Dynamic Factors Affecting the Performance of the Antillean Fish Trap

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INTRODUCTION

Traps constructed of sticks and galvanized wire mesh are used throughout the islands of the Caribbean, particularly in the Greater Antilles. In Jamaica (Munro, 1969), Puerto Rico (Oswald, 1962) and the Virgin Islands (Swingle et al., 1970) they are the main items of fishing gear and contribute the greatest part of the catch. They are also extensively used in Cuba (Buesa Mas, 1962) and in most of the other Caribbean Islands, but their relative contributions to the catches are unknown. They are prohibited in Florida. Their use appears to date from around 1920, when wire mesh became readily available at fairly low prices, but traps of the same basic design constructed of rattan or cane have probably been used in the Antilles for several centuries.

In this paper, the term "Antillean fish trap" is used in a generic sense, and refers to any trap constructed of galvanized wire mesh. Specific types of traps include the arrowhead or chevron trap of Puerto Rico and the Virgin Islands (Fig. 1a), the double arrowhead or Z-trap of Jamaica (Fig. 1b), and the S-shaped trap described by Buesa Mas (1962) in Cuba (Fig. 1c). The Z- and S-traps have two entrance funnels, the arrowhead has only one funnel. Simple rectangular traps are also used in some areas. The UNDP/FAO Caribbean Fisheries Development Project has recently experimented with other designs of wire-meshed traps which may in due course come into common usage.

Mesh sizes are usually of 3.17 - 4.13 cm (11/4" - 1 5/8") maximum diameter in Jamaica. Swingle et al. (1970) report a range from 1.90 - 5.08 cm (3/4" - 2") in the Virgin Islands. In Jamaica and Cuba the funnels are constructed in the "horse neck" style; that is, with a downward turn at the inner end so that the fishes enter the traps by swimming downwards through a horizontal plane. The inner aperture of the entrance funnel is usually pear-shaped, with a length of about 30 cm and a circumference of about 72 cm. The overall dimensions of the Jamaican traps average around 180 - 230 cm long (70 - 90 ins.), 100 cm wide (40 ins.) and 61 cm (24 ins.) deep.

In most areas the traps have been used most extensively in the near-shore reef areas in depths down to about 50 m. They are also used in deeper waters but losses of traps fished in deep water are often fairly high owing to currents drawing the buoys under water or washing the traps into very deep water, or to ships cutting the buoy lines with their propellers. In Jamaica, the most heavily fished area is the zone of *Acropora cervicornis* corals which extends from depths of 1 m to around 15 m, depending upon the clarity of the water.

Despite the fact that the Antillean fish trap is the main item of fishing gear in many areas, little work appears to have been done on the factors affecting its

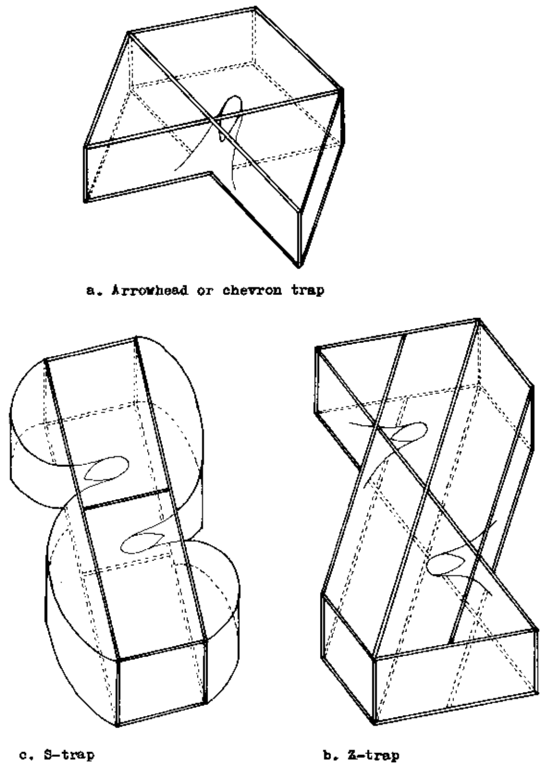

Fig. 1. Antillean fish traps constructed of wooden poles and galvanized wire mesh. (a) Arrowhead or chevron trap (Puerto Rico & Virgin Islands); (b) Z-trap (Jamaica); (c) S-trap (Cuba).

