The Discovery Bay Fishery Reserve: Its Development, Management, Monitoring Plans, and Current Status

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ABSTRACT

For years, the idea of a Marine Protected Area or Fish Sanctuary for Discovery Bay, Jamaica, has been suggested. Through collaboration of the University of West Indies' Fisheries Improvement Programme (FIP), the Discovery Bay Marine Laboratory, the Alloa Discovery Bay Fishermen's Association (DBFA), and Kaiser Jamaica Bauxite Company, plans for the Discovery Bay Fishery Reserve (DBFR) are finally nearing implementation.

The organizations and institutions working towards the establishment of DBFR all recognize the need to protect the fishery resources in Discovery Bay. Fish catches have dwindled, some species have disappeared, and the fish caught are small and often immature; therefore, it is likely that local sources of recruitment have deteriorated and the fishery cannot recover unless fishing pressure on at least part of the bredding stocks is relieved.

Current assessment of fish abundance suggests that overfishing has led to small populations of primarily juvenile individuals. The data indicate that parrotfishes are the most abundant commercially valuable fish group in the area of the proposed DBFR, and this is confirmed by catch data obtained by FIP from fishers. Large grazing fish are rare, and damselfishes are the dominant species on the reefs in Discovery Bay.

The Discovery Bay Fishery Reserve is unique in its organization, management and monitoring plans: fish catches have been recorded since 1990, baseline data on fish abundance has been collected in 1992 and 1995, permanent monitoring sites have been established, and funding has been secured for future monitoring of fish abundance and catches in Discovery Bay. Furthermore, local community support for the establishment of the DBFR has been consolidated by the Alloa DBFA, which has been instrumental in its planning. Monitoring of fish abundance and catches in the Reserve will allow for assessment of its effectiveness as a coservation and a fisheries management strategy.

INTRODUCTION

The coral reef that fringes the north coast of Jamaica provides a marine resource that is important both to fishing and tourism (Sandeman and Woodley, 1994). Overfishing has contributed to the deterioration of this resource (Hughes, 1994), especially on the north coast where the reefs are very small and easily accessible to fishers. While Jamaica was one of the first countries to introduce a marine Protected Area (Morant and Pedro Cays Management Area, 1909), the designation of MPAs for coral reef fishery enhancement is a new concept in Jamaica (Munro & Williams, 1985; Roberts & Polunin, 1993). The one functioning MPA in Jamaica is the Montego Bay Marine Park, which is primarily aimed at protecting tourism interests not fishery resources.

For nearly 20 years, an MPA or fishery reserve has been proposed for Discovery Bay, which is situated centrally on Jamaica's north coast (Figure 1). Through collaboration of the University of the West Indies' Centre for Marine Sciences, the Fisheries Improvement Programme, the Alloa Discovery Bay Fishermen's Association, and the Kaiser Jamaica Bauxite Company, the Discovery Bay Fishery Reserve (DBFR) will shortly come into existence. the DBFR has been included in the Jamaican government's plan for a system of national parks in Jamaica (NRCA, 1995). The Fishery Reserve will be located within the west side of the bay (Figure 2).

Discovery Bay

Discovery Bay lies on the north coast of Jamaica at 18 28'00N 77 24'30W. The bay forms a horse-shoe shaped embayment, with a diameter of 1.5 km. The northern seaward side of the bay is fringed by coral reefs, through which a natural channel was deepened from 5 to 12 meters in 1964 to facilitate the movement of bauxite bulk carriers into the bay. The bay is mostly deep, reaching 55 meters. The west fore-reef is only about 300 meters across, whereasa the east fore reef extends nearly a kilometer seaward (Figure 2).

