae favored by low winter water temperatures, may combine with temperature and salinity to limit the development of diverse coral populations in the Gulf. The implications of the potential contribution of this region's reservoir of hardy coral phenotypes to the Indo-Pacific coral fauna during an era of general worldwide environmental stress are discussed.

INTRODUCTION

"*...reef corals flourish best in the range 25°-29°C...within a salinity range of 34-36 parts per thousand....However, in the Abu Dhabi area coral reefs are growing under conditions of elevated temperature and salinity. The only indication of extreme conditions is the reduction in the number of genera.*" Kinsman (1964).

This landmark paper by D.J.J. Kinsman represented a major paradigm shift for coral biologists in their thinking about the tolerances of corals to physical stresses. Corals had been traditionally considered to be highly stenotopic organisms with very limited endurance of changes in temperature, salinity, turbidity and nutrient

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concentrations typical of clear, oligotrophic open ocean water (Dana, 1843, 1872; Mayer, 1914, 1915; Vaughan, 1916, 1918; Edmondson, 1928; Wells, 1957). Water temperature was considered to be especially limiting and corals were believed to live close to fixed upper temperature limits usually considered to be around 30°C and lower limits of around 16°C, with little chance of survival outside of this limited temperature range (Mayer, 1914, 1918; Edmondson, 1928).

Kinsman's observations along the Abu Dhabi coastline in the 1960s indicated that tolerances of Arabian Gulf corals well exceeded such limits. He found 11 species surviving temperatures up to 36°C and in salinities up to 48‰, substantially expanding the temperature and salinity environments previously considered to limit coral survival. With the increased opportunities for making reef surveys and conducting research in the Arabian Gulf that have occurred in the past 40 years, our knowledge of the environmental conditions of this unique area and the number of species that occur there has greatly increased. The following report summarizes information for the coral communities that occur in the Arabian Gulf region and discusses the principal factors that define and limit these communities. These findings are compared to conditions that generally apply to corals and reefs in the Indo-Pacific region, and the implications of the generally more hardy Arabian Gulf corals in the context of Pacific-wide coral bleaching events will be discussed

COMPARISON OF GULF CORAL DIVERSITY TO THE INDO-PACIFIC

The coral community of the Gulf is a subset of the great Indo-Pacific tropical faunas, which stretch across the Pacific and Indian Oceans from the west coast of Central and South America to the east coast of Africa. The pattern of distribution of numbers of coral genera indicated for this vast region (Veron, 1993) shows maximum numbers of genera and species in the triangle enclosed by the Philippines, Indonesia and New Guinea with numbers of genera decreasing in all directions to lows of less than 10 east of Hawaii, along Japan, south Australia and South Africa. Numbers of genera in the Gulf region are shown in Figure 2 in Veron (1993) to be >20 in both the Arabian Gulf and the Gulf of Oman with latest figures of 28 and 33 genera, respectively (Table 1). By comparison, estimates of numbers of coral genera in the Red Sea range >75 including 57 reef forming genera (Sheppard and Sheppard, 1991), substantially more than the number for the Gulf region.

Greater detail on the composition and diversity of zooxanthellate coral genera and species in the Gulf region (Figure 1) are provided in Table 1 and these data are compared with similar information for the entire Indo-Pacific region from Cairns (1999). The Cairns (1999) values unite numerous synonymies from previous estimates of taxonomic listings and therefore represent a conservative estimate of coral diversity for the Indo-Pacific region. The estimates for the Arabian Gulf and the Gulf of Oman are synthesized from many sources throughout the Gulf region. Of the 656 species among 109 genera of zooxanthellate corals for the Indo-Pacific listed by Cairns (1999), only about 10%, or 68 species among 28 genera, occur in the Arabian Gulf and 68 species among 33 genera in

Table 1. Numbers of genera, species and numbers of species in a family as a percent of all species found (% Total) in the Indo-Pacific Region, Arabian Gulf and Gulf of Oman.

	Indo-Pacific[1]			Arabian Gulf[2,3,4,5,6,7]			Gulf of Oman[3,7,8,9,10]		
Taxa	Genera	Species	% Total	Genera	Species	% Total	Genera	Species	% Total
All Families	109	656		28	68		33	68	
Acroporidae	4	199	30%	2	11	16%	3	10	15%
Fungiidae	11	44	7%	1	1	1%	1	1	1%
Siderastreidae	6	27	4%	5	8	12%	5	7	10%
Faviidae	24	103	16%	8	21	31%	4	20	29%
Dendrophylliidae	3	15	2%	2	4	6%	3	4	6%

[1] Cairns (1999)
[2] Burchard (1979)
[3] Sheppard and Sheppard (1991)
[4] Hodgson and Carpenter (1995)
[5] Carpenter et al (1996)
[6] Riegl (1999)
[7] Sheppard (1987)
[8] Sheppard and Salm (1988)
[9] Glynn 1993
[10] Coles (1996)

the Gulf of Oman. Within the Gulf region the distribution of species among families is quite anomalous compared to the Indo-Pacific as a whole. The family Acroporidae, which is the most diverse in the Indo-Pacific with nearly 200 species or 30% of all species reported, has only 10-11 species in the Gulf region or about 15% of the total species reported. A similar reduction in species is shown for Fungiidae in the Gulf with only one species reported (1% of total) compared to 44 species (7% of total) for the Indo-Pacific. By contrast, the families Siderastreidae, Faviidae and Dendrophylliidae have percentages of total species two to three times greater in the Gulf region than in the Indo-Pacific (Table 1).

Within the Arabian Gulf (Table 2), there are moderate geographic variations in numbers of species and species types found in various areas. Maximum numbers of species reported thus far have been in the central Gulf along the coasts of Saudi Arabia and Bahrain (Burchard, 1979; Sheppard, 1988) where about 40 species have been reported. Reported numbers of species decrease going north and south with about 35 species reported for both Kuwait (Hodgson and Carpenter, 1995) and the UAE (Reigl, 1999). By comparison, in the Gulf of Oman (Table 2), 68 species have been reported for the Capital Area of Muscat and Daymaniat Islands alone (Sheppard and Salm, 1988; Coles, 1996) equal to the total number for the entire Gulf inside of the Strait of Hormuz. The differences in species occurrence within the Gulf probably correspond to different environmental factors affecting corals in various areas and they may also relate to greater habitat diversity available for coral settlement and growth on the reefs around the island areas offshore of Saudi Arabia and Bahrain.