performance or upon the effects of these small-meshed traps upon the fish communities. In Jamaica, where the intensity of fishing on the near-shore reefs appears to be higher than in any other island in the Caribbean, the abundance of fishes on the reefs is remarkably low. We are working on the hypothesis that the low density of fishes is a direct consequence of exploitation with small-meshed traps; that is, that the largest reef fishes and thus usually those which mature at a relatively large size are subjected to severe biological overfishing, while the smaller reef fishes which mature before recruitment to the traps are subjected to intense exploitation with a correspondingly low stock density, but are not biologically overfished. Radical changes in the composition of the fish communities might result from such a situation and we have undertaken an investigation of the composition of communities of fishes in the Port Royal reef system and of the factors affecting the performance of the traps as a preliminary step to a more extensive investigation.

Methods of investigation

Most of the information reported here has been obtained by SCUBA observations of the composition of trap catches. Traps are placed in depths of 20 - 45 feet (7.1 m - 13.7 m) in the *A. cervicornis* zone of the inner reefs of the Port Royal reef system, and the accumulated contents of the traps are counted as frequently as possible. The traps are emptied and reset at each new moon or full moon, and are subjected to the minimum of disturbance in the interim.

In addition, trap fishing is conducted on all reefs in the Port Royal area to provide fishes for routine biological analysis. Traps are set and retrieved by SCUBA divers, partly in order to avoid having to buoy the traps and the resultant thefts, and also to ensure that traps are set at precisely the desired depths.

Expression of results

Regular SCUBA observations and counts of the contents of a trap yield a set of data which can be expressed in a number of ways; either as total cumulative ingress into the traps, or mean daily ingress, or as total cumulative "catch" or mean daily "catch". The "catch" refers to the number of live fishes which would have been captured if the trap had been hauled at the time of observation. In contrast, the term ingress refers to the number of fishes or invertebrates *known* to have entered the trap and ignores losses due to deaths of fishes in the trap (including predation) and losses due to escapement. As such, "total ingress" is a minimum estimate and cannot account for fishes which enter the traps and then die and are eaten, or escape, in the interval between observations. Nor can those fishes be accounted for which enter the traps, are counted and then escape or die and are then replaced by another of the same species. The "soak" is the period between the setting and hauling of a trap.

Results of ordinary trap fishing are expressed as total catch or as catch per day soaked.

Composition of the catches

Within the near-shore *A. cervicornis* reefs there appear to be few species of fishes or invertebrates which will not enter traps. In the Port Royal reef system, on the south coast of Jamaica, we have captured 95 species of fishes and invertebrates by means of routine fishing with traps covered with 4.13 cm (1 5/8 inch) diameter wire mesh. Details of the composition of these catches are given in Table 1. Parrot fishes, surgeon fishes and grunts predominate in the catch and *Haemulon plumieri* (8.1%) and *Acanthurus chirurgus* (7.6%) are the most abundant species in terms of weight. Nevertheless, diversity is very high and while the ten commonest species comprise about 50% of the catch, the remaining 50% is comprised of 85 species.

"Lunar" periodicity

Initial data on trap fishing and the experience of local fishermen indicated that catches were affected by moon phase or by the corresponding tidal rhythms. Sets of traps used in the observation dives were therefore set and emptied on successive new and full moons and thus subjected to a 14 - 16 day soak between hauls.