The bay is surrounded by rocky shores except on the sheltered south-east side, where there is a sandy beach 500 meters long named Puerto Seco (the name originally given to the bay by its Spanish explorers because they found no land-based fresh water source). A row of large private villas front onto the sea on the east side of the bay. Port Rhoades, the loading facility of Kaiser Jamaica Bauxite Company (KJBC), occupies the south-west corner. A majority of the rocky wooded land to the west of the bay is managed by KJBC and is still undeveloped. On the cliffs above the western shore, KJBC has established Columbus Park (an educational park and viewpoint). On a low headland to the north, is the Discovery Bay Marine Laboratory (Woodland, 1987). There are two fishing beaches in the bay, Old Folly, immediately east of Port Rhodes, and Top Beach, north of Puerto Seco beach (Figure 2).

Jamaica's North Coast

In contrast to many other parts of the Caribbean, reefs on the north coast of Jamaica are barren of fishes. The major cause of the impoverished fish populations on the north coast is undoubtedly ovefishing (Munro, 1974; Koslow *et al.*, 1988; Gill *et al.*, in press; Miller *et al.*, in press). Furthermore, the north coast suffers more than the south due to its very narrow shelf. The southern shelf is up to 20 km wide and there are several large off-shore banks over which the

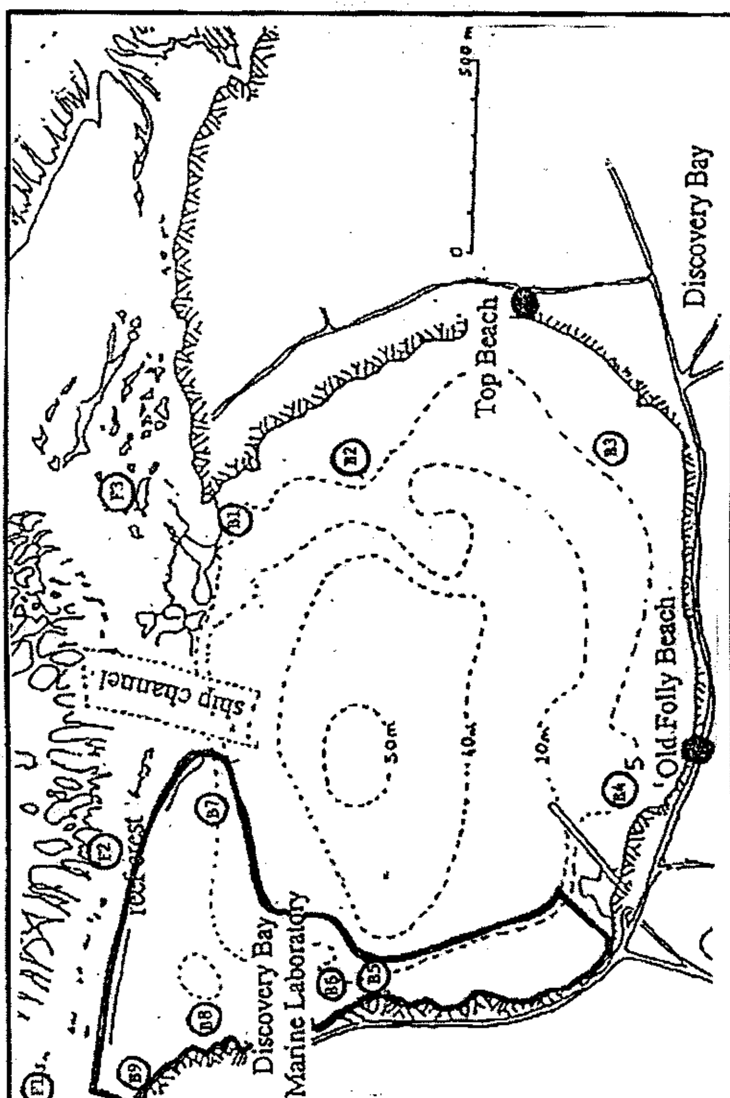

