Outmigration and Movement of Tagged Coral Reef Fish in a Marine Fishery Reserve in Jamaica

JOHN L. MUNRO
ICLARM Caribbean/Eastern Pacific Office
158 Inland Messenger Service
Road Town, Tortola
British Virgin Islands

ABSTRACT

Between December, 1996 and May, 1998, a total of 6,947 coral reef fish were marked and released within the Discovery Bay Fishery Reserve, on the north coast of Jamaica. Nearly 6,000 recaptures have been obtained (including multiple recaptures of the same individuals). Most recaptured fish were caught in the project's traps, fishing within the fishery reserve, and re-released. Additionally, several hundred fish have been returned by fishers operating in adjacent areas.

The Discovery Bay Fishery Reserve is comprised of 27.5 ha of backreef and seagrass beds with few patches of live coral and is mostly less than 2 m deep. It serves principally as a nursery habitat for coral reef fish. However, the mark-and-recapture program has shown that some species remain resident in the reserve for extended periods and biomasses of these species appear to have increased substantially. Other species move out of the reserve with increasing size and two species of parrot fish have moved substantial distances (tens of km) along the narrow northern shelf of Jamaica.

It is concluded that for most species the fishery reserve serves to delay the age and size at recruitment to the trap and spear fisheries and is therefore enhancing catches in the fisheries in adjacent waters. Species which take up residence in the reserve have the potential to supplement the heavily depleted spawning stock biomasses.

KEY WORDS: Catch rates, mark and recapture, recruitment

INTRODUCTION

The coral reef fish resources of Jamaica have been heavily exploited for many years, particularly on the narrow northern shelf, where high population densities and limited employment opportunities make fishing an occupation of last resort for numerous people. The principal method of capture is by the use of wire-mesh Antillean fish traps (Munro 1983) but spear fishing has become increasingly important, particularly as it offers opportunities for income for young men with minimal capital. The fishing intensity in all areas is extremely high. The small mesh of the traps ensures that almost all species become

catchable captured well before maturity and that the larger species have negligible chance of survival to maturity (Munro 1983).

Catch rates have declined in recent years and the value of the catch has fallen markedly as the abundances of more valuable species such as groupers, snappers and large grunts have been reduced to negligible levels. In some cases these fish have virtually disappeared. Large species of parrotfish (Scaridae), triggerfish (Balistidae), angelfish (Pomacanthidae) are very rarely seen. Trap catches are dominated by small species of parrotfish and surgeonfish (Acanthuridae). Moray eels (Muraenidae) are the major piscivores and squirrelfish (Holocentridae), grunts (Haemulidae), goatfish (Mullidae), the small jack, *Caranx ruber*, and the snapper, *Lutjanus apodus*, comprise the other predatory species.

The coral reefs of Jamaica have been seriously overgrown by algae and coral cover reduced to a few percent in most areas. This has been attributed to the die-off of the sea urchin, *Diadema antillarum*, combined with the reduced abundance of herbivorous fish as a result of overexploitation (Hughes 1994).

The University of the West Indies has operated a Fisheries Improvement Project, based at their Discovery Bay Marine Laboratory, since 1988. This project has addressed the social and organisational problems of fishers in the vicinity of Discovery Bay, has persuaded them to increase the mesh size of their fish traps and helped to organise co-operatives and associations (Woodley 1994, Sary et al 1997). One outcome was a decision by the Alloa Fishermen's Association in Discovery Bay to set aside an area as a fishery reserve. These fishers operate from Old Folly beach in the south-west part of Discovery Bay and set fish traps mostly, but not exclusively, on the shelf to the west of the channel entrance to the Bay and in deep waters (>10 m) within the Bay.

The Discovery Bay Fishery Reserve consists of 27.5 ha of shallow backreef and bay margins on the western side of the Bay, adjacent to the Discovery Bay Marine Laboratory (Figure 1). The reserve is largely less than 2 m deep, with substantial stands of seagrass in the seaward portion and mostly-dead patch reefs separated by stretches of sand elsewhere. An ancient circular sink hole in the middle of the reserve has a maximum depth of 12 m. The northern boundary of the reserve is marked by a crest of hurricane-generated reef rubble which has a few shallow openings to the ocean at the western end. The 10 m depth contour marks the eastern boundary within the Bay. The reserve has been operational since November 1996. The boundaries are marked by buoys and the reserve is patrolled intermittently. However, the Reserve does not yet have legal status and there is no legal means of preventing people from fishing within its boundaries. Nevertheless, the trap fishers generally respect the boundaries. Spear fishers, who roam up and down the coast, regularly traverse the Reserve but appear to be more interested in fishing on the fore reef.