Table 2. Gulf region variations and contrasts in coral species numbers.

Area	Species	Source
Kuwait	35	Hodgson & Carpenter (1995)
Saudi Arabia	41	Burchard (1979)
Bahrain	40	Sheppard (1988)
Dubai, UAE	34	Reigl (1999)
Gulf of Oman	68	Sheppard & Salm (1988)Coles (1996)

Disjunct distributions of many genera and species contribute to the differences in species numbers within the Gulf indicated above. Species of the acroporid genus *Montipora* and the poritid genus *Goniopora* are quite common in the waters of the northern Gulf from Saudi Arabia to Kuwait but are not reported from along the coast of the UAE. Nor has any fungiid genus or species been reported along the UAE coast although fungiids rarely have been found further north (Burchard, 1979; Hodgson and Carpenter, 1995). By contrast, Reigl (1999) found two new *Acropora*, three *Porites* and three faviid species not previously reported in the Gulf off Dubai in the UAE. Surprisingly for an area so isolated, only three endemic coral species have been listed for the Arabian Gulf, *Acropora arabensis* Hodgson and Carpenter, 1995, *Acropora* *downingi* Wallace, 1999 and *Porites harrisoni* Veron, 2000, which is the finger *Porites* common in the Arabian region that was formerly called *Porites compressa*. Two endemic species have been listed for the Gulf of Oman. *Acanthastrea maxima* Sheppard and Salm, 1988 was first collected from the Gulf of Oman and has since been found in the northern Gulf off Kuwait (Hodgson and Carpenter, 1995; Carpenter et al., 1997). *Parasimplastrea simplicitexta,* previously considered to be a newly discovered "living fossil" (Sheppard and Salm, 1988; Coles, 1996), has also recently been renamed *Parasimplastrea sheppardi* Veron, 2000.

POTENTIAL CAUSES OF LIMITED GULF CORAL DIVERSITY

With only about 10% of Indo-Pacific coral species occurring in the Arabian Gulf, some combination of factors has limited the recruitment, settlement, survival and growth of reef corals in the region, eliminating many species and perhaps favoring a few that are adapted to the uniquely harsh conditions of the Gulf. Potential limiting factors include:

- temperature extremes above and/or below usual coral tolerance limits
- high salinities
- macroalgal competition
- past and present isolation of the Arabian Gulf from the Indo-Pacific
- oil production and pollution

Dealing with these in reverse order, there is little indication that oil production and pollution have substantially impacted corals resident in the Gulf region despite the vast production and transport of petroleum that has been underway for over 50 years. During the last two decades two extensive oil spills have occurred in the northern Arabian Gulf without apparent effect on reef corals in the area. The bombing of the Nowruz oil platforms in 1983 during the Iran-Iraq war caused the release of an estimated 500,000 barrels into the northern Gulf (Linden et al., 1990), one of the largest spills that had been recorded up to that time. No impact or change that could be related to this spill was detected by monitoring of reef corals at Jana, Juryad, Karan and Kurayn Islands, Manifa, or Tarut Bay during studies conducted from 1985 to 1987 (Coles et al., 1988). The Nowruz spill was relatively minor compared to the release of over 10 million barrels of oil from three oil terminals and a number of tankers near Mina al-Ahmadi, Kuwait in January 1991 at the end of the Gulf War (Sadiq and McCain, 1993). No indication of oil pollution or impact on corals from this series of oil spills was detected on reef surveys around three islands off the coast of Kuwait in July 1991 (Downing, 1991, 1992), off Saudi Arabia in December 1991-January 1992 (Jones and Richmond, 1992; McCain et al., 1992), or on reefs from Bahrain to Kuwait in May 1992 (Fadlallah et al., 1993). Raw petroleum's most toxic low molecular weight compounds rapidly evaporate to the atmosphere and impacts of oil slicks act primarily at the water surface, where the major impact on corals would be on coral planulae before settlement. It is likely that oil spills are less toxic to adult corals in the Gulf than usually assumed, unless the oil contamination is continuous (Guzman et al., 1991; Loya, 1975) or is brought into direct contact with coral surfaces (Johannes et al., 1972).

The entrance to the Gulf at the Strait of Hormuz is only about 50 km wide, restricting circulation of water to the Gulf from the Arabian Sea. During the last glacial period at about 17,000 years ago sea level lowering reduced water in the Gulf to a minimum and it was largely a dry basin with only a small area of sea water extending in from the Gulf of Oman (Sheppard et al., 1992). All coral settlement and growth in the Gulf therefore has occurred since the beginning of the present interglacial period about 15,000 years ago. However, it is unlikely that isolation has been a primary determinant of the limited species diversity in the Arabian Gulf since the same or even greater isolation has occurred in the Red Sea. Sheppard and Sheppard (1991) report over 180 species of corals to occur in the Red Sea where coral species diversity is the highest of any area in the western Indian Ocean (Veron, 1993). Since the Red Sea has a sill at its entrance, it is likely that it was cut off from the Indian Ocean during the last glacial period and became hypersaline, prohibiting coral survival until sea level rose high enough to allow free exchange of seawater (Sheppard et al., 1992). Although seasonal northward blowing winds drive surface water into the Red Sea more than is the case for the Gulf, surface circulation in both water bodies is primarily driven by excess net evaporation over precipitation which results in net inflow of surface water for both. The resulting turnover time is approximately 3 to 5.5 years in the Gulf compared to about 200 years for the Red Sea (Sheppard et al., 1992), probably due to the much lower total volume of the Gulf. This indicates that the Arabian Gulf has ample exchange with the Indian Ocean via the Gulf of Oman, and that the much more limited diversity of corals within the Gulf is probably due to factors other than isolation.