Figure 1. Location of Discovery Bay, Jamaica

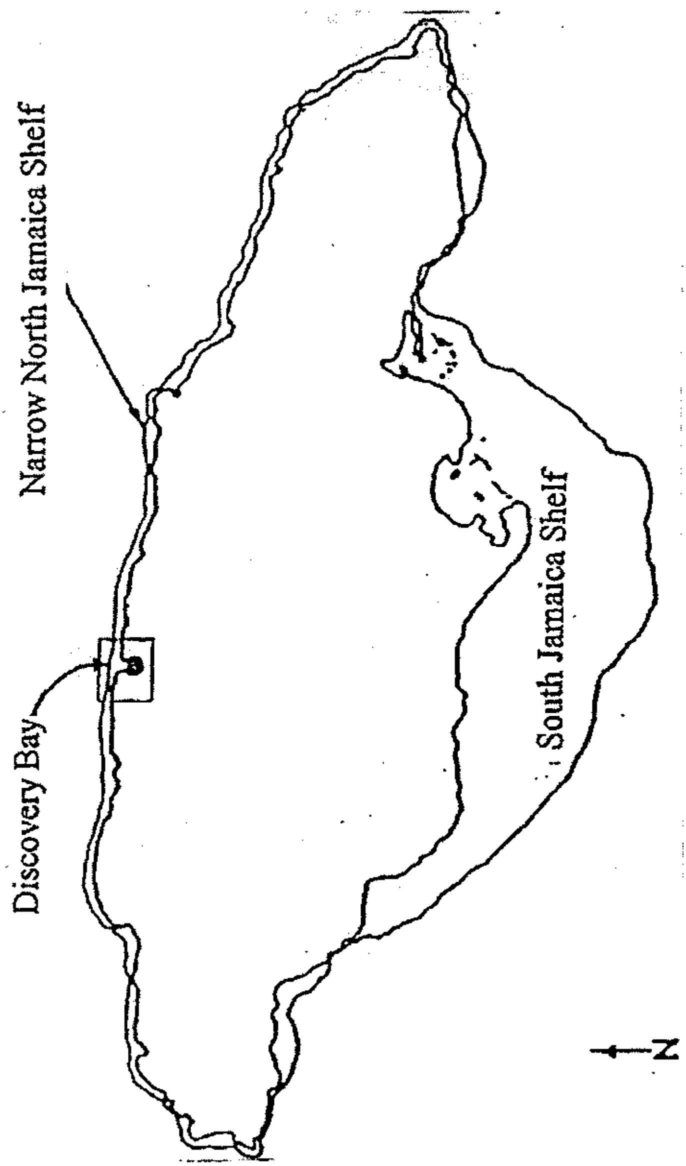

Figure 2. Discovery Bay, with proposed boundaries of the Discovery Bay Fishery Reserve (Marine Protected Area) outlined by the thick black line. Fish monitoring sites are indicated by the encircled numbers.

fishermen can disperse. On the north coast, fishing is concentrated on the narrow fringing reef, where total fish population has always been relatively small; however, in earlier times, there were regions of local abundance (Sandeman and Woodley, 1994).

The state of benthic communities at Discovery Bay has been documented by photographic quadrats and line transects since 1976; corals are greatly reduced in abundance and algae are unusually common. To some extent, these changes can be attributed to catastrophic natural disasters: hurricane Allan in 1980, hurricane Gilbert in 1988, and the mortality of the important grazing sea-urchin, *Diadema antillarium*, in 1983. (*D. antillarium* has been making a slow recovery since 1993, though only in shallow water). However, deforestation, agricultural practices and coastal development have led to siltation on reefs while an increasing output of human wastes has accelerated eutrophication (nutrient loading) of freshwater run-off (Woodley, 1987) into the bay. Eutrophication and siltation are the main causes of the shift in dominant reef organisms from corals to fleshy algae.