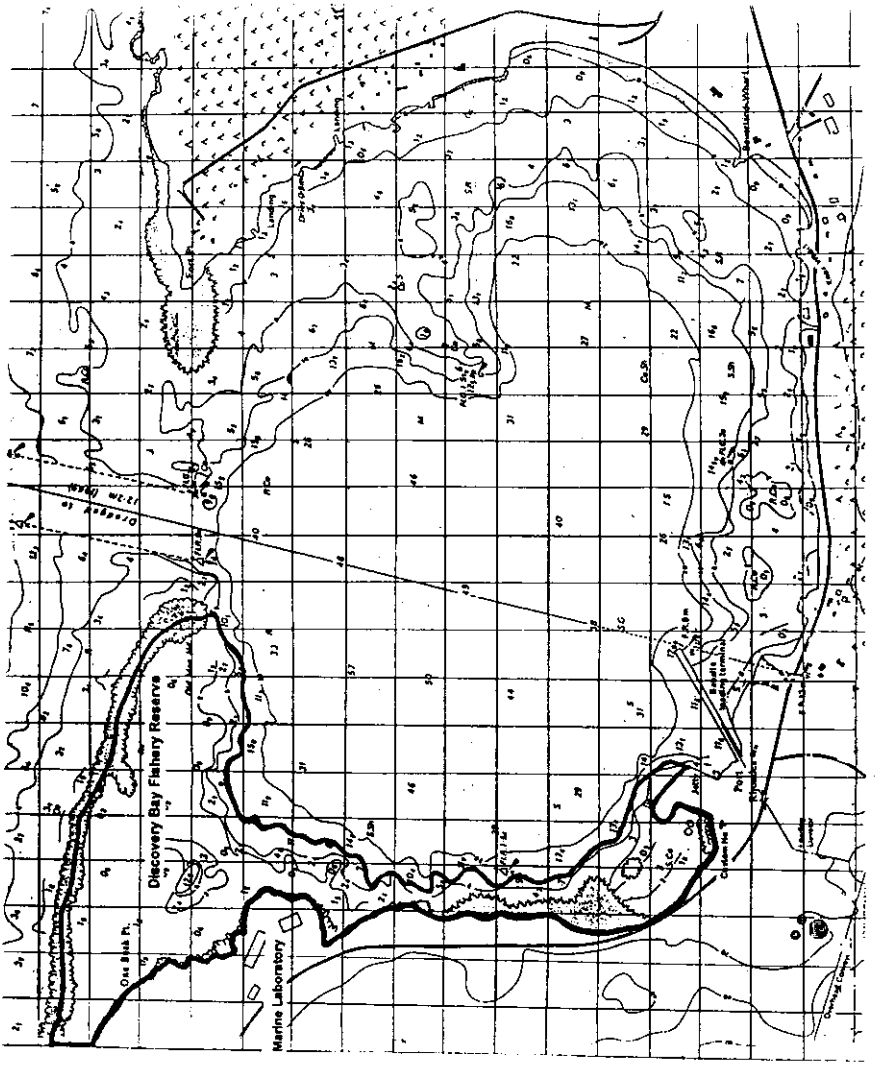

Figure 1. Discovery Bay, Jamaica, showing the location of the Discovery Bay Fishery Reserve.

Part of the activities of this project, which we operate on a collaborative basis with the Centre for Marine Sciences of the University of the West Indies, has investigated the rates of out-migration and biomass increase in the Fishery Reserve. The principal question addressed has been whether or not such a small and shallow fishery reserve would have any beneficial effect on the fish resources and the fishers.

Rakitin and Kramer (1996) found that trap catch rates for a number of species declined with increasing distance from the centre of the Barbados Marine Reserve. This effect was evident at distances of over 3 km and was attributed to outmigration from the reserve, but they were unable to document the same effect by underwater visual census. In contrast, Corless et al. (in press) found that there was limited movement of all common reef species in a 70 day period after tagging in the Soufriere Marine Management Area in St. Lucia.

