Status of the Jamaica Reef Fishery and Proposals for its Management

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ABSTRACT

Since 1968 the annual fish production from the inshore fishery in Jamaica has been approximately 6980 t despite an 85 percent increase in the effective fishing effort. Since the late 1950's the fishing fleet has been undergoing a process of mechanization using outboard engines. Although the total number of boats increased by only 21 percent between 1968-1981, the effective fishing effort increased by 85 percent. Since 1968 the catch per effective canoe (C_w/E) has been declining at an average annual rate of 133 kg/year, and in 1981 was 59 percent of the 1968 catch rate. A logarithmic plot of C_w/E) against fishing intensity produces a linear relationship, which has been used to produce a total catch curve. This curve suggests that maximum yields were probably obtained in 1975/1976, after which the fishery entered a phase of overexploitation characterized by declining catch rates. There has also been a change in the species composition, with the percentage of highest-valued species, e.g., Lutjanidae, declining from 42 percent of the total catch in 1968 to 29 percent in 1981. Simultaneously, lower-valued fish, e.g., Acanthuridae, increased from 30 percent to 41 percent over the same period.

The above suggests that effective management of the fishery is overdue. An initial management plan is described setting out concepts, objectives and various strategies. Factors such as the problem of increasing new entries into the open-access fishery are discussed. The suggested management proposals involve mesh-size regulation in traps by means of a 2-staged introduction of 3.81 cm (1.1/2 inch) mesh; seine net mesh size regulations and spearfishing regulations. Also recommended is the control of fishing effort through the creation of 12 fish sanctuaries initially. Other management measures include a resource enhancement or artificial reef program, the continuation of fishing industry surveys, a fishermen's information and publicity campaign and establishment of a fisheries management council.

Implementation and enhancement problems are also briefly discussed.

INTRODUCTION

In Jamaica, the demand for fish and fish products is very great and growing. The local marine fishery supplies only approximately one-third of the total demand. Unemployment is high and fishing is one of the few job opportunity options for a large segment of the coastal population. Simultaneously, the fishing industry is moderately subsidized by the Government and the fishery is an open access one. The consequence of this scenario is that there is increased competition for the existing fishery resources. Historically, the fishery has been comprised of numbers of fishermen operating from a large number of scattered sites and these persons fished the coastal shelf (Figure 1) using mainly unmechanized canoes. Since 1957, there has been increasing use of outboard engines and since about 1970, an increasing number of slightly larger fiberglass canoes.

The physical characteristics of the island shelves affect the fishable resources. The north shelf of Jamaica (see Figure 1) is very narrow and nowhere exceeds 1.4 km in width before plunging vertically to deep (>100 m) waters. This restricts the size of the coral reefs and importantly, makes these smaller northern reefs very accessible due to their proximity to the shore. The south shelf, on the other hand, measures about 24 km at its widest point and provides considerably more fishable area.

Increase in Fishing Effort

In 1981 an estimated 3,760 canoes operated from the 184 fishing beaches of the island. In mid-1985 there were over 16,000 persons registered as fishermen and of these 4,000 are sport and part-time fishermen, meaning there are at least 12,000 commercial fishermen. In 1981, and probably at the present time, approximately 95% of these full-time fishermen operated in inshore areas and these fishermen produce 88% of the total landings. These fishermen use mainly Z-traps using 3.14 cm (1.1/4 inch) meshwire and lesser numbers of nets, handlines and spearguns.

Catch Statistics

Results of sample surveys of the Jamaican fishery done in 1962, 1968, 1973 and 1981 are shown in Table 1.

The mean annual production based on Table 1 is 6,987 tonnes. These figures represent landings from the island shelf only. The quantity of fish landed, when adjusted for oceanic pelagic species, gives production rates of 17 kg/ha, 19 kg/ha, 20 kg/ha for 1968, 1973 and 1981 respectively. These are probably the highest production rates for any area in the Caribbean. Yields in other Caribbean areas with well-developed fisheries varied between 6.0 kg/ha in Cuba and 15.5 kg/ha in Martinique (Munro, 1983).

