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BIOLOGICAL AND MANAGEMENT ASPECTS OF A CARIBBEAN MANGAL: WEST HARBOUR, JAMAICA

by

BARBARA A. CHOW*

ABSTRACT

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Observations are given for the first time of West Harbour, a pristine south-coast Jamaican mangal. West Harbour is shown to be a diverse and extensive mangal (22.5 km^2) with a high degree of representativeness with respect to mangrove community types. The classical mangrove zonation is evident, a fringing seaward almost mono-specific *Rhizophora* fronting backswamp basin *Avicennia*. Mangrove community types are varied; overwash, fringe, basin and scrub *Rhizophora*, and basin and scrub *Avicennia*. A broad scale survey recorded a total of 45 plant and 183 macrofaunal components of the biota which included the endangered Antillean manatee, *Trichechus manatus manatus*. Floristic and faunal notes are given. Implications of the findings for the conservation of West Harbour are discussed.

Key words: **Mangrove ecology, *Avicennia*, *Rhizophora*, *Trichechus manatus manatus*, conservation, West Harbour, Jamaica.**

INTRODUCTION

Although island mangals provide good study situations due to their small size and diverse geomorphology (WEST 1977), ecosystem orientated research in the insular Caribbean has historically lagged behind that of continental countries (ROLLET 1981; POR & DOR 1984; SNEDAKER 1989; SCHAEFFER-NOVELLI & CINTRON 1990). This has hampered the development of conservation strategies and few Caribbean islands have conducted conser-

* Centre for Marine Sciences, University of the West Indies, Mona, Jamaica.

vation orientated research for the designation and management of mangrove protected areas in spite of their ecological and economic importance (LUGO & SNEDAKER 1974; HAMILTON & SNEDAKER 1984; HATCHER *et al.* 1989).

In Jamaica, in spite of an active history of marine scientific research, only 3 of the over 20 mangals islandwide had been studied up to the 1980's (GREENFIELD 1985; CHOW 1989). These comprise single reports on the natural history of two sites, Cockpit-Salt River (WADE *et al.* 1972) and Cabaritta (WOODLEY 1971) and numerous (> 30) articles on aspects of the biology, botany and autecology of the Port Royal mangal (GREENFIELD 1985). While the ecology of Cabaritta and Cockpit-Salt River, both fringe wetlands, may not have changed significantly since those early studies (CHOW 1991a; 1991b) the same cannot be said for the Port Royal mangal. Located adjacent to the polluted Kingston Harbour, the Port Royal mangal represents a disturbed system particularly in recent years (GOODBODY 1987; BACON 1989; JONES 1989; CHOW & GOODBODY 1989) and its usefulness as a benchmark site may be restricted. Because of an increasing trend of areal losses and perturbations (HUDSON 1983; CHOW 1987) and the need for the development of conservation strategies (BRATZ 1982), there is a need to expand knowledge of Jamaican mangals. Study of an undisturbed mangal site, with national and regional representativeness, is warranted particularly as numerous studies had already been conducted on freshwater wetlands (BJORK 1983; NRCD & TGI 1981; RICHARDS 1985). West Harbour, slated for national park development since 1977 (NPA 1977), but about which very little was known, was chosen as the study site. This investigation – 1984-1986 – was undertaken to add to the knowledge of West Harbour, in particular, and Caribbean island mangals as a whole.

STUDY AREA

West Harbour (17°46' N, 77°11' W), on the south coast of Jamaica, is a large ($\approx$ 11.7 km^2, shallow (mean depth $\approx$ 2 m) embayment surrounded on all sides by mangrove forest (Fig. 1). Nearshore hydrography is shallow (<15m) and *Thalassia testudinum* Konig grass beds extend to small patch reefs located some 1.7 km offshore.