TABLE 1

Composition by Weight of Antillean Z-Trap Catches from the *Acropora cervicornis* Zone (5 - 15 m) of the Port Royal Reefs, Jamaica. Mean Soak, 12 Days; Maximum Diameter of Mesh, 4.13 cm (November 1969 - September 1970)

Scaridae	16.4%	*Sparisoma chrysopterum*	4.5%
		Sp. viride	3.3%
		Sp. aurofrenatum	2.7%
		Scarus croicensis	2.0%
		Other scarids (6 spp.)	3.9%
Acanthuridae	15.2%	*Acanthurus chirurgus*	7.6%
		A. coeruleus	4.9%
		A. bahianus	2.6%
Pomadasyidae	11.6%	*Haemulon plumieri*	8.1%
		Other pomadasyids (9 spp.)	3.5%
Palinuridae	8.1%	*Panulirus argus*	7.0%
		P. guttatus	1.1%
Serranidae (excluding hamlets)	7.9%	*Epinephelus guttatus*	2.7%
		Petrometopon cruentatum	2.0%
		E. striatus	1.8%
		Other groupers (3 spp.)	1.5%
Chaetodontidae (excluding *Chaetodon* spp.)	7.8%	*Pomacanthus arcuatus*	4.4%
		Holacanthus ciliaris	2.3%
		Other angel fishes (2 spp.)	1.1%
Majidae	4.3%	*Mithrax spinosissimus*	4.3%
Lutjanidae	4.0%	*Lutjanus apodus*	1.5%
		Other lutjanids (6 spp.)	2.5%
Carangidae	3.5%	*Caranx ruber*	2.9%
		Other carangids (3 spp.)	0.6%
All other families	21.2%	All other species (48 spp.)	21.2%
	100 %	Total species = 95	100 %

Figure 2a shows fluctuations in the catch rates of all species of fishes in traps which have been set and hauled at random intervals during the course of the lunar month. Figure 2b shows a similar pattern and is derived from analysis of observed rates of ingress into traps which have been regularly set and hauled at successive new and full moons. Both graphs show pronounced depressions in catch rates shortly after the quarter-moons; that is, at moon ages 10 and 24 in the case of the data derived from trap fishing and at moon ages 8 and 23 - 24 in the case of the data derived from SCUBA observations. Figure 2a shows a peak in catch rates at the new moon and peaks at 15 and 21 days after new moon, while Figure 2b shows a pronounced peak in the rate of ingress 4 days after new moon and a broad peak, which may be bimodal, extending from 12-20 days after new moon; that is, around the time of the full moon. Figure 2b also shows examples of intra-monthly variations in rates of ingress of some of the characteristic reef fishes, *Haemulon plumieri, Sparisoma aurofrenatum* and *Acanthurus coeruleus.* The patterns of intra-monthly variations in catch rates are largely dissimilar but all agree in having decreased rates on ingress shortly after

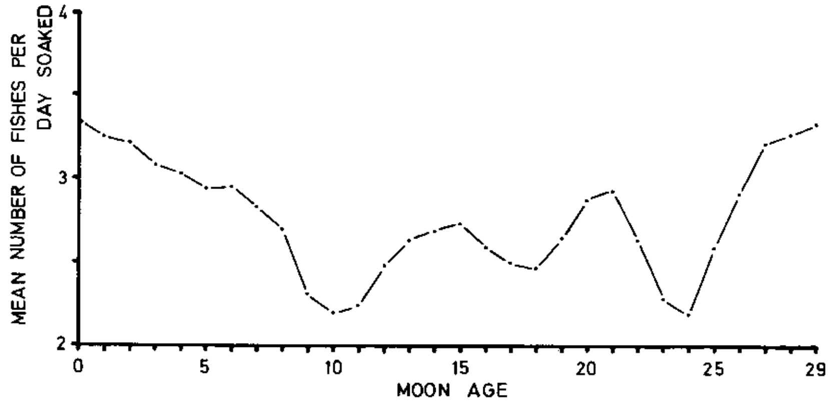

Fig. 2a. Intra-monthly fluctuations in catch per day soaked of Antillean Z-traps at the Port Royal reefs, Jamaica (February-September 1970). Soaks exceeding 8 days are excluded from the analysis. Number of traps hauled = 425; Number of fishes = 6,345.