Table 1. Total annual landings (island shelf) from Government Fishery Surveys

Year	Estimated Production (tonnes)
1962	10,909
1968	6,572
1973	7,233
1981	7,157

Source: Chuck, 1963; Nembhard, 1970; Russell, 1975; Sahney, 1983

Fishing Effort (Measure of Effort)

The best available measure of fishing effort in the Jamaican fishery is the number of canoes in operation. There are essentially two types of canoes, (1) Mechanized (having outboard engines) and (2) unmechanized (propelled by oars/sails). There are marked differences in their characteristics and capabilities. To obtain a standardized unit of effort, unmechanized canoes are converted to their equivalent as mechanized canoes, based on the ratio of fish production per type of boat, as follows:

$$\text{Effective canoe effort} = \text{mech. canoe} + \text{unmech. canoe} - \frac{\text{Catch/mech. canoe}}{\text{Catch/unmech. canoe}}$$

When canoe numbers are compared for 1968, 1973 and 1981, we obtain the results shown in Table 2.

Changes in Effective Effort

Table 2. Fishing Effort Variation

Year	Total Canoes	Mechanized Canoes	Unmechanized Canoes	Effective Canoes
1968	3105	1047	2062	1559.5
1973	3059	1427	1632	2045.2
1981	3760	2020	1740	2881.4

Source: Gov't. Surveys

Between 1968 and 1981 the total number of canoes increased by 21% but the effective canoe effort increased by 85% mainly due

Figure 1. Fishing areas of Jamaica and 200 m isobath

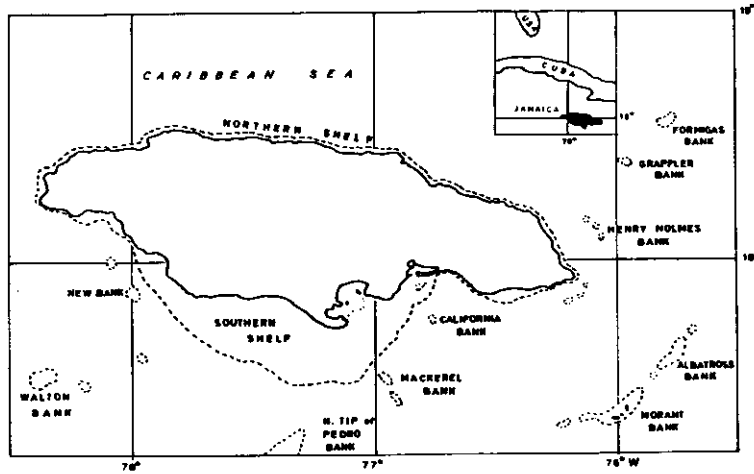
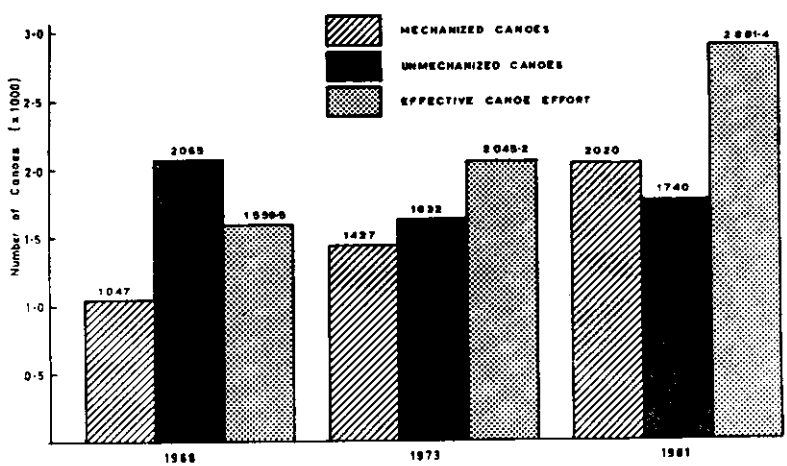


Figure 2. Changes in effective canoe effort between 1968,1973 and 1981



to a 93% increase in the number of mechanized canoes. See Figure 2.