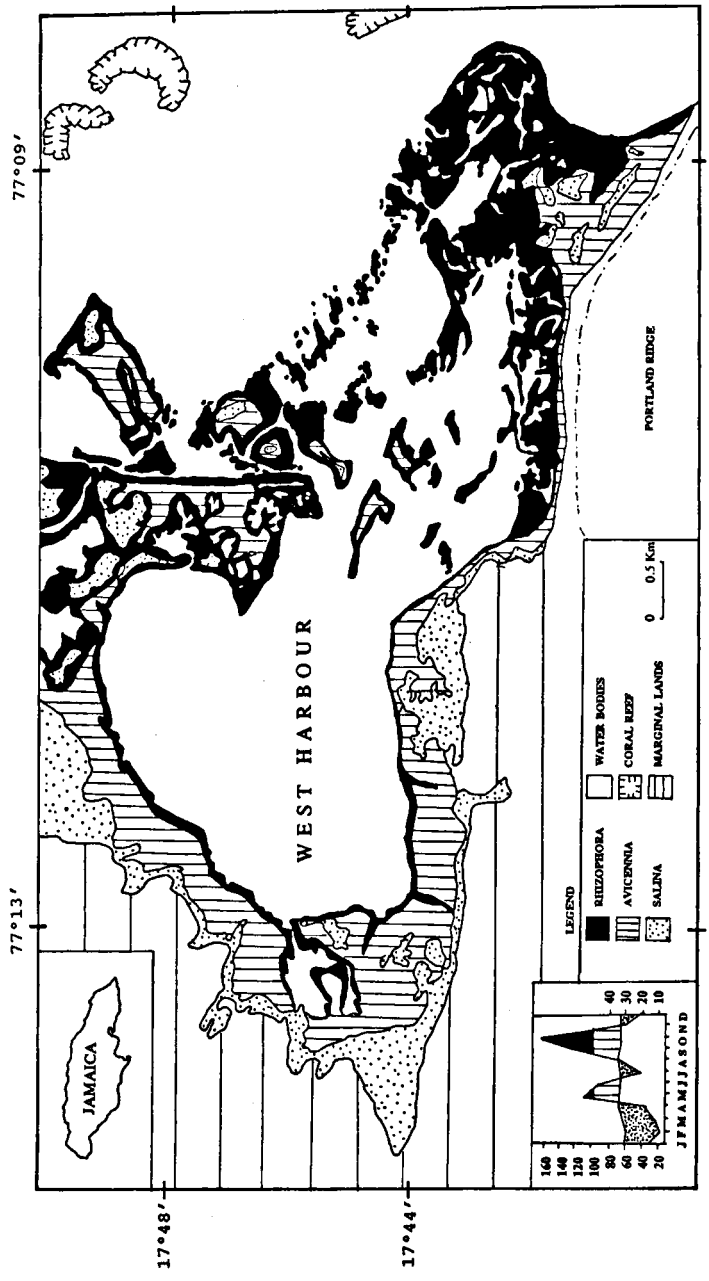

FIGURE 1 – Physiographic ecology of the West Harbour mangal, Jamaica.

The tides are weak microtidal semidiurnal forces; the mean tidal interval being 23 cm (after SHERWIN & DEEMING 1980; KJERFVE 1989). Mean wind speed is expected to be similiar to Kingston Harbour (0700 h : 2 $m.s^{-1}$; 1300 h: 7.5 $m.s^{-1}$) (SHERWIN & DEEMING 1980).

Riverine influences are absent and the climate is classified (after HOLDRIDGE 1967) as tropical dry with less than 127 cm of precipitation annually on a few rain days (CHOW 1989). Annual air temperatures range between 20.30 °C (winter minimum) and 31.35 °C (summer maximum) and relative humidity averages between 88.63% (morning) and 67.67% (evening). An inset of the temperature rainfall diagram is given in Figure 1. Stipuled areas indicate periods in which evaporation exceeds precipitation.

A recent history of damage from hurricanes and perturbations is lacking (WADE 1974; BACON 1989; GRAY 1990).

METHODS

Mangal delineation

For management, descriptive and comparative purposes, it was necessary to standardize the definition and delineation of the mangal site. MACNAE's (1968) definition of the mangal incorporates the mangrove plant species, associated flora and fauna, sediment, creek channels and small water bodies that drain the area. This was expanded to incorporate not only salinas as suggested by CINTRON *et al.* (1978) but the wetland basin as well (ADAMUS & STOCKWELL 1983). THOM's (1975; 1982) geomorphic approach which interprets the development of mangrove vegetation as a response to coastal processes was adopted to delimit mangal as a physiographic unit. Mangals in Jamaica and the insular Caribbean are predominantly coastal and fringing (WEST 1977), it was necessary to develop a guideline for identifying and distinguishing sites in which the mangrove vegetation was continuous between adjoining landforms. A mangal site was distinguished therefore on the basis of landform. On this basis West Harbour, a leaky lagoonal site was distinguishable from Peake Bay to the north, a fringing swamp on a sandy beach with a number of old shorelines visible on aerial photographs. Separation is therefore based on the presence of marked coastal features *i.e.* bays in contrast to indentation. The principles of maritime boundary delimitation (UN 1982) were adopted so that the 'internal' waters (Article 8) within a mangrove embayment were identifiable as part of the mangal site. The site was mapped with the use of 1983 black and white aerial photographs at scale 1:5000. Vegetation type was distinguished on the basis of tone and texture and verified with ground truthing. Mensuration of areal coverage was obtained with a KEUFFEL & ESSER polar planimeter.

Water Quality

Ambient water quality with respect to salinity, temperature, pH, nitrites ($N\text{-}NO_2$), nitrates ($N\text{-}NO_3$) and phosphates ($P\text{-}PO_4$) was monitored at twelve stations monthly for twelve

months. Inorganic nutrients were determined with the use of a Technicon II auto analyser. Dissolved oxygen and BOD_5, for logistic reasons, were determined for only two months. Additionally, diurnal variabiliy of salinity, temperature and pH was investigated at two locations within the seaward overwash islands during summer (June) and spring (April).