METHODS

The project has undertaken a mark and recapture program since December 1996. A fleet of 10-15 double-arrowhead fish traps (Figure 2), constructed with plastic-coated 1 inch (3.3 cm maximum aperture) hexagonal mesh, has been fished within the fishery reserve. The traps were usually hauled and reset twice per week. The catches were retained alive in large bins, and each fish identified, tagged and released in the same area where it was captured. Previously tagged fish were re-measured and released. Eels and non-marketable species were not tagged. The tagging operations were conducted from December 1996 to May 1998. The recovery program will continue, at least until June 1999.

Three types of fish tags have been used. T-bar anchor tags (Hallprint TBF-1 fine and TBA-1 standard), which are applied with a tagging gun, were used on medium and larger fish. Fingerling tags (Floy FTF-69), with individual needles which are used to pass an elastic vinyl thread through the anterior cartilage of the dorsal fin, were used on the smallest fish.

Discovery Bay and the adjacent fore reef was divided into a grid system using 3 seconds of longitude (92.5 m squared) to identify tagging and recovery stations. Recoveries by fishers operating along the coast were identified by reference to known local fishing sites.

Tagged fish captured by fishers were purchased at three times the market price. Additionally, after fifteen months of operations, all fishers who had captured tagged fish were invited to a social function at which tag numbers were entered in a lottery and numerous prizes were distributed to winners in various categories. This probably helped to maintain a degree of enthusiasm for the project. However, some tagged fish were undoubtedly overlooked by fishers and, in some cases, tags were pulled out and discarded by uncooperative fishers.

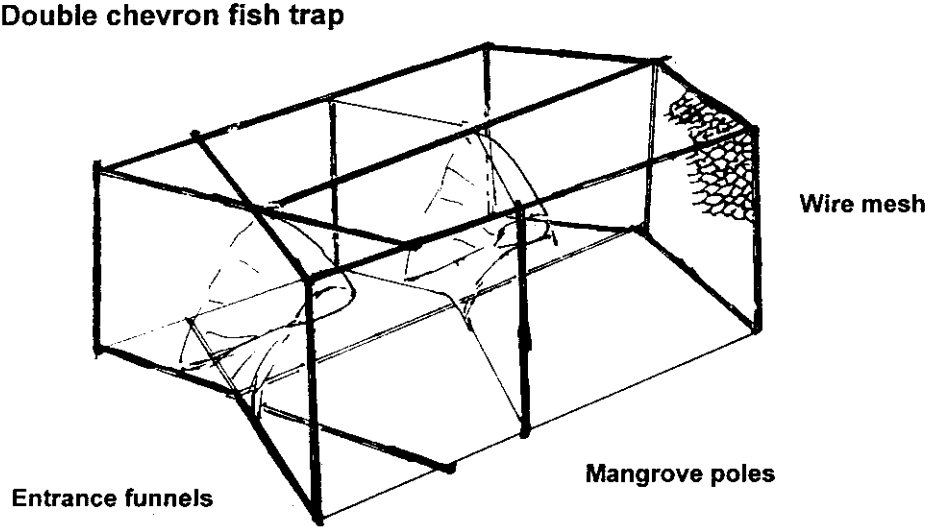

Figure 2. Double chevron fish trap constructed of 1-inch (3.30 cm maximum aperture) coated galvanised wire mesh and mangrove poles. Trap dimensions are 122 cm (48 in) along the side, 86 cm wide (36 in) and 61 cm (24 in) high.

RESULTS

A total of 6,949 fishes (48 species) were tagged and 5,919 recoveries (25 species) were obtained to 23 October 1998, including multiple recaptures of individuals. The principal species are listed in Table 1.

Clearly, there are substantial differences between species, but some generalisations can be made. Most of the smaller species remained in the reserve and many were repeatedly recaptured at the same trapping station. These included the small grunts, *Haemulon flavolineatum*, *H. aurolineautum* and *H. sciurus* and the mojarra, *Gerres cinereus*. Surgeonfish fell into an intermediate category and while most remained in or close to the reserve for extended periods, other individuals (e.g. *Acanthurus bahianus*) moved up to 3.5 km from the tagging station within a relatively short period (Figure 3). The schoolmaster snapper, *Lutjanus apodus*, behaved in a similar fashion.

Surprisingly, parrotfish proved to be highly mobile. *Sparisoma aurofrenatum* was found in the reserve for extended periods (up to 380 days) but a number were recaptured between 0.5 and 3 km from the reserve (Fig. 3). Many of these were recaptured within Discovery Bay and had not moved onto the shelf.