Catch per Unit Changes

The data show that while total annual catch has remained fairly constant since 1968, the fishing effort increased significantly. The catch per effective canoe ($C_w E$) for 1968 was 4,123 kg, for 1973, 3,536 kg and for 1981, 2,484 kg. Figure 3 illustrates changes in catch per effective canoe and shows a steady decline in the catch per effective canoe. By calculating the correlation coefficient and the associated t-score at one degree of freedom ($r = 0.999$, $t = 70.205$), we are 99% confident that the relationship is not due to chance. The actual rate of decline by linear regression is 133 kg per canoe per annum. If we use 1968 as the base year, by 1973 the catch per effective canoe had fallen to 84% and by 1981 to 59%, of the 1968 figure.

Figure 4 is a plot of catch per effective canoe against numbers of effective canoes. It shows that the catch per effective canoe decreases as number of effective canoes increases. Calculating the correlation coefficient and t-score at one degree of freedom ($r = 0.99962$, $t = 36.291$) we are 98% confident that the relationship is not due to chance. In other words, despite an 85% increase in effort, there was a 41% decline in catch per unit effort.

Fishing Intensity and Catch Effects

Fishing intensity is measured as the numbers of effective canoes (mechanized) per square kilometer of shelf. The total area of island shelf and proximal banks is 3,420 sq km. Fishing intensities for 1968, 1973 and 1981 are 0.45, 0.60 and 0.84 mechanized canoe per sq km respectively. Figure 5 shows a plot of the natural logarithms of catch per effective canoe per year ($\ln C_w E$) against effective canoes per sq km (f). The relationship is linear and produces the following regression line:

$$\ln (C_w/E) = 8.9811 - 1.3760 \times f.$$

Figure 6 shows a plot of total catch, is constructed from the regression line and converted to tonnes per sq km per year. The figure suggests that a maximum yield of approximately 2,100 kg per sq km per year are attained by a fishing intensity of about 0.75 mechanized canoe per sq km.

We suggest that the data indicate that in 1968 the inshore fishery was generally underexploited. By 1973 the fishing intensity had increased to about 0.6 canoe per sq km and maximum yield was being approached. It is estimated that this maximum yield was attained around 1975/1976. Since then, the fishery has entered a phase of overexploitation characterized by declining catch rates as fishing intensity increases.

Figure 3. Changes in catch per effective canoe in Jamaica waters with time

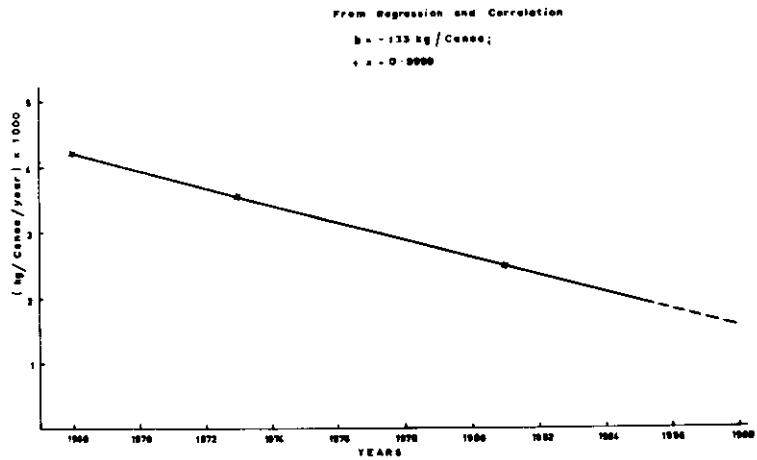
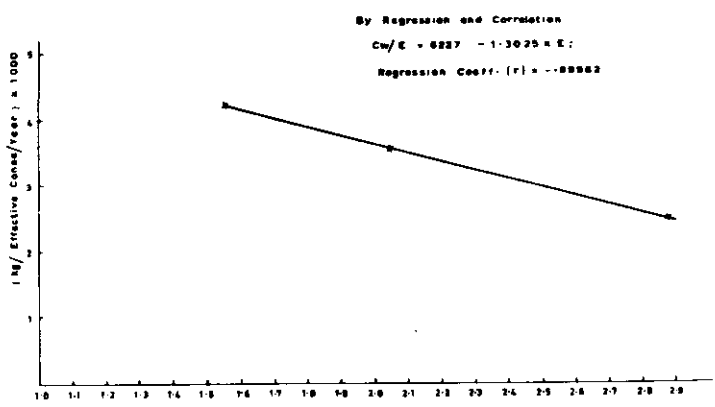