Broad scale survey

A total of 50 visits were made to the site between 1984 – 1986 as part of a broader study (CHOW 1989) to examine mangal processes. During this period observations and collections of the flora and macrofauna were conducted on foot or by snorkeling. Particular attention was given to the ichthyofauna due to the importance of mangals as fish nurseries and their comprehensive treatment in the literature (LUGO & SNEDAKER 1974; THAYER *et al.* 1977; CINTRON & SCHAEFFER-NOVELLI 1984). Collections were made monthly over a six month period in the main lagoon with the use of a beam trawl consisting each of three 5 minute trawls at low speed. Supplemental information for the ichthyofaunal list was obtained from snorkel observations and examination of fishermen's catches who used gill nets, pots and handlines in West Harbour. Additionally, a push net (mesh size ≈ 1 cm) was utilized in creek channels to supplement data on smaller bodied fishes.

RESULTS

Mangal delineation

TABLE 1
STRUCTURAL FEATURES OF THE WEST HARBOUR MANGAL

Parameter	Size (km^2)
Catchment area	≈ 40.0
Total water surface area	11.7
Inner lagoon	7.5
Outer lagoon	4.2
Total forest coverage	7.4
Rhizophora	5.1
Avicennia	2.3
Thorn-scrub	< 0.1
Salina coverage	3.3
Total mangal	22.5

The West Harbour mangal (Fig. 1) is delimited by the landward extent of salina in the west and north-west, by the landward extent of the forest or salina to the south, by the seaward extent of overwash islands to the east in which the border is drawn to connect the outermost points of the outer-

most islands with that of the headland. Structural features of the West Harbour mangal are presented in Table 1.

Water Quality

TABLE 2
ANNUAL VARIATION IN WATER QUALITY, WEST HARBOUR (N=12)

Parameter	Inlets	Inner Harbour	Outer Harbour
Salinity ‰	39.7 ± 0.6	39.4 ± 0.7	38.9 ± 0.6
Temperature °C	29.3 ± 0.3	29.2 ± 0.3	29.1 ± 0.3
pH	7.89 ± 0.03	8.06 ± 0.02	8.15 ± 0.03
Oxygen* mg l^{-1}	4.83 ± 0.02	5.22 ± 0.02	6.19 ± 0.02
BOD_5* mg l^{-1}	0.9 ± 0.0	0.9 ± 0.0	0.9 ± 0.0
S.S. mg l^{-1}	5.08 ± 0.73	5.38 ± 0.73	3.75 ± 0.35
N-(NO_2) µg at. l^{-1}	0.49 ± 0.50	0.50 ± 0.04	0.49 ± 0.04
N-(NO_3) µg at. l^{-1}	0.45 ± 0.13	0.40 ± 0.05	0.43 ± 0.06
P-PO_4 µg at. l^{-1}	0.31 ± 0.05	0.30 ± 0.05	0.30 ± 0.05

* Average for January and February only.

TABLE 3
DIURNAL VARIATION IN WATER QUALITY (N=24)
(daily averages are given in parentheses)

	Spring	Summer
Temperature °C	29.0 – 31.5 (30.6)	27.0 – 32.0 (29.2)
Salinity ‰	35.0 – 43.0 (39.8)	36.0 – 40.0 (38.7)
pH	7.3-8.3 (8.0)	8.0-8.5 (8.3)

West Harbour waters exhibited a stable physicochemical regime over the study period (Table 2). Temperature and salinity were slightly elevated in comparison with values for Pigeon Cay, 27.7 ± 0.4 °C and 35.3 ± 0.7 ‰, located some 12 km offshore and the Port Royal mangal as described by SIUNG (1976). This may be related to the restricted hydrography of West Harbour. Diurnal variation in water temperature, salinity and pH is more marked, particularly with respect to salinity (Table 3).

The nutrient profile of West Harbour contrasts the more frequently reported and nutrient richer estuarine areas of Terminos Lagoon, Mexico (DAY *et al.* 1982); Caroni Swamp, Trinidad (BACON 1970); and South Florida (ODUM *et al.* 1982). The oligotrophic nature of West Harbour waters is typical of other Jamaican mangals; STEVEN (1965) reports values of 0.78 ($N\text{-}NO_2 + NO_3$) and 0.08 ($P\text{-}PO_4$) µg at.l^{-1} from water adjoining a mangrove lagoon while SIUNG (1976) reports 1.29 ($N\text{-}NO_2 + NO_3$) and 0.65 ($P\text{-}PO_4$) µg at.l^{-1} from the Port Royal mangal. These values are fivefold higher than those of surrounding oceanic waters described by BEERS *et al.* (1968); 0.18 ($N\text{-}NO_2 + NO_3$) and 0.03 ($P\text{-}PO_4$) µg at.l^{-1}.