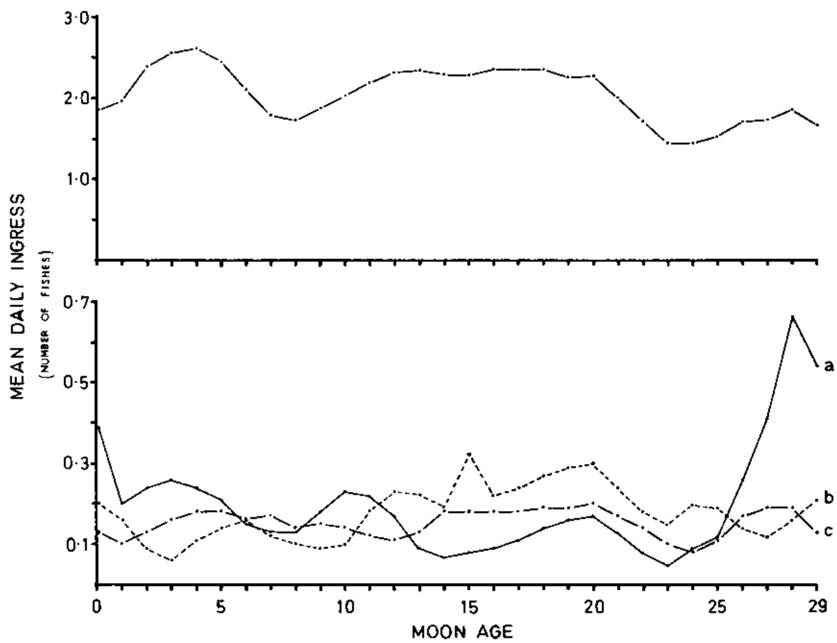

Fig. 2b. Intra-monthly fluctuations in the mean daily rate of ingress into Antillean Z-traps at the Port Royal reefs, Jamaica (February-July 1970). Number of traps observed = 471; Number of fishes observed = 2,500. (i) All species. (ii) (a) *Acanthurus coeruleus* (Acanthuridae) (b) *Sparisoma aurofrenatum* (Scaridae) (c) *Haemulon plumieri* (Pomadasyidae).

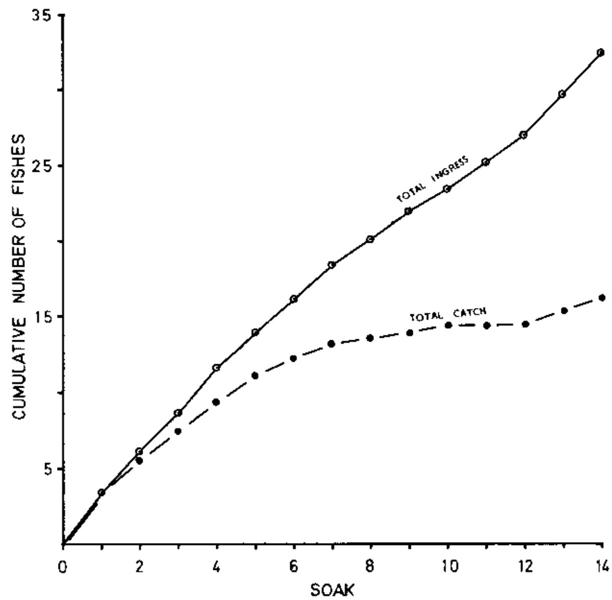

Fig. 3. The relationships between total cumulative ingress, total cumulative catch and duration of soak of Antillean Z-traps at the Port Royal reefs, Jamaica (February-July 1970). All traps are hauled and reset at successive new and full moons. Soak, 14-16 days.

the quarter moon, usually at moon ages 8 - 9 and 23. Moon ages of 8 - 9 and 23 correspond almost exactly with the times of the neap tides at Port Royal and we have therefore concluded that the very real variations in the profitability of catches within the lunar month are a result of a general *depression* in catch rates which is related, perhaps for complex ecological reasons, to the periods at which tidal currents reach their minimum velocity.