Figure 4. Changes in catch per effective canoe



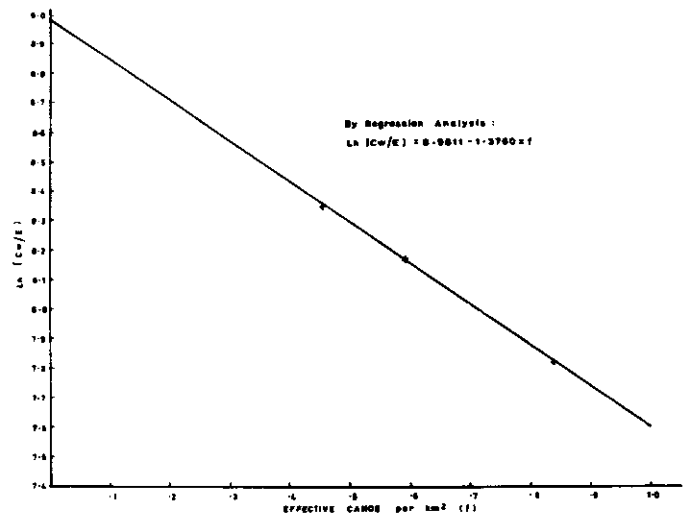


Figure 5. Natural logarithms of catch per effective canoe per year and effective canoes per km^2.

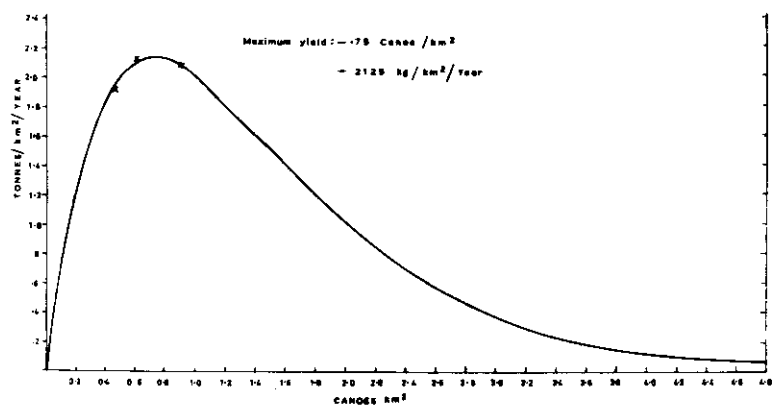


Figure 6. Calculated total catch curve. Note maximum at 0.75 canoes/km^2.

Changes in Species Composition

There have been significant changes in the species composition of the landings of finfish from the inshore fishery since 1968. These changes are summarized in Table 3. This table shows that the percentage composition by weight of higher valued species ("quality" fish such as snappers) appears to be decreasing, while the percentage of lower valued species ("common" and "trash" categories such as squirrelfish, surgeonfishes and parrotfishes), appears to be increasing. The economic benefits from the fishery are thus also declining. Also implied are more subtle changes in the trophic relationships of the coral reef fish community. However, we do not discuss this aspect further in this paper.