Broad scale survey – Flora

An extensive mangal has developed around the West Harbour lagoon with numerous overwash (≈ 200) and large mangrove islands punctuating the entrance channel (Fig. 1). The classic mangrove zonation was observed; seaward fringing almost monospecific *Rhizophora mangle* L. stands on firm clean peat, and inland or basin *Avicennia germinans* L. forests on soft peaty muds. *Laguncularia racemosa* (L) Gaertn. and *Conocarpus erectus* L. were rare. Structurally, the mangrove communities were low; forest height rarely exceeded 7 m. A variety of community types (LUGO & SNEDAKER 1974) were observed: fringe, basin and scrub *Rhizophora* (< 1 m height), and basin and scrub *Avicennia* forests. Scrub *Rhizophora* occurred in inland more saline depressions as noted in other Caribbean localities (WEST 1977; SNEDAKER 1989) but also as a less common seaward fringe. Progradation of young *Rhizophora* tree clumps and seedlings were common in the *Thalassia* shoals of the harbour entrance similar to that reported from southern Puerto Rico (BANUS & KOLEHMAINEN 1975).

The terrestrial flora (Table 4) was low in diversity (13 species) but this is characteristic to the climate regime (ASPREY & ROBBINS 1953). First time observation of the epiphyte, *Broughtonia sanguinea* (Sw.) R.Br. on *Avicennia* trees was made. Such occurrences were rare and limited to southern stands proximal to the dry limestone forests of Portland Ridge. Also of note was the occurrence of anomalous aerial roots, albeit rarely, on *Avicennia* as was noted in Florida and Costa Rica by SNEDAKER *et al.* (1981).

TABLE 4

CHECKLIST OF THE FLORA AND FAUNA OF THE WEST HARBOUR MANGAL
(L: lagoon; F: forest; R: *Rhizophora* rhizophore; M: muds; C: creek chanels; S: salina),
(* fish species caught in otter trawl)

TAXA	HABITAT
KINGDOM PLANTAE	
Chlorophyta	
Cladophoropsis membranacea (J. Agardh) Boergesen	L
Dictyosphaeria cavernosa (Forssk{a0}l) Boergesen	R, L
Valonia sp.	R, L
Acetabularia crenulata Lamouroux	R, L
Batophora oerstedi J. Agardh	L
Cladocephalus luteofuscus (Crouan) Boergesen	R
Halimeda incrassata (Ellis) Lamouroux	L
H. opuntia (Linnaeus) Lamouroux	L
Avrainvillea asarifolia Boergesen	L
Penicillus capitatus Lamarck	L
P. dumetosus (Lamouroux) Blainville	L
P. lamourouxii Descaine var. gracilis	L
Udotea flabellum (Ellis & Solander) Lamouroux	L
Caulerpa mexicana (Sonder) J. Agardh	R, L
C. prolifera (Forssk{a0}l) Lamouroux	R, L
C. sertularoides (Gmelin) Howe	L
C. verticillaria J. Agardh	L
Phaeophyta	
Dictyota divaricata Lamouroux	R
Padina vickersiae Hoyt	L
Sargassum natans (Linnaeus) Meyer	L
Turbinaria turbinata (Linnaeus) Kuhtze	L
Rhodophyta	
Catenella repens (Lightfoot) Batters	R
Fosliella lejolisii (Rosanoff)	L
Gracilaria sp.	L
Acanthophora spicifera (Vahl) Boergesen	R
Bostrychia sp.	R, M
Laurencia sp.	R, L
Pterocladia americana Taylor	L
Anthophyta (= Angiospermae)	
Thalassia testudinum Konig	L
Halodule beaudettei Den Hartog	L
Syringodium filiforme Kutzing	L
Broughtonia sanguinea (Sw.) R. Br.	F

TAXA	HABITAT
Batis maritima Linnaeus	F, S
Salicornia perennis Mill.	S
Portulaca halimoides Linnaeus	S
Sesuvium portucalastrum (Linnaeus) Linnaeus	S
Opuntia jamaicensis Britton & Harris	S
Stenocereus hystrix (Haw.)	S
Acacia tortuosa (Linnaeus)	S
Rhizophora mangle Linnaeus	M, L
Avicennia germinans Linnaeus	M
Conocarpus erectus Linnaeus	M
Laguncularia racemosa (Linnaeus) Gaertn.	M
Ipomoea pes-caprae (Linnaeus) R. Br.	S
KINGDOM ANIMALIA	
SUBKINGDOM METAZOA	
Porifera	
Verongia fistularis (Pallas)	R
Dysidea fragilis (Montagu)	R
Haliclona viridis Duchassaing & Michelotti	R
Liosina monticulosa (Verrill)	R
Sigmadocia caerulea Hechtel	R
Tedania ignis (Duchassaing & Michelotti)	R
Ulosa hispida Hechtel	R
Mycale microsigmatosa Arndt	R
Biemna microstyla De Laubenfels	R
Halichondria melanadocia De Laubenfels	R
Terpios zeteki De Laubenfels	R, L
Geodia sp.	R, L
Chondrilla nucula Schmidt	R
Coelenterata (= Cnidaria)	
ANTHOZOA	
Aiptasia tagetes (Duchassaing & Michelotti)	L, R
Condylactis gigantea (Weinland)	L
Telesto riisei (Duchassaing & Michelotti)	R, L
Porites furcata Lamarck	L
Manicina areolata (Linnaeus)	L
HYDROZOA	
Millepora c.f. complanata Lamarck	R
SCRYPHOZOA	
Cassiopea xamachana Bigelow	L
Annelida	
POLYCHAETA	