Catch per day soaked

We have studied the relationship between the catch and the length of time that a trap is left immersed in the water (the "soak").

Owing to the wide variations in catch that occur, even when traps are set adjacent to each other, it was not possible for us to define the relationship between catch and soak by means of routine trap fishing. However, by using SCUBA techniques, we have been able to follow the build-up of catches in individual traps, each of which are hauled and reset on successive new and full moons. This procedure eliminates a major source of variability in the data, and we have obtained relatively smooth curves showing the relationships between cumulative ingress, cumulative catch and duration of soak (Fig. 3). All of the observed traps were set and hauled on successive new and full moons and as a result of the lunar or tidal phenomena which depress the catch at the neap tides, the curves showing cumulative ingress and catch are slightly sigmoid in shape.

The fraction of the ingress which is lost from the traps increases steadily with increasing soak, and reaches 50% after 14 days. This suggests that given sufficient time a very large proportion of the fishes which enter the traps may escape; even if the escape be the result of random movements in the trap. We have seen relatively few dead fishes in our traps and the corpses of those seen have often remained in the trap for several days before disappearing thus suggesting that losses caused by predators are relatively small. Also, substantial numbers of fishes have been observed to disappear from traps which contain no predators at all.

If escapement is the major factor accounting for the differences between observed ingress and observed catch, then very substantial increases in productivity could be achieved by including in the design of the entrance funnels a device which will prevent the fishes from swimming out of the funnels.

Figure 3 shows that the curve indicating cumulative catch may tend towards an asymptote, taking a form similar to that of the adult phase of a growth curve. This raises the possibility that it may be feasible to treat such data in terms similar to those used for describing growth rates of organisms, i.e., in terms of the asymptotic level beyond which the catch will not increase, and in terms of the rate at which this level is approached. We intend to explore this possibility, particularly in relation to the different economic returns which may be expected as a result of varying the duration of the soak.

Changes in the composition of the catch with increasing soak

Our SCUBA observations have shown that there is a succession of species captured in the traps. Figure 4 shows the relative percentage frequency of observations of specimens of sixteen of the most important species of fishes and crustaceans captured in traps. These species fall into three groups; those showing a progressive decline in frequency of occurrence with increasing duration of soak, those which show no significant changes in frequency of occurrence, and those which show a progressive increase in relative frequency of occurrence. The species included in the last group do not usually appear in traps until several days have elapsed.

In general, it is not possible to distinguish any features which characterize these groups of species other than to note that *Scarus croicensis* and *Sparisoma aurofrenatum*, both of which decline steadily in relative abundance, are the two species which are most often found dead in the traps, although the proportion of dead fishes is very small. *Panulirus argus*, the spiny lobster, increases steadily in relative abundance with increasing duration of soak and is perhaps attracted to dead fishes in the traps.

Conspecific attraction to captured fishes

Analyses have been conducted to verify observations that in many cases a trap appears to capture large numbers of individuals of the same species or genus with the result that traps set adjacent to each other in essentially identical environments may yield radically different catches.

The observation records were therefore scanned to determine whether or not the presence of fishes of a particular species in the trap resulted in increased catches of that species.