Table 3. Changes in species composition

Year	1968	1973	1981
Quality fish wt. (kg)	2,763	2,192	2,016
%	42	30	29
Common fish wt. (kg)	1,523	1,780	1,960
%	23	25	27
Trash fish wt. (kg)	1,994	2,808	2,897
%	30	39	41

Source: Gov't. Surveys.

The available data suggest that the inshore fishery of Jamaica is well into the overfishing phase. The fishery is characterized by falling catch rates, static total catches and declining catch value due to species changes trending towards those of reduced market value. Another characteristic for which we present no data but offer our observations, is that there is also an accompanying reduction in the mean size of fishes landed. In short, the Jamaican fishery is in crisis and in urgent need of management and control.

MANAGEMENT OBJECTIVES

The present management plan is based on the following premises. Firstly, that acceptable conservation and management proposals should prevent overfishing while attempting to achieve on a continuous basis, the optimum yield from the fishery and

also that the measures should not discriminate between fishermen from different areas. It is also accepted that conservation and management measures should, as far as possible, promote the efficient use of fishery resources and that they should as far as possible minimize costs and avoid duplication. Further, we feel that the regulations should be flexible enough to allow for proper reaction to changes in economic and biological conditions. The measures suggested should have the support of the majority of the fishermen involved and be formulated in full cognizance of the costs of necessary enforcement.

SUGGESTED MANAGEMENT STRATEGIES

Management of multispecies fishery resources may be accomplished by a number of "classical" strategies including the following:

1. Gear limitations (e.g., mesh size adjustments).
2. Fishing effort regulation.
3. Harvest limitations or quotas.
4. Closed seasons.
5. Closed areas (fish sanctuaries and scientific reserves).
6. A catch monitoring or statistical system.
7. Non-biological methods (e.g., fishing beach infrastructure improvement).

Given present Jamaican fishing industry conditions, it is thought that the following methods would be more amenable to the fishing communities and reduce socio-economic displacements:

1. Gear limitations.
2. Fishing effort regulation.
3. Closed areas.
4. Resource enhancement (Artificial Reefs Program).
5. Establishment of a Fisheries Management Council.
6. A Fishermen's Education and Publicity Campaign.

Gear Limitations

Mesh Size Regulation in Traps

The regulation of mesh sizes in a multispecies fishery is troublesome. In summary, the problem is that a mesh large enough

to allow one species to grow to optimal size, may permit practically all of another species to escape.

It is proposed to increase the mesh size of all fish traps. It was Munro (1974) who first presented extensive Jamaican data to show that mesh sizes between 4.95 cm (which has an aperture between meshwire knots of 3.81 cm or 1.1/2 inches) and 8.25 cm mesh (with interknot aperture of 6.35 cm or 2.1/2 inches) would give substantially greater yields at most levels of fishing intensity than 3.30 cm (1.0 inch interknot aperture) and 4.13 cm (1.1/4 inch interknot aperture). It must be emphasized that the figures in parentheses are not the equivalent in inches but represent aperture between knots. Munro (1974) suggested that a trap mesh size of 6.60 cm with an interknot aperture of 5.08 cm or 2.0 inches, was in the "best interest" of the fishery. However, the more deep-bodied fishes would be preferentially selected, while small cylindrical-sectioned fishes would be nearly completely eliminated from trap catches.

Work by Nicholson and Hartsuijker (1983) in their extensive testing of 4.13 cm (1.1/4 inch interknot aperture) mesh traps, suggested that even with a 0.63 cm or 1/4 inch increase in mesh, trap catches suffered immediate losses. These losses were of the small and soft-bellied fishes such as coneys (Cephalofolis fulva), goatfishes (Pseudupeneus maculatus and Mulloidichthys martinicus), parrotfishes (Scaridae), small grunts (Pomadasyidae) and squirrelfishes (Holocentridae).