Competition with macroalgae has been proposed to be a primary limiting factor to reef corals on high latitude reefs (Johannes et al., 1983) that may exceed in importance the restrictive influences of low temperatures. Seasonal blooms of macroalgae which dominate reef surfaces do occur during the winter in the Arabian Gulf (McCain et al., 1984; Coles, 1988; Coles and Fadlallah, 1991) and along the coast of Oman from Dhofar to Ras al Hadd during summer upwelling when water temperatures reach 18°C or lower (Sheppard et al., 1992). In the northern Arabian Gulf winter extensive growths of macroalgae such as *Sargassum* and *Colpomenia* may proliferate and overgrow corals to the point that the coral surfaces are invisible from above (McCain et al., 1984; Coles, 1988; Sheppard et al, 1992). After return of summer temperatures starting in April, the algae rapidly disintegrate and disappear, leaving reef corals, primarily *Porites harrisoni,* with no apparent tissue damage as the dominant benthic form. Live coral coverage was not negatively affected by seasonal algal overgrowth during monitoring from 1985 to 1987 when total coral coverage ranged up to 75% and algal coverage up to 74% in different seasons (Coles, 1988). A similar phenomenon occurs in coral areas along the southeast Oman coast during summer northeast monsoons, except that the dominant algae are species of *Sargosiopsis zanadini* and the kelp, *Eklonia radiata* which begin appearing in about May during the seasonal low temperatures and high nutrients caused by upwelling. The algae then disappear by October with the after the end of the monsoon (Barratt et al., 1988; Sheppard et al., 1992). Thus seasonal low temperature is likely a primary factor limiting corals through both direct influences on coral life processes, and indirectly through competition by macroalgae, the other dominant potential occupant of the benthic habitat.

The Arabian Gulf, along with the Red Sea and certain areas off Western Australia, is one of the few areas in the world where corals occur in a region of elevated salinity (Coles and Jokiel, 1992). Restriction by the narrow opening of the Strait of Hormuz, high surface evaporation and minimal freshwater inflow other than from the Tigris-Euphrates River result in the salinity of the Arabian Gulf averaging around 42 ppt in open water (John et al., 1990). Salinity further increases going southward along the Saudi Arabian coastline to an average greater than 50 ppt in open water and increases to 70 ppt in bays in the Gulf of Salwah, (Coles and McCain, 1990; John, et al., 1990). The maximum salinity reported to be survived by reef corals along the Saudi Arabian coast is 46 ppt (Coles, 1988), but Kinsman (1964) reported massive *Porites* in Abu Dhabi waters with salinity up to 48 ppt. Sheppard (1988) listed three species of corals surviving salinities of 48-50 ppt off the coast of Bahrain and found a decrease of approximately one species of corals with each ppt increase in salinity from 41-50 ppt.

Table 3. Comparison of coral salinity limits (from Coles 1993).

Location	Ambient Range (°/oo)	Tolerance Range(°/oo) Upper	Lower
Atlantic-Pacific	35-37	40-45	15-20
Arabian Gulf	40-42	47-49	20-23

Corals dominant in the Gulf's high salinity environment have been tested for their upper and lower salinity tolerances and compared with corals from more typically oceanic conditions (Coles, 1988). Twenty-day exposures to salinities above and below ambient levels for *Porites* species in the Arabian Gulf, Hawaii and Florida (Table 3) indicated that the upper salinity tolerance limits of Gulf *Porites* is about 5 °/oo higher than the Porites from Hawaii or Florida. This suggests an upward shift in upper salinity tolerance limits by Gulf corals that corresponds closely to the increased salinity of ambient Gulf water above usual oceanic conditions. These comparisons included one species, previously identified as *Porites compressa* in both Hawaii and the Arabian Gulf (Coles and Fadlallah, 1991; Hodgson and Carpenter, 1995; Coles, 1988, Carpenter et al., 1997), now renamed *Porites harrisoni* in the Gulf and Red Sea regions (Veron, 2000). An attempt to acclimate *P. harrisoni* from the Gulf to higher salinities over a 25-day period did not result in increasing the coral's tolerance above 49 °/oo. However, the lower salinity tolerance limit of this species was experimentally reduced to about the lower tolerance limit of Hawaiian *Porites compressa* by gradually reducing the salinity environment of Arabian *P. harrisoni* over a period of 35 days (Coles, 1988).

These results and observations suggest that the elevated salinity of the Arabian Gulf is an important limiting factor in determining the composition of the resident coral community and that the upper limit for coral survival is about 50 ppt. The decreasing numbers of coral species that occur with increasing salinity and the relatively few species that occur overall suggest that salinity tolerance has been a major factor in limiting the coral species diversity of reef corals within the Gulf.

Table 4. Seawater temperature ranges reported for high latitude coral reefs (from Coles and Fadlallah 1991).

			Temperature (°C)		
Location	Lat.	Long.	Min.	Max.	Range
Saudi Arabia	27° N	50°E	11.4	36.2	24.8
Qatar	25° N	51°E	14.1	36.0	21.9
Abu Dhabi	24° N	54°E	16.0	36.0	20.0
Florida	25° N	80°W	13.3	32.8	19.5
Heron Island	23° S	152°E	16.0	35.0	19.0
Kuwait	29° N	48°E	13.2	31.5	18.3
Japan	35° N	140°E	18.0	29.5	16.5
Abrolhos Is.	29° S	113°E	17.0	28.0	11.0
Midway Is.	28° N	177°W	18.2	28.3	10.6
Gulf of Aqaba	29° N	35°E	20.0	28.0	6.0

In addition to elevated salinity, the temperature environment of the Gulf region presents one of harshest challenges in the world to resident corals. Table 4 indicates regions of high seawater temperature ranges where corals and reefs occur. Locations in the Gulf have the highest ranges with reported values for the Saudi Arabian coastline ranging about 11 to 36°C, or nearly 25°C, and Qatar and Abu Dhabi ranging 20°C or more. By contrast, temperature environments more typical of tropical and subtropical areas are shown in Figure 2. In the tropics, as shown for Enewetak in the Marshall Islands, annual temperature extremes range only about 26-30°C, while in Hawaii, the range is about 21-27°C. Even a difference as small as this between ambient temperature ranges has been shown to result in differences in coral temperature tolerance (Coles et al., 1976) that are closely linked with ambient conditions. Corals at Enewetak survived upper stress temperatures about 2°C higher than congeners in Hawaii, a difference closely corresponding to the 2°C difference in summer ambient sea temperatures between the two areas. In both areas, continuous increments of 1-2°C above ambient annual maximum temperature induced loss of zooxanthellae and pigmentation (bleaching), and 3-4°C above annual ambient maximum was lethal after exposure of a few days.