TAXA	HABITAT
Sabellastarte magnifica (Shaw)	L, R
Pseudobranchiomma emersoni Jones	R
Arthropoda, CHELICERATA	
Latrodectus geometricus C. Koch	F
Arthropoda, CRUSTACEA	
Lepas anserifera Linnaeus	L
Chthalamus angustitergum (Pilsbry)	R
C. proteus Dando & Southward	R
Balanus improvisus Darwin	R
B. eburneus Gould	R
Pseudosquilla ciliata (Fabricius)	L
Penaeus brasiliensis Latreille	L
Alphaeus sp.	L, R
Panulirus argus (Latreille)	L, R
Callinectes sapidus Rathbun	L
Pachygrapsus gracilis (De Saussure)	M
Goniopsis cruentata (Latreille)	M
Cardiosoma guanhumi (Latreille)	M
Ucides cordatus (Latreille)	M
Uca rapax (Smith)	M, S
Uca thayeri Rathbun	M
Aratus pisonii (H. Milne Edwards)	M, F
Sesarma curaçaoense De Man	M
Insecta, PTERYGOTA	
Nasutitermes nigriceps (Haldeman)	F
Oiganthopus sp.	F
Paraclius sp.	F
Stenobanus jamaicensis Newstead	F
Aedes aegypti (Linnaeus)	F
Culicoides furens (Poey)	F
Mollusca	
GASTROPODA	
Littorina angulifera Lamarck	F
Cerithium eburneum Bruguière	M
Cerithidea costata Da Costa	M
Crepidula plana Say	M, L
Nitidella laevigata Latreille	M
Melongena melongena Linnaeus	L
Leucozonia nassa Gmelin	R
Vasum muricatum Born	R
Olivia reticularis Larmarck	R, L
Crassispira sp.	M
Bulla striata Bruguière	M

TAXA	HABITAT
Turbonilla interrupta Totten	R
Aplysia sp.	L
Melampus coffeus Linnaeus	M, F
Arca imbricata Bruguière	R
Barbatia cancellaria Lamarck	R
Brachiodontes citrinus Roding	M
Isognomon radiatus Lamarck	R
Pinctada imbricata (Roding)	L
Codakia orbicularis Linnaeus	M
Chama macerophyla Gmelin	R
Anomalocardia brasiliana Gmelin	M
Arcopagia fausta Pulteney	M
Tellina c.f. aequistriata Say	L
Echinodermata	
ASTEROIDEA	
Oreaster reticulatus (Linnaeus)	L
Eucidaris tribuloides (Lamarck)	L
Echinaster echinophorus (Lamarck)	L
OPHIUROIDEA	
Ophiastis savignyi (Muller & Troscel)	R
ECHINOIDEA	
Diadema antillarum (Philippi)	L
Tripneustes esculentus (Leske)	L
Lytechinus variegatus (Leske)	L
Echinometra viridis (Agassiz)	L
HOLOTHUROIDEA	
Astichopus multifidus (Sluiter)	L
Chordata, Urochordata	
ASCIDIACEA	
Ascidia nigra (Savigny)	R
Perophora bermudensis Berrill	R
P. viridis Verrill	R
Ecteinascidia turbinata Herdman	R
E. styeloides (Traustedt)	R
Botrylloides nigrum Herdman	R
Symplegma viride Herdman	R
Microcosmus exasperatus Heller	R
Eudistoma olivaceum (Van Name)	R
Lissoclinum fragile (Van Name)	R
Polyclinum constellatum Savigny	R
Chordata, Vertebrata (= Euchordata)	
CHONDRICHTHYES	
Aetobatis narinari (Euphrasen)	L