MARINE PROTECTED AREAS (MPAs)

The Importance of MPAs as a Conservation Strategy

Reserves can increase local abundance, mean size and biomass of the protected fish species (Man *et al.,* 1994). They are generally aimed at increasing species abundance and long-term survival of valuable fish species. There are currently approximately 1000 designated MPA's world-wide (Akegbejo-Samsons, 1994; McNeil, 1994), with about 135 found in the Caribbean. The majority of the world's MPA's are found in tropical marine areas, especially on coral reefs in developing countries which rely heavily on the exploitation of reef fish as well as on tourism. When other conservation strategies are considered, fishery reserves on tropical reefs provide relatively inexpensive conservation alternatives for developing countries. The relative ease of enforcement of MPAs compared with other conservation strategies, and the minimal requirement for information on fish biology of the stocks, means that initial costs of an MPA are less than many other management strategies (Roberts and Polunin, 1991; Roberts and Polunin, 1993). Also, since coral reef habitats represent high species diversity, protecting them benefits a number of species. Furthermore, fishery reserves provide protection to the coral reef habitat from direct physical damage caused by fishing boats, anchors, and gear.

The advantages of establishing MPAs for sustaining fish populations, consist of the following: protection of spawning stocks (Tongilava, 1990; Van't Hof, 1990; Craik, 1992: Roberts and Polunin, 1993; McManus, 1994), provision of recruits to replenish fishing grounds (Craik, 1992; Roberts and Polunin, 1993; McManus, 1994), protection of genetic diversity (Roberts and Polunin, 1993; McManus, 1994), and maintenance of the habitat and community structure (Roberts and Polunin, 1993).

Other advantages exist in establishing MPAs which have a social, political or economic basis such as facilitating sustainable use of resources (Kenchington, 1989; Van't Hof, 1990; Craik, 1992), tourism (Kenchington, 1989; Van't Hof, 1989; Craik, 1992; McManus, 1994), local recreation (Kenchington, 1989; Van't Hof, 1990; McManus, 1994), and scientific research and education (Kenchington, 1989; Tongilava, 1990; Van't Hof, 1990; McManus, 1994). The most immediate advantage to fishers may be the enhancement of fish catches in adjacent unprotected areas through emigration or dispersal (Craik, 1992; Roberts and Polunin, 1993).

Problems associated with existing MPAs

Van't Hof (1990) estimated that of the approximately 135 MPAs in the Caribbean, 75% are not truly protected because they do not have effective management. About 75% of the MPAs in the Caribbean are managed by governments exclusively, but only about 25% have effective daily management. The main reason for this lack of management, and thus, the inability to meet the conservation aim of the MPAs, is the lack of funding for management programs (Van't Hof, 1990). As a result, 75% of Caribbean MPAs are not meeting their goals of conserving habitat, providing for sustainable resource use, or providing for recreational and educational opportunities for the public (Van't Hof, 1990). To improve management effectiveness, MPAs must gain public support, must have an effective structure for administering management programs, which, of course, must have adequate funding.

The procedures used to designate MPAs have been slow and haphazard in many countries (McNeil, 1994). There seems to be a lack of clarity regarding the objectives of most MPAs, which often results in poor management and assessment (McNeil, 1994). There is often a problem with legislating MPAs where MPAs are not protected enough legally, which can lead to MPAs being revoked easily (McNeil, 1994). But foremost, is the lack of scientific data. There is little known regarding what factors should be considered when selecting and designing MPAs, as well as regarding the number of MPAs required to adequately protect fish stocks and where they should be established.

More scientific information is required to make wise decisions regarding the planning, management and implementation of MPAs, so that optimal conditions for conservation of fish species may be attained. For instance, we need a better understanding of recruitment biology to fully understand the effects of exploitation of fish (Upton, 1992; Roberts and Polunin, 1993).

THE DISCOVERY BAY FISHERY RESERVE (DBFR)

Location

The designated area for the fishery reserve is the west back-reef, immediately in front of the Discovery Bay Marine Laboratory (DBML). The boundaries are as follows: (i) the reef crest to the north, (ii) the north-south line drawn south of the canoe channel, (iii) a line following the 10 meter depth contour to the south-west back to Columbus Park, (iv) the shoreline to the south (Haley, 1994) (Figure 2).