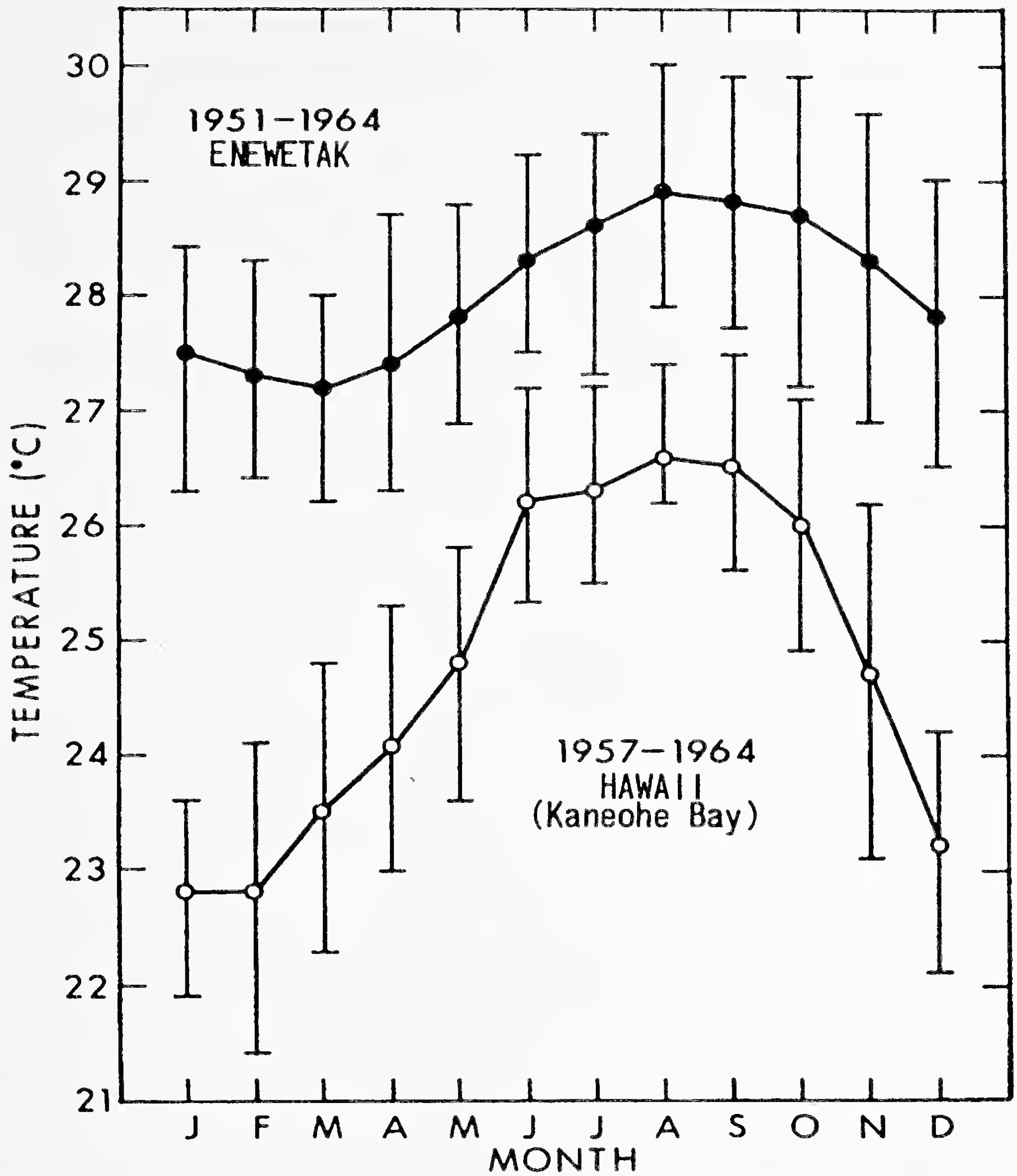

Figure 2. Annual seawater temperatures for Kaneohe Bay, Oahu, Hawaii and Enewetak Atoll, Marshall Islands. Bars indicate upper and lower monthly mean maxima and minima (from Coles et al., 1976).

In contrast to upper temperature limits of 29 to 31°C that apply to corals in most tropical and subtropical regions, reef corals in the Arabian Gulf routinely live in summer temperatures of 32-33°C and may survive up to 35°C for limited periods of time. Kinsman (1964) reported annual water temperatures of up to 40°C at Abu Dhabi where corals occurred and where dominated by *Acropora*, normally considered a temperature sensitive genus. Coles (1988) reported temperatures in Tarut Bay, Saudi Arabia of up to 35-36°C without visible effects on corals, and Sheppard (1988) reported August temperatures over 35°C where *Porites harrisoni (*listed as *P. nodifera)* thrives and forms reefs off Bahrain. Subsequent observers in the Gulf have extended these observations to continuous measurements which indicate that the maximum temperature that can be tolerated by corals in the Gulf for any substantial period of time is around 35°C. Temperatures exceeding 35°C along Saudi Arabia (Fadlallah and Lindo, in Wilkinson, 1998), Bahrain (Uwate in Wilkinson, 1998; Wilkinson, 2000), and the UAE (George and John, 1999; Riegl, 1999) for weeks in 1996 and 1998 resulted in extensive bleaching of all coral species, followed by death of table *Acropora* and recovery of *Porites* species.