TAXA	HABITAT
Dasyatis americana Hildebrand & Schroeder	L
OSTEICHTHYES	
Megalops atlanticus (Valenciennes)	L
Centropomus undecimalis (Bloch)	L*
Harengula sp.	L
Opisthonema oglinum (LeSueur)	L
Gymnothorax funebris Ranzani	L
Gambusia puncticulata Poey	L, C
Cyprinodon variegatus Lacépède	L, C
Strongylura timucu (Walbaum)	L, C
Hemiramphus brasiliensis (Linnaeus)	L
Holocentrus ascensionis (Osbeck)	L
Hippocampus reidi Ginsburg	L
Rypticus saponiceus (Bloch & Schneider)	L*
Caranx latus Agassiz	L
Lutjanus apodus (Walbaum)	L, C*
L. griseus (Linnaeus)	L, C*
L. jocu (Bloch & Schneider)	L
Ocyurus chrysurus (Bloch)	L*
Eucinostomus argenteus Baird & Girard	L*
E. gula (Cuvier)	L
Diapterus rhombeus (Cuvier)	L, C*
Eugerres plumieri (Cuvier)	L*
Gerres cinereus (Walbaum)	L
Haemulon sciurus (Shaw)	L*
H. bonariense Cuvier & Valenciennes	L*
H. melanurum (Linnaeus)	L
Archosargus rhomboidalis (Linnaeus)	L*
Bairdiella ronchus (Cuvier)	L*
Chaetodon capistratus Linnaeus	L*
Eupomacentrus fuscus (Cuvier)	L
Abudefduf taurus (Muller & Troscel)	L
Halichoeres poeyi (Steindachner)	L
Sparisoma croicensis Bloch	L
S. rubriprinne (Cuvier & Valenciennes)	L*
S. viride (Bonnaterre)	L*
Mugil curema Valenciennes	L
M. cephalus Linnaeus	L*
Sphyraena barracuda (Walbaum)	L
Bathygobius soporator (Cuvier & Valenciennes)	L
Acanthurus chirurgus (Bloch)	L
Scorpaena grandicornis Cuvier & Valenciennes)	L
Bothus ocellatus (Agassiz)	L, C*
Balistes vetula Linnaeus	L
Monocanthus tuckeri Bean	L
Lactophrys triqueter (Linnaeus)	L

TAXA	HABITAT
Sphaeroides greeleyi Gilbert	L*
Diodon holocanthus Linnaeus	L*
Reptilia	
Chelonia mydas Linnaeus	L
Crocodylus acutus Cuvier	M
Anolis sp.	F
Aves	
Pelecanus occidentalis Linnaeus	L, F
Fregata magnificens Matthews	L, F
Egretta alba Linnaeus	F, S
E. thula (Molina)	F, S
E. caeruela (Linnaeus)	F, S
E. tricolor Gosse	F, S
E. rufescens Gmelin	F, S
Bubulcus ibis Linnaeus	F, S
Ardea herodias Linnaeus	F, S
Butorides virescens Linnaeus	F, S
Nycticorax nycticorax (Linnaeus)	F, S
N. violaceus (Linnaeus)	F, S
Eudocimus albus (Linnaeus)	F, S
Pandion haliaetus (Linnaeus)	L
Falco sparverius Linnaeus	F
Buteo jamaicensis (Gmelin)	F
Charadrius semipalmatus Bonaparte	S
C. vociferus Linnaeus	S
C. wilsonia Ord	S
Squatarola squatarola (Linnaeus)	S
Catoptrophorus semipalmatus (Gmelin)	S
Arenaria interpres (Linnaeus)	S
Himantopus himantopus Linnaeus	S
Sterna hirundo Linnaeus	L
S. maximus Boddaert	L
S. albifrons Pallas	L
Gelochelidon nilotica Gmelin	L
Zenaida asiatica (Linnaeus)	F
Z. macroura (Linnaeus)	F
Columba leucocephala Linnaeus	F
C. inornata Vigors	F
C. passerina Linnaeus	F
Aratinga pertinax Linnaeus	F
Coccyzus minor (Gmelin)	F
Anthracothorax mango (Linnaeus)	F
Ceryle alcyon (Linnaeus)	F
Myiarchus barbirostris (Swainson)	F

TAXA	HABITAT
Mimus polyglottis (Linnaeus)	F
M. gundlachii Cabanis	F
Coereba flaveola (Linnaeus)	F
Dendroica petechia (Linnaeus)	F
Quiscalus niger (Boddaert)	F
Vireo altiloquus (Vieillot)	F
Tiaris olivacea (Linnaeus)	F
Mammalia	
Trichechus manatus manatus (Moore)	L

Although small salinas with gradients of wetness and substrate conditions occurred within the forest interiors, salinal development was best landward of the forest where it formed a wide (≈ 1 km) almost continuous belt. Here vegetation was sparse consisting of cactus-thorn scrub (Table 2) akin to the arid coastal faciation described by ASPREY & ROBBINS (1953); substrate was of fine sands. Partially inundated during high tides, these areas were largely dry with fine sands. A small stand of scrub *Avicennia* (0.4 km^2 large) was evident. Senescence was associated with salinal development of the drier interiors of the larger islands and mangrove mainland.

The aquatic flora (Table 4) was diverse comprising 17 Chlorophyta, 4 Phaeophyta, 7 Rhodophyta and 3 Anthophyta (31 species). The composition of the macroalgae was similiar to that described from other mangals (Bahamas: WILCOX *et al.* 1975). *Bostrichya* sp. occurred intertidally on both *Rhizophora* and *Avicennia* roots associated with *Acanthophora spicifera* (Vahl) Boergesen and *Cladophoropsis membranacea* (J. Agardh) Boergesen.