But, importantly to our argument, Nicholson and Hartsuijker (1983) also stated that in spite of reduction in numbers through natural mortality, increased mesh size would have beneficial long-term effects on catch weight and catch value.

Given the present Jamaican conditions, it is proposed that a two-staged regulation of mesh size for fish traps be introduced as soon as possible. This may be set out as follows:

Stage 1:

Firstly, no trap fishing will be permitted with a wire mesh aperture which measures less than 4.13 cm (having a interknot aperture of 1.1/4 inches). This is intended to eliminate 3.30 cm mesh with its 1.00 inch interknot aperture.

Stage 2:

Having established over a period of time, through monitoring the fishery that all traps have mesh with dimensions not less than 4.13 cm (1.1/4 inch interknot aperture), the regulation may be changed to read "no trap fishing will be permitted with mesh wire with an aperture of less than 4.95 cm (1.1/2 inches interknot aperture)". These mesh-size selections are thought to be more in keeping with minimizing the earning losses and socio-economic displacements which may occur with regulation and enforcement of mesh size limits in the trap fishery. Of the greatest significance is the production by Munro (1974) of calculations which showed that the 0.63 cm or 1/4 inch increase in trap mesh size that we recommend here, would produce

increases in the relative value of Jamaican trap catches of approximately 11% on the south shelf and approximately 16% on Pedro Bank, if properly enforced.

Seine Net Limitations

Many species of commercially valuable fishes in their juvenile stage inhabit shallow sheltered coastal embayments (Ross, 1982) and it is at this stage and in these areas that they are extremely vulnerable to small mesh traps and especially beach seine nets which often use meshes of less than 4.0 cm (1.57 inches) in stretched mesh aperture.

We propose that seine nets should possess a bunt (bag area) constructed of mesh measuring not less than 4.0 cm (1.57 inches). The wings of the seine net should be of a mesh aperture of not less than 6.0 cm (2.36 inches stretched mesh).

Spearfishing Limitations

It is proposed that there be a ban on the importation of spearguns for 2 years in the first instance. During this time the effects of the ban should be monitored. Undoubtedly, there would be an upsurge in the use of homemade spearguns but their range and accuracy is considerably less than those of commercial guns. The intended effect is that some fishes that might otherwise have been taken would be allowed to escape or grow to maturity. After 2 years, the ban may be assessed so as to continue or lift the ban.

Fishing Effort Regulation

Fish effort can be identified as a function of four factors as mentioned by Anderson (1977). These are: (i) number of fishing units, (ii) their individual harvesting power, (iii) their spatial distributing, (iv) the total time spent fishing. Therefore, in order to alter the total amount of fishing effort, one or more of these components will have to be changed. It should also be noted that the main types of regulation affecting total effort are: area or seasonal (time) closures; imposition of quotas; gear restrictions; limitations on the number of boats; various forms of taxes and also licensing programs.

We propose to regulate fishing effort in Jamaica by introducing the following measures:

The creation of an initial number of twelve fish sanctuaries and at least one scientific reserve. This measure is intended to modify the spatial distribution of fishing effort by easing fishing pressure on existing resources in selected areas. It is further intended that at a later stage, following monitoring and analyses of results of existing sanctuaries and reserves, that additional closed areas be introduced, especially to fill in geographic gaps islandwide.

Fish sanctuaries are thought to be important in the management of Jamaican fisheries because many commercially valuable reef

fishes dwell as juveniles, though not always exclusively, in shallow areas and protected seagrass-floored embayments between the shore and the outer reefs (Ross, 1982). These areas offer protection from predators and other unfavorable ecological factors and also help to provide an adequate food supply. There are many such areas around Jamaica, but some are more valuable than others for providing pre-adults for adjacent reef fishing areas. It is largely on these grounds that the fish sanctuaries were chosen. The single initial Scientific Reserve was chosen because of the proximity to the U.W.I.'s Discovery Bay Marine Laboratory. The Fish Sanctuaries to be created are shown in Figure 7.