The West Back-Reef

The west fore-reef and back-reef, located immediately seaward of DBML, are the most studied regions of Discovery Bay. The back-reef is dominated by the sandy lagoon zone, 1-5 meters deep, which grades seaward into the shallow rear zone of the reef crest. In the lagoon, there are irregular fields of turtle-grass (*Thalassia testudinum*) and plains of sand, which in 3-5 M, may be hummocky from the burrow-mounds of ghost shrimp (*Callianassa sp.*). In shallower areas with coarser sand, there are abundant calcareous algae such as *Halimeda incrassata, Penicillus capitatus* and *Udotea flabellum*. Within 100m of the reef flat are found increasing quantities of coral rubble, mostly old slabs of *Acropora palmata*, beneath which is a rich invertebrate fauna. Closer to the rear zone are scattered massive coral heads and patches of *Siderastrea siderea* and *Montastrea annularis*, many of them dead and eroded. Dense mats of fleshy and calcareous algae often grow on the coral heads and on the shallow hard grounds that abut the rear zone (Woodley, 1987).

Planning and Mangement

The establishment of the Discovery Bay Fishery Reserve is funded under the Discovery Bay Environmental Management Project (DBEMP). The DBEMP originated as a proposal drafted by Dr. J.D. Woodley, Director of the Centre for Marine Sciences at the University of West Indies, Dr. M. Haley, Director of Discovery Bay Marine Laboratory (DBML), and four other faculty of The University of West Indies. In September 1994, the proposal was presented to Kaiser Jamaica Bauxite Company, and in March of 1995, funding for DBEMP was approved.

All parties involved with the creation of DBFR agree that for this reserve to be successful and sustainable, it needs local support, particularly the cooperation of the fishermen. The Fisheries Improvement Programme (FIP) has worked in Discovery Bay since 1988 to raise fishers' awareness of sustainable fishery practices and promote the benefits of reserves.

Management plans of the reserve, outlined by Woodley *et al.*, 1994, will be organized with and executed by the Alloa Discovery Bay Fishermen's Association. All parties agree that the reserve will be ineffective unless there are staff to enforce the no-fishing regulation, and funds have been secured for this purpose. Presently, boundaries have been decided and agreed upon by all parties involved. Marker buoys have been purchased and funding secured to hire a Fishery Reserve manager and rangers for two years (the duration of the DBEMP proposal). Monitoring will be aided by the fact that the boundaries selected for the reserve are in close proximity to DBML, and also because the majority of fishers support the choice of boundaries. These boundaries will be expanded in stages to include some of the fore-reef (Haley, 1994), provided local support exists for such expansion.

Base-line Data and Recommendation for Fish Monitoring (Black, 1996)

There is currently insufficient evidence for the extent to which MPAs enhance adjacent fisheries (Roberts and Polunin, 1993; McNeil, 1994). Base-line data and ongoing monitoring are essential to assess the effectiveness of the DBFR as a conservation strategy and fisheries enhancement tool.

Base-line data on fish community structure and habitat types in Discovery Bay were collected during the summer of 1995 (July-August). This data will be used to monitor future changes in fish community structure with the implementation of the DBFR. Furthermore, recommendations were made for future fish monitoring at DBFR.

Methods

Underwater, visual, fish censuses were conducted at twelve sites in Discovery Bay (Figure 2) using the *Bohnsack and Bannerot Census Technique (Stationary Fish Census Technique)*, and the *Belt Transect Census Technique* as described by Rogers *et al.*, 1994. Slight modifications were made due to particular conditions at Discovery Bay, such as low visibility at some sites. The radius of the cylinder used for the *Bohnsack and Bannerot* method was 5 M, and the distance on either side and above the 50 M transect sampled for the *Belt transect* method was 2 M.