Remarkably, temperature tolerance has been extended at the lower end of the tolerance range for corals in the Arabian Gulf as well, probably through adaptation to periodic cold exposures. Annual temperatures do not normally drop below 26°C in the tropics and 21°C in the subtropics (Figure 2) and coral reefs have been traditionally considered to be restricted from areas where temperatures decrease below 18°C. A lower temperature limit of 18°C for coral feeding has long been considered to restrict long term coral survival (Mayer, 1915; Edmondson, 1928), and more recent studies have indicated that corals in Hawaii survive only two weeks below 18°C (Jokiel and Coles, 1977) and that metabolic activity for Australian corals ceases below this temperature (Crossland, 1984).

Corals in the Arabian Gulf withstand temperatures well below these traditionally accepted lower limits for extended periods. Shinn (1976) observed substantial recovery of *Acropora* off Qatar two-and-a-half years after temperatures estimated at 13°C killed all corals in the area. Downing (1985) stated temperatures below 15°C as likely to be encountered in coral areas off Kuwait over several days or weeks, and temperatures at Kubbar (Island) to be as low as 13.2°C (Downing, 1992). Figure 3 shows the

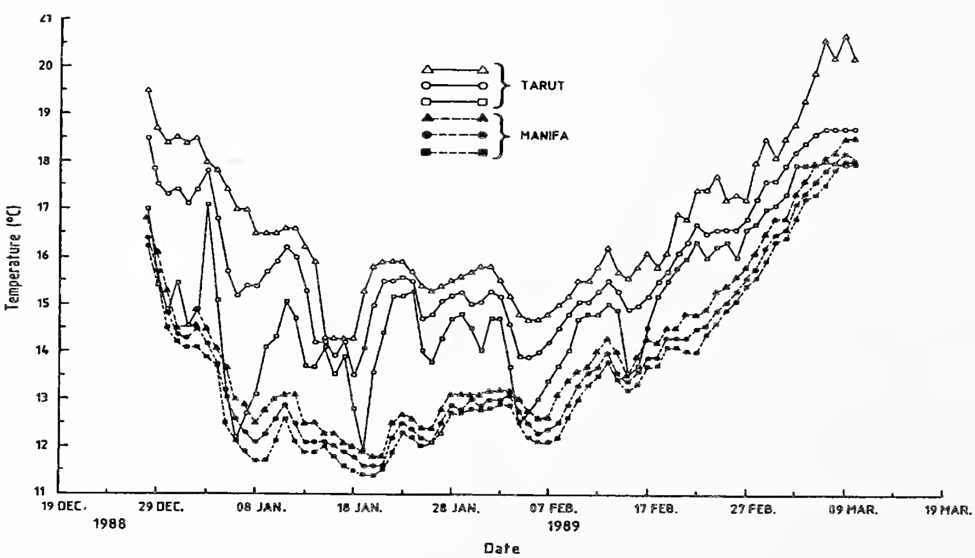

Figure 3. Daily mean, maximum and minimum temperatures based on hourly averages at Manifa (2 m) and Tarut Bay (1 m), Saudi Arabia December 1988 – March 1989 (from Coles and Fadlallah, 1991).

seawater temperatures that occurred on reefs of Saudi Arabia during a cold event in December 1988 to March 1989 when mean daily temperatures were as low as 13-14°C (Coles and Fadlallah, 1991). Minimum daily temperatures at fell below 11.5°C at 2.5 m depth on four consecutive days the northern site (Manifa) and below 12.5°C at 1.5 m depth at the southern site (Tarut B ay). Temperatures did not rise above 16°C for 62 days at the Manifa site or for 35 days at the Tarut Bay site. Only nominal stress symptoms and no mortality were observed for corals at the Tarut Bay reef. In contrast, extensive mortality occurred at the Manifa reef, where all *Acropora* and most *Platygyra* corals were killed and *Porites* species showed pronounced stress symptoms with loss of zooxanthellar pigment and sloughing of surface tissue. However, recovery of this species was evident by April and *Porites* corals appeared normal by September. *Platygyra* and faviid corals that had apparently lost all their coral tissue were found to have areas of regrowth along their bases, but no recovery of *Acropora* was indicated.

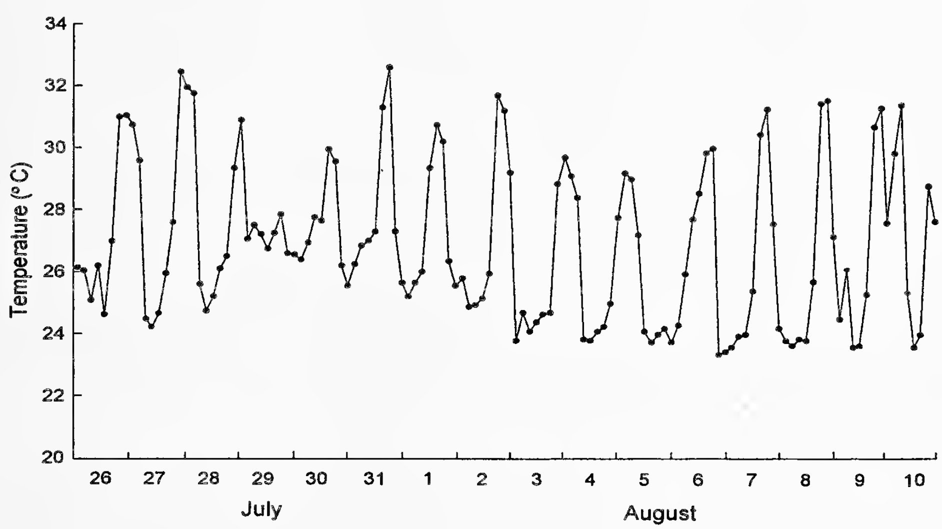

Figure 4. Bottom temperatures at three-hour intervals at 10 m depth off Fahal Island, Oman, July - August 1992 (from Coles, 1997).