The larger parrotfish, *S. chrysopterum* (L_∞ = 45 cm) and *S. viride* (L_∞ = 60 cm) moved freely from the reserve (Figure 3). One individual *S. viride* remained

within the reserve for over 400 days, while others moved several km from the reserve within 100 days and one individual was recovered 16 km east of the reserve. In contrast, *S. chrysopterum* mostly had left the reserve within 120 days and large numbers were recaptured 3-10 km from the reserve and two at 27-28 km to the east.

In contrast, the striped parrotfish, *Scarus iserti*, appeared to remain in the reserve for extended periods and, with one exception, all recaptures were within the reserve or on its fringes. The exception was a 26 cm fish captured 26 km east of the reserve after 405 days. The low number of returns of this species from outside the reserve is difficult to explain. Reeson (1975) found that above 16 cm total length this species was catchable in 1.25" mesh, the size used by most fishers, so gear selectivity does not explain the lack of returns.

Table 1. Principal species of fishes marked and recaptured within and outside of the Discovery Bay Fishery Reserve. Number of recaptured fishes includes multiple recaptures of the same individual.

Species	Number tagged	Number recaptured inside reserve	Number recaptured outside reserve
Sparisoma aurofrenatum	958	1,024	42
Scarus iserti	1,120	1,093	5
Sparisoma chrysopterum	105	651	131
Acanthurus bahianus	824	600	26
Holocentrus ascensionus	183	333	5
Sparisoma viride	356	234	25
Holocentrus rufus	248	246	10
Acanthurus coeruleus	165	217	10
Pseudupeneus maculatus	154	181	4
Acanthurus chirurgus	435	151	7
Haemulon flavolineatum	273	113	1
Haemulon aurolineatum	188	109	0
Lutjanus apodus	73	93	4
Gerres cinereus	193	92	0
Haemulon sciurus	145	80	1
Mulloidichthys martinicus	161	71	0
Caranx ruber	148	35	2
Other species	275	325	0
Totals	6,949	5,646	273

A comparison of the size frequency distributions of fishes recaptured within and outside the reserve shows that for the three parrotfish (*S. aurofrenatum, S. viride* and *S. chrysopterum*) the minimum sizes taken outside the reserve are substantially larger than within (Figure 4). This is not accounted for by differences in mesh size used by the fishers since these species can be retained by 1.25" mesh at sizes of 14, 15 and 17 cm TL respectively (Reeson 1975). Therefore, it is concluded that the fish are mostly using the shallow waters of the reserve as a nursery and that for that part of the stock which is within the reserve recruitment to the fishery is delayed and yields correspondingly improved.

Our fishing operations in the reserve provide us with a record of relative abundance of all species, expressed as number of fish/trap/night. The records appear to fall into three groups:

i) Species in which changes in catch rates vary erratically with no significant changes over time. This group includes all three species of acanthurids, the French grunt, *H. flavolineatum*, and the squirrel fishes, *Holocentrus ascensionus* and *H. rufus*. These are species which occupy the reserve for extended periods as juveniles but which move out and perhaps return on an irregular basis.

ii) Species in which there are marked seasonal variations in catch rates but without any increase in relative abundance within the reserve. This includes *S. chrysopterum, H. sciurus* and the two species of goat fish, *Mulloidichthys martinicus* and *Pseudupeneus maculatus* (Figure 5 a-d). In each case there are one or two influxes of recruits per year which occupy the shallows of the reserve for several months and then move elsewhere.

iii) Species in which there is a progressive increase in catch rates which can be attributed to increases in the numbers of fish resident in the reserve. This includes the parrotfish, *S. aurofrenatum*, in which catch rates have steadily increased from negligible levels, and *S. viride*, in which the trends are less clear because of the wide range in confidence limits (Figure 5 e,f).

Catches of less abundant species were too small to permit any conclusions.

DISCUSSION

A number of species which were tagged in substantial numbers were never recovered outside of the reserve. These included *G. cinereus* and *H. aurolineatum* which appeared to be resident in the Discovery Bay Fishery Reserve. However, no tagged *M. martinicus* and only four specimens of *P. maculatus* were returned from outside the reserve despite the pronounced seasonal changes in abundance which must be accounted for by movement elsewhere.

All of the other common species were found to move out of the reserve (and perhaps return) frequently, on an irregular basis, seasonally or progressively.