Resource Enhancement (Artificial Reefs Program)

Artificial reefs or tire reefs have been shown to work successfully in Jamaican waters (Aiken, 1979). It is envisaged that the present small-scale program of creating artificial reefs, undertaken by the Fisheries Division, be expanded. The benefits of a tire reef program are many. Tires are the most suitable local material as they are virtually indestructible, non-polluting, relatively easy to handle on land and sea and they do not easily sink into the substrate. Interspecific competition for space, availability of shelter from predation and food supply, are three major limiting factors affecting fish population size and the tires' function to provide shelter from predators and themselves serve as substrates for the attachment of marine flora and fauna which serve as food. It has also been demonstrated that fish use the vertical relief offered by the tires as reference points for schooling (Smith and Tyler, 1971; 1972).

It is important to note that these artificial reefs, when they become fully developed with significant resident fish populations, will be made available to fishermen. We suggest that large artificial reefs of not less than 2,000 tyres be constructed at the following locations shown in Figure 8.

Continuation of Fishing Industry Surveys (Catch Monitoring)

The vital importance of statistical information on the fishery for even the most rudimentary form of management cannot be over-emphasized. The Ministry of Agriculture has organized and implemented, with the assistance of the Fisheries Division, four surveys, the most recent being for the year 1981. The FAO has stated that this last survey (Sahney, 1983) could be used as a model for regional fishery surveys. We recommend that these surveys be continued even on the present irregular basis. It is further recommended that any new survey should be organized with regional concepts in mind and should use standard definitions to enable international data comparisons. Such surveys are especially useful considering that the present paper is almost entirely based on the results of previous surveys.

Figure 7. Proposed fish sanctuaries and scientific reserves

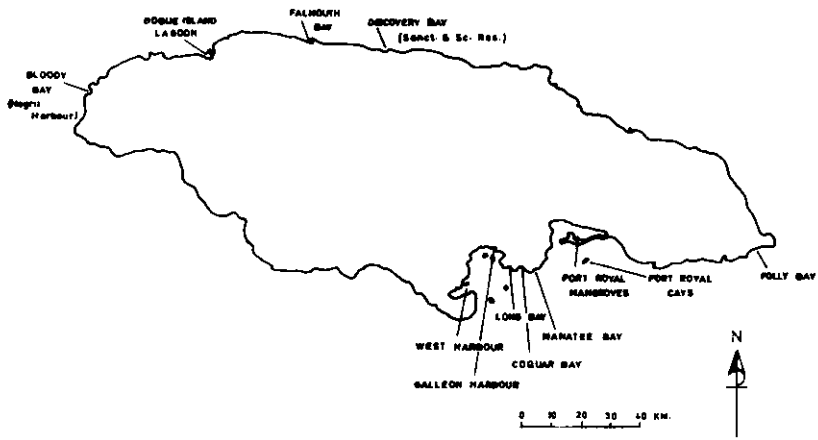
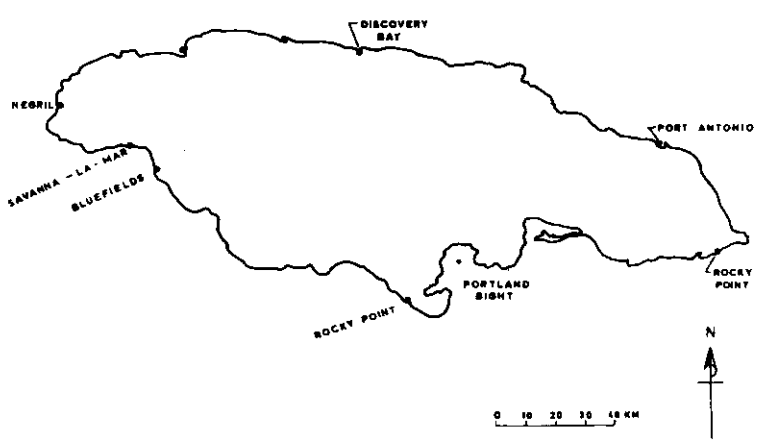