Another unique and interesting temperature environment occurs in the Gulf of Oman, which is influenced by upwelling from the Arabian Sea south of Ras al Hadd. Along the southeastern Oman coast directly exposed to upwelling, temperatures decrease between May and September to 18°C or lower and macroalgae growth competes with reef corals for bottom cover as previously described. Gyres of this cold water sweep into the Gulf of Oman where the cold water becomes covered with sun-heated surface water of 30°C or more and a steep shallow thermocline is formed at around 5 to 10 m depth. Under tidal and current influences, both water masses can reach corals in this depth range within a few hours, exposing them to rapid temperature fluctuations of up to 6 to 8°C in 24 hours (Quinn and Johnson, 1996; Coles, 1997) off Fahal Island in the Muscat Capital Area. Overall, bottom temperatures ranged 7°C or more on 14 of 163 days sampled June through August in 1992 and 1994 (Figure 4). No stress symptoms were observed for the abundant and diverse coral community that lives in this area (Coles, 1997), and quantitative measurements along transects showed no significant changes in coral abundances or species composition from this highly fluctuating temperature environment (Coles, unpublished data).

These findings indicate that exposure to temperature and salinity extremes characteristic of the Gulf region is selective for varieties and species of corals that are adapted to the conditions that are unique for this area. The most unusual aspect of this adaptation is that coral temperature tolerances have apparently been extended at both the upper and lower limits of the normal temperature tolerance range.

GULF CORALS AND INDO-PACIFIC CORAL BLEACHING

During the last 20 years, there have been repeated instances of coral bleaching and mortality over extensive areas of coral reefs throughout the world. First noted on a large scale in 1982 in the eastern Pacific (Glynn, 1983, 1984) and the Great Barrier Reef (Oliver, 1985), coral bleaching reports have increased, correlating with occurrences of the El Ni o Southern Oscillation (ENSO) (Glynn, 1993b; Hoegh-Guldberg, 1999; Wilkinson et al., 1999; Wilkinson, 2000) and associated increases in water temperatures above normal ambient maxima (Jokiel and Coles, 1990; Brown, 1997a). A major concern is that El Ni o events may be increasing in both strength and frequency above a increasing temperature baseline, causing frequent coral bleaching and damage and resulting in permanent alteration or elimination of coral dominated reefs throughout much of the Indo-Pacific (Hoegh-Guldberg, 1999).

The 1998 El Ni o bleaching event was the most extensive and severe that has been recorded, with large areas of bleaching and subsequent death of corals occurring on the Great Barrier Reef, Palau, Tahiti, Samoa and throughout the East Pacific, Southeast Asia, the Indian Ocean and the Arabian Gulf (Wilkinson, 1998, 2000; Carriquiry et al., 2001; Glynn et al., 2001; Jimenez et al., 2001). Along with El Ni o events is a long-term trend of increasing ambient water temperatures, and some computer model projections have suggested that the temperature stresses thus far associated with El Ni o years will become ambient maxima within 30 years, exceeding presently recognized temperature tolerance limits annually (Hoegh-Guldberg, 1999). Coral bleaching and mortality during this event was especially severe within the Indian Ocean in areas outside of the Arabian Peninsula where temperature elevations above long term mean maxima reached as high as 2.5°C and were >1°C for up to 7 months (Spencer et al, 2000). This produced coral bleaching up to 100% and mortality up to 95% in the Maldives, Seychelles, Chagos Archipelago and Kenyan Coast. In the year after the 1998 bleaching event in the Indian Ocean McClanahan, *et al.* (2001) found a 75-85% decrease in hard and soft corals on Kenyan reefs and 88-220% increases in turf and fleshy algae. Sheppard et al. (2002) reported near total mortality to 15 depth in the northern atolls and to >35m depth in the southern atolls of the Chagos Archipelago, followed by substantial bioerosion of the dead colonies. Interestingly, both Spencer et al. (2000) and Sheppard et al. (2002) reported that corals in lagoon sites and areas of restricted circulation showed less bleaching and survived better than those on seaward slopes, suggesting local adaptation by corals more routinely exposed to warmer temperatures in shallow areas.

In contrast to the extensive mortality that occurred in the open Indian Ocean, little to no coral bleaching and mortality resulted during the 1998 El Ni o along the Arabian Sea coast of Oman or in the Gulf Oman. In southern Oman up to 95% of the more sensitive coral species showed some bleaching near Mirbat, but no mortality followed (Wilson and Claereboudt, in press). No bleaching occurred further north on the Arabian Sea coast, nor in the Gulf of Oman, where Wilson and Claereboudt, (in press) reported that surface temperatures of 30-32°C occurred from mid-April to December 1998. The onset of upwelling from the summer monsoon probably helped prevent higher seawater temperatures from inducing coral bleaching, but previous short-term exposures to temperatures such as was reported for 1990 to be as high as 39°C (Salm, 1993) may have induced acclimatization or selective adaptation for thermal tolerant corals.

If the upper temperature tolerances of corals are fixed limits and the projected trends in water temperatures do occur, we may be facing a potential demise of coral as a major biotope and constructor of reefs in the lower latitudes of the tropics. Coral bleaching has consistently occurred where normal summer sea temperatures have exceeded ambient by 1-2°C for more than a few days (Hoegh-Guldberg, 1999) and coral mortality has followed where these elevated temperatures have persisted for weeks. This has meant a bleaching and mortality threshold of around 30°C for most of the tropics. However, both experimental studies and temperature information for the Arabian region suggest that upper temperature limits are not fixed, but rather related to the thermal history of the area where they occur. Thus Gulf region corals, while tolerating long-term normal summer temperatures up to 33°C that would be lethal to corals elsewhere in the Pacific, but still show bleaching and mortality when temperatures reach 35°C or above for days to weeks (Salm, 1993; George and John, 1999; Riegl, 1999).