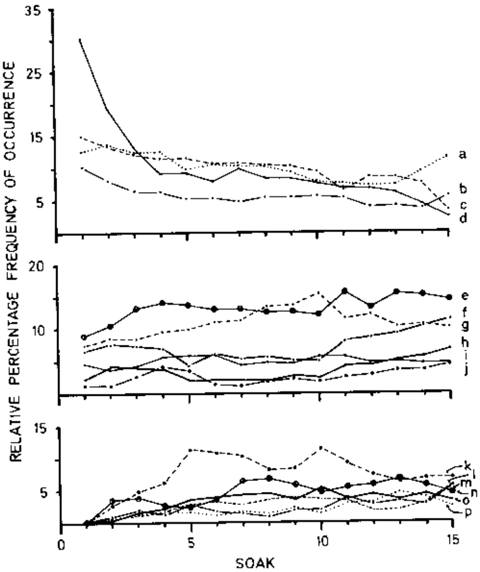

Fig. 4. Changes in the relative percentage frequency of occurrence of sixteen common species of fishes captured in Antillean Z-traps, in relation to the duration of the soak.

Key to symbols:

a)	*Acanthurus bahianus*	b)	*Petrometopon cruentatum*
c)	*Sparisoma aurofrenatum*	d)	*Scarus croicensis*
e)	*Haemulon plumieri*	f)	*Acanthurus chirurgus*
g)	*Acanthurus coeruleus*	h)	*Pomacanthus arcuatus*
i)	*Panulirus guttatus*	j)	*Lutjanus apodus*
k)	*Sparisoma viride*	l)	*Mithrax spinosissimus*
m)	*Holacanthus ciliaris*	n)	*Sparisoma chrysopterum*
o)	*Panulirus argus*	p)	*Caranx ruber*

Figure 5 shows that in the case of *Haemulon plumieri* this appeared to be substantially correct. When more than four *H. plumieri* were present in the trap the subsequent daily ingress of *H. plumieri* rose sharply. The various species of scarids and acanthurids yield similar, but less striking, results. Holocanthids, acanthurids, pomadasyids, scarids, and carangids have all been observed to be attracted to captured conspecifics. When this occurs the fishes tend to swim side by side on either side of the wire mesh. This often results in the fish which is at liberty being inadvertently led down the entrance funnel and retained in the trap.

Conspecific attraction may, therefore, to a large degree, account for the high between-trap variability in catches which is a feature of this fishery.

Effect of structure of traps

Extensive comparative work has been done using Cuban S-traps and Jamaican

Z-traps. The S-traps are easier and cheaper to construct, and are lighter and more easily handled, particularly under water. Z- and S-traps have been set in pairs, unbaited, and the catches compared. Comparison of 41 pairs of catches showed that catches of the S-traps were 29% greater by numbers and 25% greater by weight, but owing to the high variability encountered, the differences were only significant at the 80 - 90% level of probability and further comparisons need to be made before the differences are established.

A limited amount of fishing done with arrowhead traps indicated that they caught only about half as much as the Z-traps.

Traps shaded on the upper surfaces with interwoven palm fronds captured fewer scale fishes, but rather more spiny lobsters than unshaded traps, and shade is therefore not a factor inducing fishes to enter the traps.

We have therefore concluded that the continuous curves of the S-trap guide fishes to the entrances and that this probably accounts for the superior performance of these traps. Likewise, the number of entrance funnels is also important.

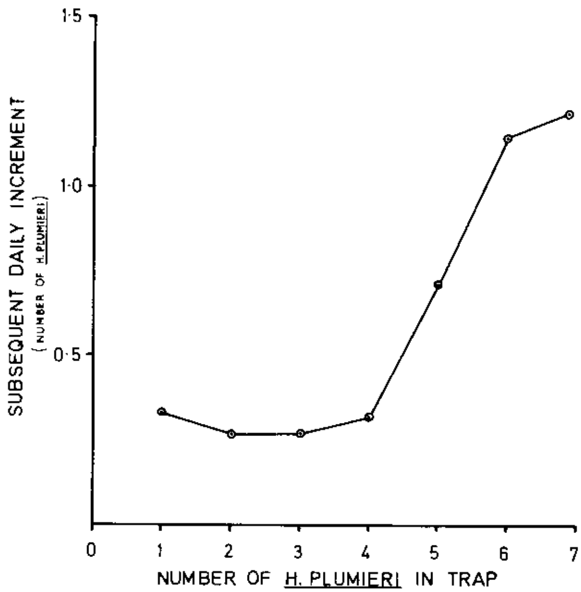

Fig. 5. The effect of conspecific attraction upon catches of *Haemulon plumieri*.