Sampling took place over a two month period. Three factors were taken into consideration for site selection; distinguishably of the site, limitations of depth, and habitat representation. Three sites are located within the fore-reef, and 9 within the back-reef (Figure 2). Three sampling events took place at each site, and these events were seperated by approximately 2 weeks. Each sampling event consisted of 2 samples: one *Belt Transect*, and one *Bohnsack and Bannerot Census Technique.*

Results and Recommendations

The most abundant fish species counted during censuses were *Stegastes spp.* (beaugregory, dusky, and threespot damselfish), *Scarus spp.* juveniles (striped/princess parrotfish juveniles), *Chromis cyanea* (blue chromis), and *Thalassoma bifasciatum* (bluehead wrasse) (Figure 3). The fore-reef censuses were dominated by Pomacentridae (*Chromis spp.*), and Labridae, whereas Pomacentridae (damselfish) and Scaridae were the most abundant families included in censuses at the back-reef sites (Figure 4). Please refer to Appendix I for a list of species and codes, and Appendix II for a list of families and codes.

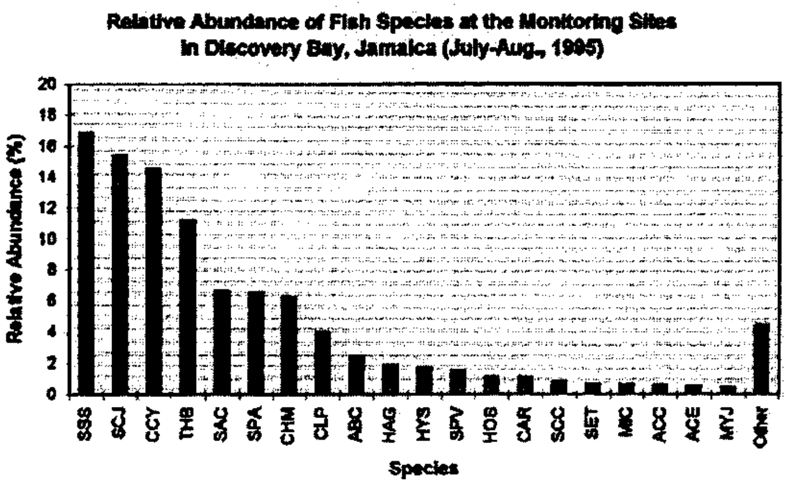

Figure 3. Relative abundance of fish species at the monitoring sites in Discovery Bay, Jamaica (July-Aug., 1995). Data were averaged for the two census techniques (Belt Transect Census Technique and the Bohnsack and Bannerot Census Technique).

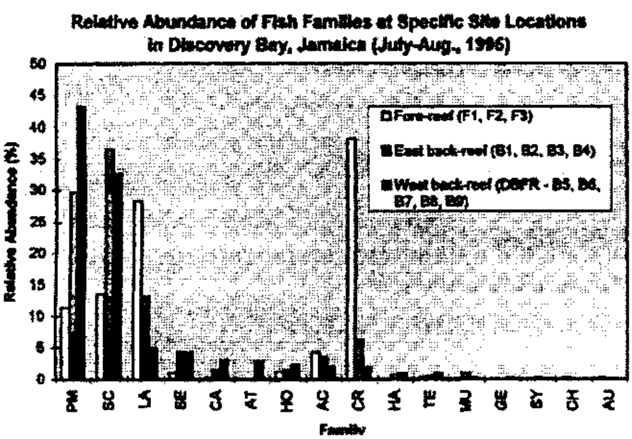

Figure 4. Relative abundance of fish families at specific site locations in Discovery Bay, Jamaica (July-Aug., 1995). Data were averaged for the two census techniques (Belt Transect Census Technique and the Bohnsack and Bannerot Census Technique).