Given the low diversity of corals in the Gulf relative to the Indo-Pacific, it appears that comparatively few species have adapted to the harshness of the conditions there, and that not all corals will have the capacity to adapt to the increasing water temperatures projected for the next half century. Whether such adaptation can happen at all will depend on the rapidity with which temperature increases occur compared to the corals' genetic and physiological capabilities to adjust to this environmental challenge. One viewpoint is skeptical: "...Present evidence...suggests that corals and their zooxanthellae are unable to acclimate or adapt fast enough to keep pace with the rapid rate of warming of tropical oceans" (Hoegh-Guldberg, 1999). Direct experimental evidence of coral capability for short-term acclimation is limited to results from a single study (Coles and Jokiel, 1978; Brown, 1997b) and more research is needed on this important issue. However, evidence for the existence of adaptive processes in corals and zooxanthellae is ample, as reviewed by Brown (1997b) who concluded: "It is also possible that bleaching may be a damage-limitation process which permits corals to withstand stressful periods while harbouring a reduced zooxanthellae population....On a geological time scale, corals have shown themselves capable of colonizing extreme environments such as the Arabian Gulf where rigorous physical conditions have...demanded the evolution of particular genetic strains of both the coral hosts and their zooxanthellae."

As we enter a new era of environmental challenges for the survival of corals and coral reefs, the survival of this biotope through millennia of stressful conditions in the Arabian Gulf perhaps provides some hope that sufficient adaptation can occur to moderate the worst impacts of projected temperature elevations.

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CAN THE ALDABRA WHITE-THROATED RAIL *DRYOLIMNAS CUVIERI ALDABRANUS* FLY?

BY

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The Aldabra White-Throated Rail *Dryolimnas cuvieri aldabranus*

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ABSTRACT

The Aldabra White-Throated Rail *Dryolimnas cuvieri aldabranus*, endemic to Aldabra Atoll (Seychelles), has long been considered the last flightless bird of the western Indian Ocean islands. However, this study represents the first quantitative approach to determine the rail's capacity for sustained, level flight. Morphological, physiological and behavioral aspects are considered in determining its actual and theoretical capacity for flight. Wing loading calculations suggest that it can fly. All other evidence, most importantly the greatly reduced breast musculature, indicate flightlessness. The Aldabra Rail originated from Madagascar, where the nominate form is volant, but only weakly. The Aldabra Rail evolved as a ground forager in the absence of any adult predation, i.e. without any apparent need to fly. This, combined with energetic advantages to becoming flightless, has led to the Aldabra Rail losing its capacity for flight.

INTRODUCTION

Aldabra Atoll (9° 24' S, 46° 20' E) is home to the last flightless bird of the western Indian Ocean islands (Hambler et al., 1993): the Aldabra White-throated Rail (hereafter Aldabra Rail) *Dryolimnas cuvieri aldabranus*. It is currently classified a subspecies of the nominate form on Madagascar (Benson, 1967). A major difference between the two taxa is that the form on Madagascar can fly, whereas *aldabranus* is thought to be flightless (Taylor and van Perlo, 1998).

The Aldabra Rail's ability to fly has been questioned since it was first studied. Abbott (in Ridgway, 1895) describes them "flying at each other like game cocks". Frith (1977) more accurately describes this fighting behavior, making it clear that they leap at each other using their wings to assist them but certainly not flying. Abbott also states "that they are not absolutely flightless, but use their wings to assist them in leaping…" (Ridgway, 1895). Benson (1967) considered the wings so short as to render them "virtually flightless". Penny and Diamond (1971) report flying abilities similar to that of the domestic chicken, qualified by describing flapping as used to assist in jumping, which presumably means they did not believed it capable of powered flight. While such observations are commonplace

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on Aldabra, there are no records of Aldabra Rails actually flying — defined here as sustained, level flight.

The Aldabra Rail's inability to fly has thus far been inferred from behavioral observations only (principally a lack of observations of birds flying), and there has been no quantitative approach to actually determine their capacity for flight. I here describe investigations made into their actual and theoretical capacity for flight using morphological, physiological and behavioral data.

METHODS

Wing-loading is the ratio between total wing area and body weight. Wing area was measured for 12 individuals by tracing the outline of the right wing in a notebook, superimposing this on grid paper and counting the number of squares more than half-covered by the wing. The resultant area was doubled for total wing area. Birds were weighed at capture using a 200 g Salter spring balance.

Two rails, trapped as part of a separate study, died in captivity. Their breast muscles (pectoralis and supracoracoideus) were completely excised when freshly dead. The tissue was weighed using a 50 g Pesola spring balance and compared against their body weight at capture.

The length of each primary feather was measured on both wings of four Aldabra Rails. This was done by inserting a ruler between the feathers until it was pressed gently against the skin of the wing, where the feather being measured exited the skin. The feather was then flattened against the ruler and measured. The lengths of all primaries on each wing were then summed and the percentage difference between summed values for right and left wings calculated.

Observations of Aldabra Rails were made in situations where flight would have been advantageous. These include catching birds by hand and, on one occasion, gently launching a bird about three meters up into the air. I carefully watched its behavior in the air and on landing.

RESULTS

Results of wing-loading calculations for Aldabra Rails (Table 1) are all well within theoretical limits for volant birds, with a mean of 0.62 g/cm^2 (± 0.08, n=12).

Aldabra Rails in the hand have noticeably small breast muscles. Dissection of two dead specimens corroborated this impression, showing very small breast muscles relative to total body weight. Aldabra Rails handled throughout the year (both newly caught and retrapped individuals) show no perceptible change in breast musculature, thus a larger sample size of breast weights (necessarily destructive) is unlikely to produce substantially different results.

Table 1. Wing area, total mass at capture and wing loading of adult Aldabra Rails.

Total wing area (cm^2)	Mass (g)	Wing loading (g/cm^2)
354	230	0.65
294	180	0.61
230	185	0.80
272	185	0.68
322	215	0.67
258	161	0.62
340	205	0.60
246	152	0.62
350	182	0.52
242	157	0.65
276	144	0.52
306	165	0.53

The fluctuating asymmetry in left and right primary feather lengths showed a consistent, unexpected bias towards longer primaries on the right wing. Further, the difference increased as primary length increased.

Table 2. Weight of breast muscle, total mass at capture and percentage of total body weight that breast muscle constitutes for two Aldabra Rails.