Dominant macroalgae included *Udotea flabellum* (Ellis & Solander), *Avrainvillea asarifolia* Lamouroux and *Cladocephalus luteofuscus* (Crouan) Boergesen; individuals were large (mean length ≈ 10 cm). *Batophora oerstedi* J. Agardh which occurred in the lagoon and mangrove muds and has been recorded in salt pools along the Palisadoes (near the Port Royal mangal) by CHAPMAN (1962). Large spherical mounds of *Halimeda incrassata* (Ellis) Lamouroux (diameter ≈ 1.5 m) were common in the grass flats offshore the lagoon. The associated *Thalassia*-macroalgal beds of the lagoon were particularly well developed; *Thalassia* leaf biomass was in the upper range of values reported in the island (JUPP 1986).

Broad scale survey – Fauna

A total of 186 faunal species including 2 endemics were recorded within the West Harbour mangal (Table 2). These included 13 Porifera, 7 Coelenterata, 2 Polychaeta, 1 Chelicerata, 18 Crustacea, 6 Insecta, 24 Mollusca, 9 Echinodermata, 11 Ascidiacea, 48 Pisces, 3 Reptilia, 44 Aves and 1 Mammalia. Additionally a number of species of gammarid amphipods, harpacticoid copepods, bryozoa and polychaetes were also collected, but were not identifiable.

The invertebrate fauna was generally similar to that of the Port Royal mangal as described by WARNER (1969) and SIUNG (1976). However, *Crassostrea rhizophorae* Guilding was not recorded and *Isognomon radiatus* Lamarck was the dominant subtidal mollusc not *I. alatus* Gmelin as reported from Port Royal and some Mexican, Colombian and Panamanian sites (ESPINOSA GARDUNO 1980; PEREZ & VICTORIA 1980). TUCKER ABBOTT (1961) identified specimens of *I. radiatus* from Morgan's Harbour, noting that their absence from the adjacent Port Royal mangal was probably due to their preference for 'oceanic' conditions. PLAZIAT (1984) further reports *I. radiata (= radiatus)* to be atypical of mangrove environments. The absence of *C. rhizophorae* may be due to requirements for more estuarine conditions (MATTOX 1939); West Harbour is little influenced by freshwater subsidies.

Porites furcata Lamarck and *Manicina areolata* (L.) were common in the grass beds fronting the harbour entrance. Partial bleaching in both species of coral was observed during March 1990. Sponge dominated epibiotic complexes akin to that of the *Rhizophora* prop roots were frequently encountered but these were never as expansive.

Only one occurrence of *Millepora c.f. complanata* Lamarck encrusting epibionts of *Rhizophora* prop root was recorded from a clear fast flowing tidal creek in the outer overwash island series. Coral growth (*Agaricia* spp.) on *Rhizophora* prop roots was also observed in Venezuela (FLORES 1980). Four species of cirripedes were recorded from West Harbour. *Chthalamus angustigergum* (Pilsbry) was the dominant cirripede in the seaward locales and replaced by *C. proteus* in creek zones. Although *C. proteus* Dando & Southward was not recorded in ACHITOV'S (1984) review of Western Atlantic cirripedes, BACON *et al.* (1984) recorded the species in seaward Trinidad locations. *Balanus improvisus* Darwin was common throughout.

A survey of 30 *Rhizophora* prop roots revealed three juvenile individuals

of *Panulirus argus* (Latreille) with carapace length (CL) less than 2 cm. Larger individuals (CL ≈ 5 cm) were observed in the crevices of the prop root berm. Such cryptic associations have been noted elsewhere (OLSEN *et al.* 1982).

Although *Cassiopeia xamachana* Bigelow could be found throughout the site, populations were dense in shallow quiet pools; as much as 11 individuals per m^2 were counted. Benthic vegetation in these pools was sparse and the organic sediments easily disturbed.

Littorina angulifera was common in seaward *Rhizophora* forests and was observed feeding on green leaves leaving a characteristic elipsoid leaf scar. Previous records report feeding on lichens and fungi (PLAZIAT 1984). The potamid, *Cerithidea costata* Da Costa, formed dense local aggregations on wet salinal muds immediately adjacent to *Avicennia* forests while *Melampus coffeus* L. was dominant on basin muds and *Avicennia* pneumatophores. On one occasion, two piglets were observed feeding selectively on *Melampus* and pneumatophores in northern *Avicennia* forests adjacent to a small fishing settlement.

Nests of the termite *Nasutitermes nigriceps* (Haldeman), first noted in Jamaica by HUBBARD (1877) but not from mangrove forests, were common in mainland and offshore *Rhizophora* forests. Four nests were censused in ten 0.01 ha plots. Another frequently encountered insect was the cricket, *Oiganthopus* sp., largely as nymphs associated with dry litter deposits on the substatum and tree crevices. In seaward *Rhizophora* forests with heavy faecal pellet deposits of *Aratus pisonii,* the endemic tabanid fly, *Stenobanus jamaicensis* Newstead was common.