Multidimensional scaling analyses (MDS) were carried out (using SYSTAT version 5) on Pearson Correlations to relate sites in terms of community structure. Pints on an MDS display which are close to one another are more similar on the basis of community structure (fish species composition and relative abundance), than points which are farther apart. A seperate MDS was carried out for each of the census techniques used. Both MDS displays show a grouping of fore-reef sites and a grouping of back-reef sites (belt transect MDS: Stress = 0.06715, RSQ = 0.98187; Bohnsack and Bannerot MDS: Stress = 0.05592, RSQ = 0.98830) (Figure 5 and 6).

The MDS display for the data obtained using the *Bohnsack and Bannerot* census technique does not include site B9 due to it's shallow depth (Figure 6). Furthermore, this display shows site B8 as distinct from the grouping of other back-reef sites (Figure 6); this is not evident when an MDS was carried out on *Belt transect* data (Figure 5). Site B8 is characterized by sandy bottom, and virtually no species were counted during *Bohnsack and Bannerot* censuses at this site. Due to the nature of the technique, *Bohnsack and Bannerot* censuses are more centralized to one habitat type. However the *Belt transect* sample extended into other habitat types, such as sea grass; therefore, fish counts for this method were more similar to other back-reef site censuses.

The following recommendations were made for future monitoring of the DBFR: to use multidimensional scaling analysis displays from these and future censuses to monitor changes in community structure over time with the implementation of the DBFR; to establish permanent markers to identify monitoring sites; to train at least two samplers to carry out censuses in future years to increase replication, or to only use the *Bohnsack and Bannerot Census Technique* for future censuses; to establish more monitoring sites which are deeper than 10 M; and to conduct a base-line study, and ongoing monitoring, at a "Control Bay" to monitor natural variability in MDS displays.

CONCLUSION

Present Status of DBFR

The government of Jamaica has included Discovery Bay in its "Green Paper: Towards a National System of Protected Areas for Jamaica" released in August of 1995 (NRCA, 1995). The National Resources Conservation Authority (NRCA) is the organization, designated by the Government, with the responsibility of environmental management of protected areas. Presently, there are two parks legislated under the NRCA Act of 1991: Blue and John Crow Mountains National Park and Montego Bay Marine Park. The Center for Marine Sciences at The University of The West Indies and Discovery Bay Marine Laboratory are currently working with the NRCA and the Department of Agriculture's Fisheries Division to secure the legal recognition and protection of DBFR.

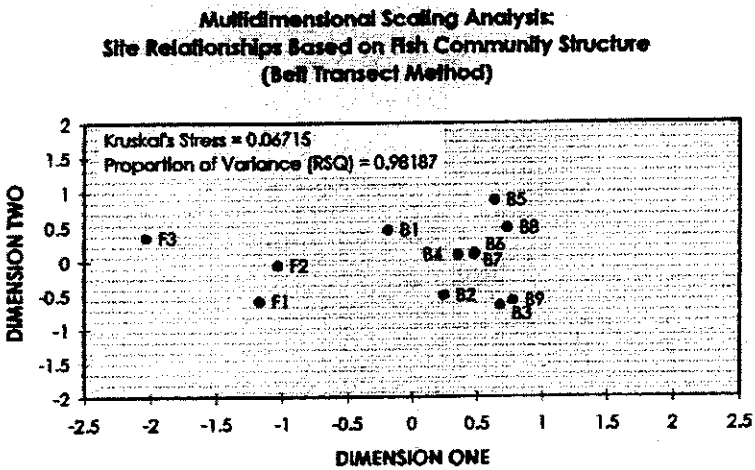

Figure 5. MDS display showing site relationships based on fish species composition and abundance data obtained using the Belt Transect Census Technique.