Breast muscle (g)	Mass (g)	%
7.15	164	4.4
5.85	201	2.9

Table 3. Fluctuating asymmetry in cumulative right- and left-wing primary feather lengths of four Aldabra Rails.

Right Wing	Left Wing	% difference
735	716	2.7
728	716	1.7
791	757	4.5
761	734	3.7

Anecdotal evidence of Aldabra Rails being unable to fly is unequivocal. In the first incident, an Aldabra Rail was cornered on a rocky ledge overhanging open water. As it leaped, fluttering, past me, I lunged for it. I failed to catch it and instead accidentally knocked it off its path while it was in mid air. Despite its flapping, it did not gain any lift or appreciable forward movement. It could not correct its course and fell quite rapidly into the water below. It swam easily to the shore and clambered out. It was seen foraging nearby within two minutes.

A second incident occurred after I had succeeded in cornering an adult bird that never attempted to fly when I captured it by hand. After briefly examining it, I took it outside and released it by gently tossing it up and away (no more than three meters vertical or horizontal). It flapped vigorously, but appeared uncoordinated in the air. I do not believe its flapping contributed any lift at all. It sawed, rolled and pitched before landing quite heavily and awkwardly. It then ran off without any obvious difficulty and was seen several times in the same vicinity over the next two days.

The last incident occurred when a free-living Aldabra Rail was discovered entangled by a metal band on its right tarsus with a mat of long, human hair. How this came about is not known. The bird held its right leg in the air and did not use it at all. Two of us pursued it and caught it after about three minutes. It was able to hop, and by flapping its wings managed to move quite rapidly. On several occasions it leapt off rocks and fallen tree trunks. At no stage did it ever gain lift, nor did it attempt to fly. It appeared to be terrified and, I believe, would have flown if it could have.

DISCUSSION

A capacity for flight is determined by three main factors: wing loading, power (≈ relative volume of flight muscles) and flapping rate (Pennycuick, 1975). Upon handling an Aldabra Rail it became apparent that calculating wing loading would be uninformative. Their wings are not substantially reduced (*contra* Benson, 1967) and they have a wing loading that lies within theoretical limits for flight (Pennycuick, 1975). They have, however, lost most of their breast musculature (this is very apparent when a bird is in the hand). Thus, they lack the power required for level flight, violating the second requirement for flight. The persistence of a large wing area, contrary to expectations of a flightless form, can be understood in the light of their nest- and chick-defense displays. In these displays wings are fanned and held vertically, which has the effect of greatly increasing the apparent size of the displaying bird (R. Wanless, unpublished data). Thus any selective pressure to evolve much smaller wings is counteracted. Asymmetry in flight organs may not compromise their efficacy in defensive displays, but would have a significant, detrimental effect in flight (Shykoff and Möller, 1999; Cadee, 2000).

The flight muscles of volant birds constitute around 15% of their body weight, with exceptions tending to be higher than this (Livezey and Humphrey, 1986; Schmidt-Nielsen, 1990). Those of the Aldabra Rail (Table 1) are considerably below the 15% average for volant birds. The bulk of flight muscles is simply too small for Aldabra Rails to engage in powered flight.

Aldabra Rails undergo an annual, simultaneous, post-breeding molt (Penny and Diamond, 1971; R. Wanless, unpublished data) and are unequivocally flightless at this time. Further, the primary and secondary feathers are generally *extremely* abraded by the onset of moult (pers. obs.); it is difficult to imagine the tattered feathers being useful in flight.

The energetic advantages of becoming flightless are well known (McNab, 1994; Feduccia, 1996). Flight muscles are amongst the most energetically demanding organs in birds (Feduccia, 1996). Reduction in the bulk of flight muscles may be adaptive (genetically based), or a result of under-development or atrophy through disuse. Whatever the cause, reduction results in a considerable energetic saving for birds that no longer need to fly. Further, powered flight *per se* demands a high metabolic rate; evolution of flightlessness allows concomitant evolution of a lowered metabolic rate, a trait common to several species of flightless rails (McNab, 1994).

White-throated Rails on Madagascar (the source population for Aldabra Rails) are, at best, marginal flyers and were probably weakly volant at the time they colonized Aldabra (Benson, 1967; Benson and Penny, 1971; Taylor and van Perlo, 1998). These birds could not have stored large amounts of fat while retaining an ability to fly due to the negative impact that this would have on wing-loading. Patrikeev (1995, in Taylor and van Perlo, 1998) describes a population of Common Coot *Fulica atra* where adults become so fat after migration that 70-80% of the population cannot fly when chased. For all landbirds on Aldabra, reproduction is closely tied to the wet NW monsoon (Benson and Penny 1971). Variable timing and amount of rainfall means that in some years rains may be late and/or far below average (Farrow, 1971; Betts, 2000). An ability to store large reserves of energy (fat) at times of abundance would be advantageous in surviving the long, dry, SE monsoon and allow birds to achieve breeding condition early in the wet season. It would further serve as an energetic insurance policy, should rains be late or fail. The original impetus for Aldabra Rails becoming flightless may well have been storing fat as an adaptation to surviving periods of scarcity.

CONCLUSION

Aldabra Rails are ground foragers and in the absence of predation on adults, evolved on Aldabra without need to fly; even on Madagascar, where numerous predators exist, they seldom fly (Taylor and van Perlo, 1998). There are numerous and considerable energetic advantages to becoming flightless, a condition to which rallids are predisposed (Taylor and van Perlo, 1998). The complete absence of observations of the Aldabra Rail flying, especially in circumstances where flight would be highly advantageous, has led to a general belief that they are flightless. Their complete, simultaneous, post-breeding molt renders adults flightless for a time without any adverse consequences. Further, flight feathers are not maintained and become extremely abraded, rendering them highly ineffective as organs for flight. While wing loading calculations suggest the Aldabra Rail could theoretically fly, the insubstantial bulk of flight muscles and asymmetry of their wings militates against this completely. I conclude that the Aldabra Rail cannot fly.

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