Where the movement is a seasonal movement of young fish into deeper water (Figure 5 a-d) the harvests will certainly benefit from delayed recruitment of that portion of the stock which is protected by the reserve.

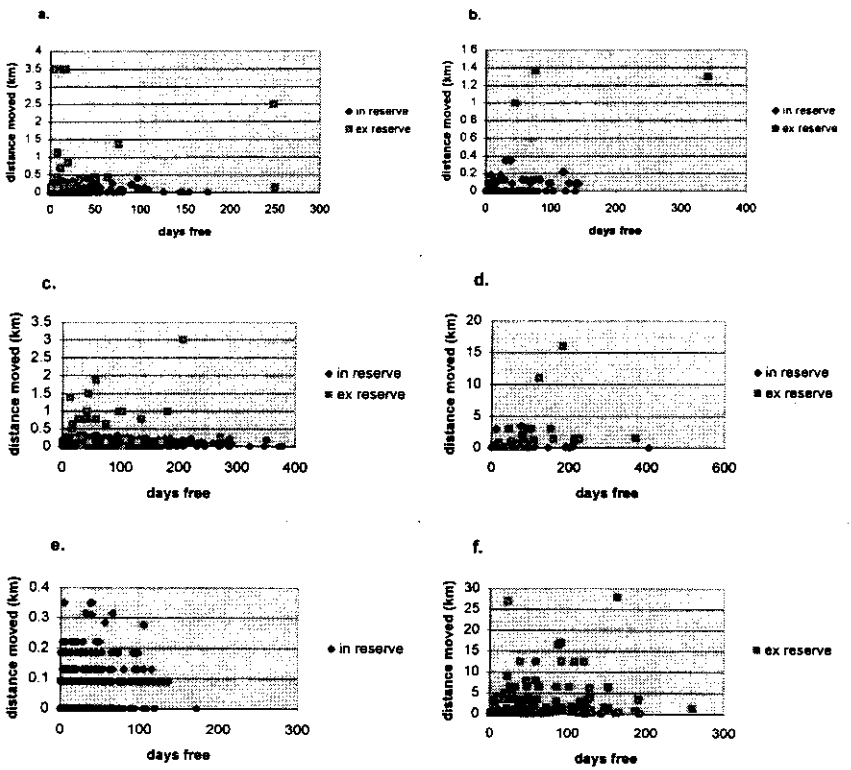

Figure 3. The relationship between distance moved and days since release for tagged fish recaptured within and outside of the Discovery Bay Fishery Reserve. a) *Acanthurus bahianus*; b) *Lutjanus apodus*; c) *Sparisoma aurofrenatum*; d) *Sparisoma viride*; e) *Sparisoma chrysopterum* recaptured within the reserve and f) *S. chrysopterum* recaptured outside the reserve.