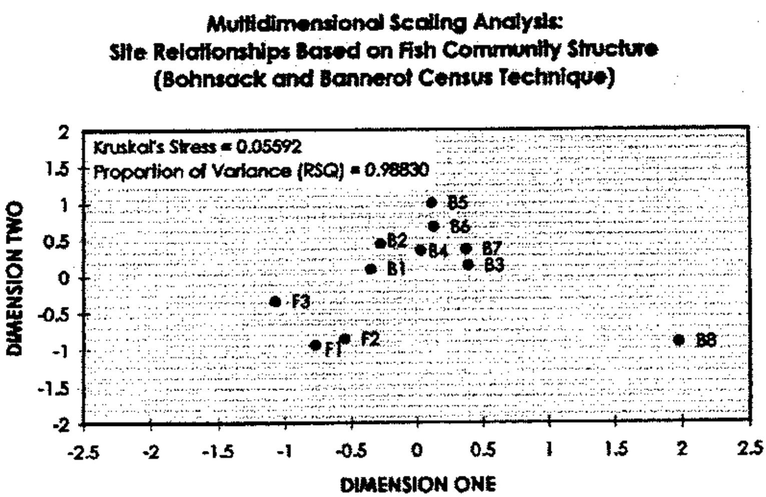

Figure 6. MDS display showing site relationships based on fish species composition and abundance data obtained using the Bohnsack and Bannerot Census Technique.

Last Remarks

The planning and management of fishery reserves requires an interdisciplinary approach because of the many economic, social and scientific concerns involved (Kenchington, 1989; Craik, 1992; Werren, 1993). All parties involved to date in the planning of DBFR have made efforts to ensure that these concerns were addressed.

The establishment of MPAs are essential in order to successfully conserve fish species diversity; however, little is known regarding the criteria that make an MPA a successful conservation strategy. Most of the information regarding MPAs is based on theory rather than scientific data. For this reason, biological monitoring, and recruitment studies on "outspill" to adjacent fisheries need to be carried out on existing MPAs.

ACKNOWLEDGEMENTS

The Discovery Bay Fish Sanctuary was conceptualized by Dr. Jeremy Woodley, Director of the Center for Marine Sciences. The University of The West Indies, Mona Campus, over two decades ago. The original groundwork, planning, meetings and negotiations are all thanks to Dr. Woodley, Dr. Haley of the Discovery Bay Marine Laboratory and the Fisheries Improvement Programme.

The funding which has transformed the Discovery Bay Fishery Reserve from a much discussed concept to a long awaited reality is from the Kaiser Jamaica Bauxite Company. Thanks to Kaiser Jamaica Bauxite Company's financial support and shared interest in the marine environment, funding for the initial phase of DBFR has been made possible.

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APPENDIX I

CODE	Species
ABC	*Acanthurus spp.*
ACC	*Acanthurus coeruleus*
ACE	*Atherinidae, Clupeidae, Engraulididae*
CAR	*Caranx ruber*
CCY	*Chromis Cyanea*
CHM	*Chormis multineata*
CLP	*Clepticus parrae*
HAG	*Halichoeres garnoti*
HOS	*Holocentrus spp.*
HYS	*Hypoplectrus spp.*
MIC	*Microspathodon chrysurus*
MYF	*Myripristis jacobus*
SAC	*Sparisoma spp.*
SCC	*Scarus croicensis*
SCJ	*Scarus spp. (juvenile)*
SET	*Serranus tigrinus*
SPA	*Stegastes partitus*
SPV	*Sparisoma viride*
SSS	*Stegastes spp.*
THB	*Thalassoma bifasciatum*

APPENDIX II

CODE	Family
AC	Acanthuridae
AT	Atherinidae
AT	Clupeidae
AT	Engraulididae
AU	Aulostomidae
BA	Balistidae
CA	Carangidae
CH	Chaetondontidae
CR	Pomacentridae
DA	Dactylopteridae
GE	Gerreidae
GR	Grammatidae
HA	Haemulidae
HO	Holocentridae
LA	Labridae
LU	Lutjanidae
MR	Muraenidae
MU	Mullidae
OP	Ophichthidae
PM	Pomacentridae
PO	Pomacanthidae
PR	Pricanthidae
SC	Scaridae
SE	Serranida
SY	Synodontidae
TE	Tetraodontidae