Effect of bait

Owing to the deaths of fishes in the traps, the traps are to a certain extent self-baiting. However, tests which were conducted to determine whether chopped fish bait was effective in increasing the catch and also in changing the composition of catches indicated that the catches in the Port Royal area were not improved by the addition of bait in the form of chopped fish. Indeed, a comparison of the catches of 27 pairs of baited and unbaited traps showed the unbaited traps to be 15% more effective in catching fishes! However, the baited traps captured fishes of slightly greater mean weight and a few more spiny lobsters than did the unbaited traps.

In Jamaica, a wide variety of fruits and vegetables are commonly used as bait. We have not been able to conduct definitive tests on these baits but the limited information that we have indicates that such items are also not very effective in attracting fishes or crustaceans to traps.

Pieces of broken porcelain are also often placed in traps or tied to the wire mesh. In some cases it is claimed that this attracts fishes, in others it is said to facilitate location and recovery of unbuoyed traps.

We have therefore concluded that at least at the low level of density of fishes encountered in the Port Royal reefs, that curiosity, inadvertent entrance and conspecific attraction are more important factors than bait in determining the magnitude of catches.

Fate of untended or lost traps

Traps which are lost or abandoned in the water have always been thought to constitute a management problem because they continue to fish and remove stock from the reefs. However, as indicated previously, a substantial portion (perhaps as much as 50%) of the fishes which enter the traps eventually escape. The individuals which do not escape live for a variable length of time depending upon physiological factors and upon their willingness to consume food in the trap - viz. dead fishes and algal growths. However, almost all fishes which have been confined in traps for periods approaching 2 weeks show obvious signs of physical deterioration including wounds from predators or abrasions from the wire mesh, often with secondary fungal infections.

The usual sequence of events is probably that increasing numbers of fishes accumulate in the traps for a period of time which probably seldom exceeds a month. The captured fishes are subjected to an increasing mortality rate, partly due to physical deterioration and starvation, but also due to predation by moray eels *(Gymnothorax moringa* and *G. funebris)* which may prey heavily on the catch and stabilize it. Finally, the traps which have accumulated large numbers of fishes may be attacked by large predators such as the nurse shark, *Gingylostoma cirratum,* and the trap may be ripped open and become inoperative.

CONCLUSIONS

(1) The rate of ingress of most species of fishes into traps is substantially depressed at or near the time of neap tides, and is about 50% greater at or around the spring tides.

(2) With increasing duration of soak, the accumulated catch in traps tends towards an asymptote indicating that soaks exceeding about 2 weeks are probably unprofitable.

(3) The decreased rate of retention of fishes in traps soaked for extended periods is probably a result of increasing rates of escapement from the traps. Increases in catch rates of up to 100% may be possible if a suitable non-return device can be fitted to the entrance funnels of the traps.

(4) Progressive changes occur in the relative composition of trap catches with

increasing soak but the causes of these changes are unknown.

(5) The presence of conspecifics in a trap results in increased ingress of that species. We believe that this accounts for much of the very high variability of catches which occurs even between adjacent traps.

(6) Antillean S-traps of Cuban design yielded catches which averaged 25% heavier than those obtained in traditional Jamaican Z-traps. We believe that the continuous curves of the S-trap serve to guide fishes into the entrance funnels more effectively than is the case with the angular Z-trap. Single-funneled arrowhead traps yielded substantially smaller catches.

(7) Within the rather impoverished fish community of the Port Royal reefs, chopped fish bait was ineffective in increasing trap catches and it is concluded that curiosity, inadvertent entrance and conspecific attraction are more important factors determining ingress into traps.

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