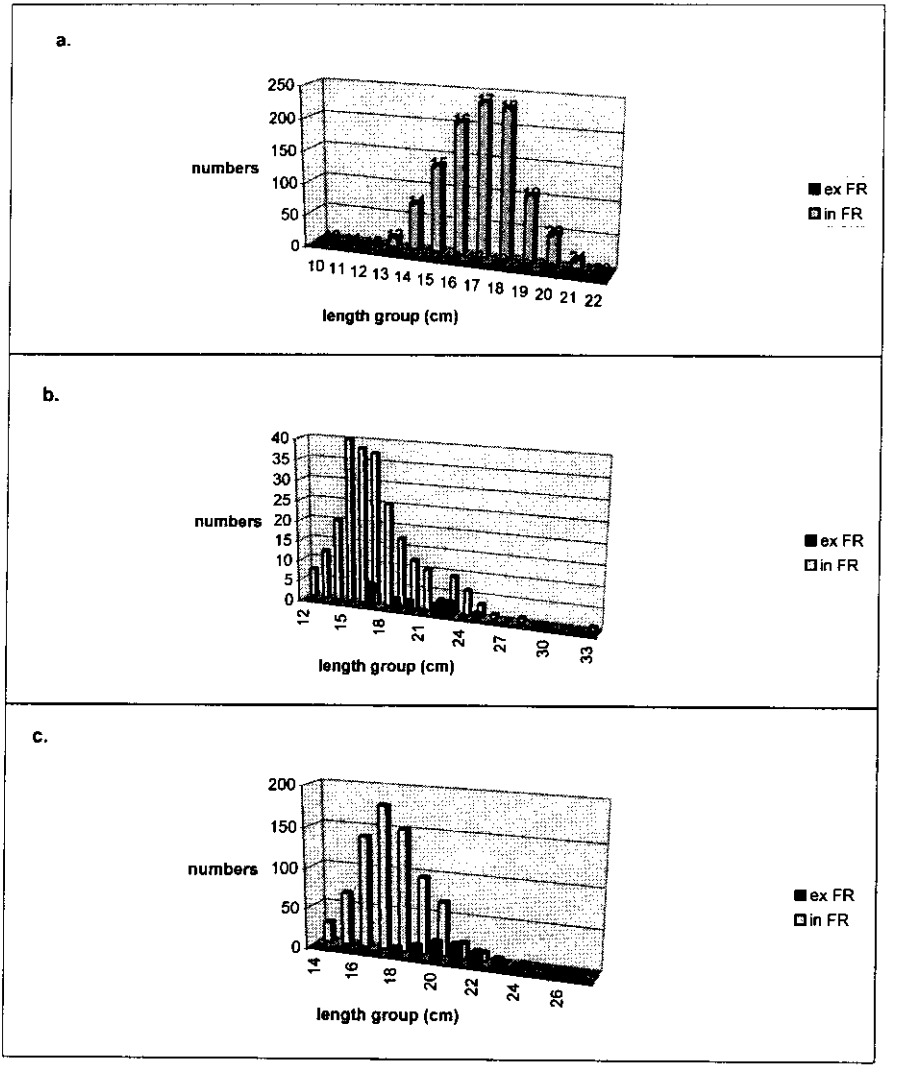

Figure 4. Size frequency distributions of three species of parrotfish captured within and outside of the Discovery Bay Fishery Reserve. a) *Sparisoma aurofrenatum*; b) *Sparisoma viride* and c) *Sparisoma chrysopterum*.

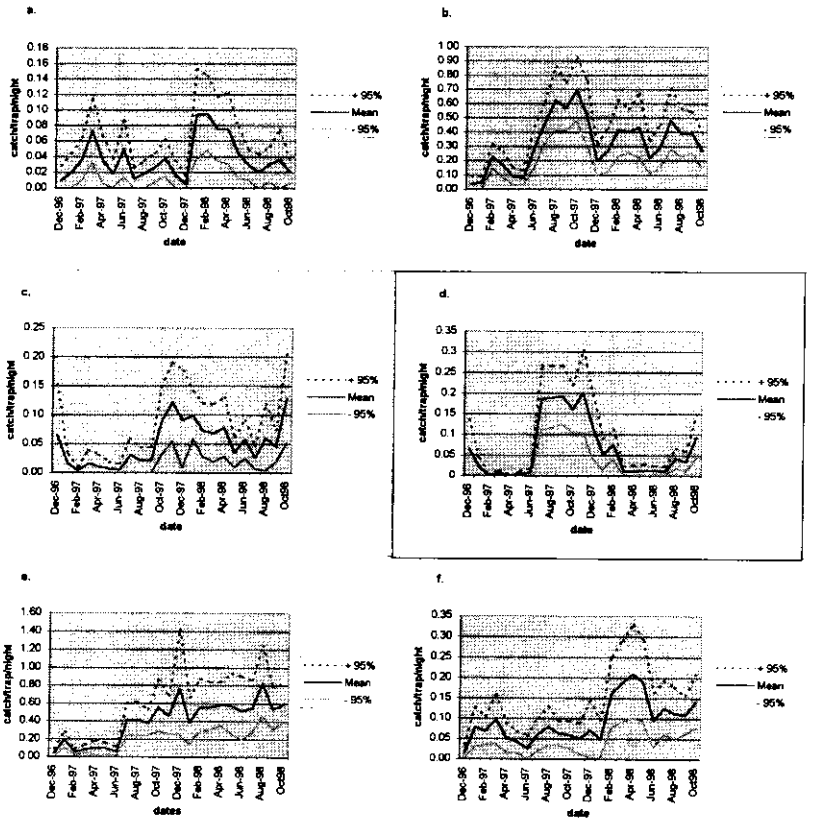

Figure 5. Changes in the relative abundance of six species of reef fishes within the Discovery Bay Fishery Reserve between December 1996 and October 1998. a) *Haemulon sciurus*; b) *Sparisoma chrysopterum*; c) *Mulloidichthys martinicus*; d) *Pseudupeneus maculatus*; e) *Sparisoma aurofrenatum* and f) *Sparisoma viride*.