Figure 8. Proposed sites of artificial (tyre) reefs



Establishment of a Fisheries Management Council

We propose that a Fisheries Management Council be established so that all the proper and varied inputs are made into any fisheries management strategies for the industry. Some of the necessary inputs would include: (a) Government administrative information, (b) Fisheries biology and statistical information, (c) Fishermen's cooperative information, (d) Legal and enforcement information.

To facilitate the inputs listed previously, council members should be drawn from the following organizations:

1) Fisheries Division, Ministry of Agriculture

2) Ministry of Agriculture, Head Office

3) Jamaica Cooperative Union, Ltd.

4) Attorney General's office

5) Zoology Department U.W.I.

6) Natural Resources Conservation Division

The Council would consider the following matters among its responsibilities (i) regulations for fisheries management, (ii) monitoring enforcement, (iii) modifications to existing regulations resulting from Fisheries Division, (iv) formulation of new management policies for submission to the Fisheries Division.

It should be emphasized that the ultimate objective and central management problem of the council will be to judge the amount of fishing appropriate to that objective, and to regulate it at that level by monitoring feed-back from the fishery and adjusting as needed.

Fishermen's Information and Publicity Program

We support the view that there is a great need to modify the attitudes of fishermen by means of educational and publicity campaigns, because these are vital to the success of any management measures implemented. No management program can succeed if it does not have the approval of the fishermen. But, before they can approve, they must be informed, and it is this information program with which we are concerned here.

There is still at the present time considerable merit to Munro's (1974) views concerning a well-planned media campaign. We suggest that a poster campaign, along with beach talks or informal question-and-answer sessions on fishing beaches organized by personnel from the Fisheries Division, will also help. Any such campaign should be directed at the need for management and the benefits of such measures. Regular use must also be made of the electronic media for the same purposes. Such

a campaign is badly needed on the north coast, and this is perhaps where such a program should begin.

Preliminary Steps for Implementation and Enforcement

The primary vehicle for implementation of management measures should be the Fishing Industry Act of 1975. Importantly, the primary monitoring body, namely, the Fisheries Management Council, will monitor, assess and recommend possible changes in the structure of the regulations. It should be mentioned that there are within the Wildlife Protection Act of 1949 sections which deal with prohibited fishing methods, e.g., explosives and poisons. It is planned that effective enforcement of these and other management regulations be implemented by (i) either the expansion of the present scheme of Agricultural Wardens who work in conjunction with Fisheries Division personnel, or (ii) the introduction of a Fisheries Warden program, where these persons will be drawn from fishermen operating within the fishery itself.

Closer cooperation must be obtained from the Marine Police especially, and a program of lectures at Police training facilities is recommended. Finally, the Government should accept that, if proper management of the fishable resources and the protection of the livelihoods of coastal communities are desirable policies, then they will necessarily have to bear the costs of acquiring, training and maintaining management structure. We suggest that the total final cost of the total collapse of the fishery will be far greater.

CONCLUSION

These, then, are our suggestions for management in the face of mounting evidence that we have presented from the reef fishery that production is being negatively affected by overfishing. The management of multispecies stocks in an artisanal fishery such as in Jamaica is still a relatively new field (FAO, 1978; Munro, 1983) and is still hampered by the problems of parameter (age, growth, mortality) estimation. However, the great body of information which is available from various local surveys and research programs now provides fishery scientists in Jamaica with a solid basis on which a framework for the proper management of the artisanal fishery can be built. Finally, it is thought that even with the use of the data, management in real terms will always be a trade-off between the needs of the artisanal fishermen, enforcement costs, financial and staff limitations and other interest groups. There are almost no options in this regard.

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