Thirty three families of fish were recorded in West Harbour. The Caribbean guppy, *Gambusia puncticulata* Poey and the killifish *Cyprinodon variegatus* Lacépède were common in creek channels and wet depressions of forest interiors. Surface aggregations of *G. puncticulata* were associated with the *Rhizophora* prop root habitat of both mainland and seaward overwash fringes whilst *C. variegatus* assumed a more benthic position in the water column.

Nineteen fish species (13 families) were obtained from beam trawls (Table 4). The composition of the catch did not differ to that reported for Puerto Rico (19 species in common) (AUSTIN 1971, AUSTIN & AUSTIN 1971; STONER 1986), South Florida (12 species in common) (THAYER *et al.* 1987), Bahamas (10 species in common) (WILCOX *et al.* 1975) and Guadeloupe

(12 species in common) (LOUIS & LASSERE 1971). The catch was dominated by *Archosargus rhomboidalis* (L.) (38% catch) and *Lutjanus apodus* (Walbaum), *Haemulon sciurus* (Shaw), *Lutjanus griseus* (L.) and *Eucinostomus argenteus* Baird & Girard comprised 50% of the catch in more or less even proportions.

The West Harbour avifauna was generally low in diversity in comparison to other coastal mangals and marshlands (CRUZ 1977; FAIRBAIRN n.d.; NRCD & TGI 1981). A total of 44 species were observed distributed among 21 families while HAVERSCHMIDT (1965) reported 87 from Suriname, and FFRENCH (1966) and BACON (1970) reported 97 and 137, respectively from Trinidad. This may be related to the continental nature of these areas. Habitat groupings include 18 water birds, 3 birds of prey and 18 terrestrial species. The only seabird roosting within the West Harbour environs was the frigate *Fregata magnificens* Matthews. The snowy egret *Egretta thula* (Molina) and the great egret *Egretta alba* L. were often observed feeding among the *Thalassia* shallows fronting the lagoon. However, the most frequently encountered species was the common stilt *Himantopus himantopus* L., feeding and breeding in the low scrub vegetation of salinas.

West Harbour has been the traditional hunting ground for the PWD Gun Club since 1937. Large flocks of doves and pigeons, particularly the white-winged dove (*Zenaida asiatica* (Linne)) are hunted for 9 weeks during August and September. This may also have some effect on avifauna diversity.

The endangered Antillean manatee *Trichechus manatus manatus* (Moore), mother and calf, were observed in the *Thalassia* shallows and mangove island inlets (depth ≈ 3 m) of the Outer Harbour. This constitutes a rare visual observation; previous censuses record less than 150 individuals in Jamaican waters (FAIRBAIRN & HAYNES 1983). This species is listed as 'threatened' in Jamaica and is protected under the Wildlife Protection Act.

DISCUSSION

West Harbour is shown to be a large diverse, highly representative marine mangal sharing features in common to island mangals. It has a high degree of naturalness and the environment is pristine and stable. These features are important to its consideration as a marine national park. The arid climate, basin topography and relatively small catchment area reduce the

incidence of episodic flood events and their impacts (GOODBODY 1961). However, the shallow hydrography, low energy current regime and open nature increase the damage risks from waterborne pollutants such as oil. Management of the West Harbour mangal should therefore focus not only on the maintainance of forest communities but interpret this through a wider water management scheme that will maintain or enhance hydrography and identify critical areas such as the overwash islands, that are susceptible to seaborne pollutants. Further studies are necessary to investigate the links between West Harbour and neighbouring ecosystems (seagrass beds and coral reefs) for the determination of integrated management guidelines for the coastal zone. However, for those Caribbean countries concerned with the status of wetland or mangal resources, a highly representative site like West Harbour should be intensively studied providing a basis from which extrapolations to other sites can be made.

Future research efforts should concentrate on standardizing the way in which mangals are described and assessed in conservation planning activities. The delineation of the mangal is of particular interest for legal and cartographic purposes since mangals respond dynamically to changes from ambient temporal and spatial hydrological and geomorphic conditions and may present complications in long term planning.

A comprehensive treatment of the mangal fauna is lacking (SNEDAKER 1989) and it is therefore incumbent to conduct broad surveys as a first documentation. While some mangals may not exhibit outstanding features at the species or community level, they may still be worth conserving as gene pools or refuge and opportunity habitats for endangered species. The critical nature of the mangal habitat may not be easy to determine, it is therefore suggested that future research determine the importance of opportunity (SCHAMBERGER & KROHN 1982) for rare, threatened or endangered species in site assessments. That the Antillean manatee was observed in West Harbour and frequently in the general Portland Bight area (FAIRBAIRN & HAYNES 1983) may therefore augur well in initiatives to not only protect the habitat but any future field measures to resuscitate the population. These findings lend support for the conservation of West Harbour and similiar mangals within the Region.

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