In the case of progressive movement out of the reserve the harvests will likewise be improved and, additionally, if the resident stock accumulates (Figure 5 e,f) there can be a significant addition to the spawning stock biomass of those species. This is of very great importance as related work (Munro and Watson 1998) has shown that recruitment rates of most of the important species in the fishery at Discovery Bay is 2-3 orders of magnitude lower than in the relatively unexploited fish communities at Tortola, British Virgin Islands (BVI). The

species in which recruitment rates are comparable with BVI are those which have extended pelagic larval phases (acanthurids, mullids) and which can be expected to drift to Jamaica from elsewhere (Roberts 1997). Also, recruitment rates of small species which mature before recruitment to the trap fishery (*S. iserti, S. aurofrenatum, H. flavolineatum*, and *H. aurolineatum*) and which consequently have sufficient local spawning stocks are relatively undiminished.

As most of the tagged fish did not move very far from Discovery Bay, it can be concluded that the fishers who have contributed a part of their usual fishing grounds to the creation of the Discovery Bay Fishery Reserve will be the prime beneficiaries. These gains will be as a result of 3-6 month delays and hence larger sizes at recruitment for some species. Other species will have reduced mortality rates as a result of periodic residence in the reserve and hence larger average sizes. A third group, mostly of small species which mature before recruitment to the commercial fishery, will have increases in spawning stock biomass and resulting increases in recruitment rates.

These results suggest that a regulatory measure which could benefit all Jamaican fisheries would be to prohibit any fishing in depths of less than 6 m, except with hook and line. All shallow reef and seagrass beds are nursery grounds for a wide range of species. However, for Jamaican fisheries to recover, substantial areas of shallow and deep reef, particularly around the eastern, upcurrent, end of the island, will need to be turned into fishery reserves or marine protected areas. Additionally, meaningful steps will need to be taken to manage the fisheries and to improve the lot of the fishing communities.

ACKNOWLEDGEMENTS

This work has been funded by the Inter-American Development Bank and executed in collaboration with the Centre for Marine Sciences of the University of the West Indies, directed by Dr. Jeremy D. Woodley. The contributions of CMS staff, J.T. Levy, V. Murray, K. Samuels, K. Lankester and K. Black-Clark are gratefully acknowledged. The support of the Director of the Discovery Bay Marine Laboratory, Dr. Michael Haley, and his staff has been an essential element in the successful execution of this project.

REFERENCES

Corless, M., B.G. Hatcher, W. Hunte and S. Scott. 1997. Assessing the potential for fish migration from marine reserves to adjacent fished areas in the Soufriere Marine Management Area, St. Lucia. *Proc. Gulf Carib. Fish. Inst.* **49**:71-98.

Hughes, T.P. 1994. Catastrophes, phase-shifts, and large-scale degradation of a Caribbean coral reef. *Science* **265**:1547-1552.

Munro, J.L., Ed. 1983. *Caribbean Coral Reef Fishery Resources.* ICLARM Studies and Reviews. Manila 276 pp.

Munro, J.L. and M. Watson. 1998. Comparative settlement and recruitment rates of coral reef fishes in moderately-exploited and over-exploited Caribbean coral reef ecosystems. International Society for Reef Studies, European Meeting, Perpignan, September 1998. Abstract.

Rakitin, A. and D. L. Kramer. 1996. Effect of a marine reserve on the distribution of coral reef fishes in Barbados. *Mar. Ecol. Progr. Ser.* **131**:97-113.

Reeson, P.H. 1983. The biology, ecology and bionomics of the parrotfishes, Scaridae. Pages 166-177 in: J.L. Munro (ed.) *Caribbean Coral Reef Fishery Resources.* ICLARM Studies and Reviews. Manila.

Roberts, C..M. 1997. Connectivity and management of Caribbean coral reefs. *Science* **278**:1454-1457.

Sary, Z., H. A. Oxenford and J. D. Woodley. 1997. Effects of an increase in trap mesh size on an overexploited coral reef fishery at Discovery Bay, Jamaica. *Mar. Ecol. Prog. Ser.* **154**:107-120.

Woodley, J.D. 1994. Facilitating changes in artisanal fishery practice at Discovery Bay, Jamaica. Pages 75-78 in: J.L. Munro and P.E. Munro (eds.) *The Management of Coral Reef Resource Systems.* ICLARM Conference Proceedings 44, Manila.