Studies on the Effects of Net Length and Soak Time on Gillnet and Trammel Net Catches on Coral Reef Areas

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ABSTRACT

The influence of net length and soak time on fish catches of gillnets and trammel net were studied on coral reefs in Puerto Rico. In the net length experiments, gillnets and trammel nets were varied in length from 100 to 300 fathoms in intervals of 100 fm. Each net of a certain length was fished for four hours over a period of 24 hours for the net length experiment. In the soak time experiments, gillnets and trammel nets of 100 fm were set for 24 hours. The nets were visually censured every four hours recording the fish caught and the position of fish in the net. The effect of soak time on fish catch was negligible for both total number and species of fish. Net length effects on the number of fish caught was significant for trammel nets. These results appear to be influenced by some non-measurable and unrecorded factors such as method of deployment of the nets, fish, behavior around the nets and type of substrate.

INTRODUCTION

A significant portion of the fishery catch in many tropical countries comes from coral reef fishes (Gomez, 1980; Grandperrin, 1978). Fisheries conducted in these areas, for the most part, are of artisanal or subsistence nature (Munro and Williams, 1985). Coral reefs and outcrops largely prevent the use of active gears such as trawls and seines. Most reef fisheries are based on the use of passive gear such as fish traps (pots), hook and line, and tangle nets (gill and trammel nets). The use of gillnets and trammel nets catch data assumes that these catches generally reflect the relative abundance of fish in the areas sampled. This raises several questions regarding the sources of variation in gillnet and trammel net catches.

A comprehensive review of gillnet selectivity was presented by Hamley (1975). All basic models, applications and shortcomings of gillnet models, and the variety of factors (thickness, materials, color of the net twine, hanging of the net, and methods of fishing) that must be considered in determining selectivity were discussed. Gillnets of variable net length and set time do not accumulate fish catches at a uniform rate (Hamley, 1975; Hubart, 1983). The efficiency of the net decreases as fish accumulate in it. Eventually, the number of captured fish reaches a saturation point and does not increase further (Baranov, 1948; Hamley, 1975; Hubart, 1983). Catch-effort models have been used to analyze stock dynamics and to predict the effects of harvest regulations (Ricker, 1975).

In its simplest form, it is assumed that a given unit of fishing effort will catch fishes in proportion to their abundance (Beverton and Holt, 1957). As a consequence, it has usually been assumed that catch-per-unit-effort (CPUE) is proportional to population size. However, this proportionality assumption has been questioned during the past few years (Richards and Schnute, 1986). A departure from linearity in the relationship of these two variables reflects varying catchability (Ralston *et al.*, 1986). This variation may be due to schooling behavior, gear saturation, gear length or any number of other factors which affect the CPUE in addition to stock abundance (Rothschild, 1977). Assumptions considered in the analysis of gillnet CPUE, such as (1) catch per unit net length is independent of net length, and (2) catch per unit set time (soak) is independent of soak time, have not been studied in tropical gillnet and trammel net fisheries. The present paper examines the sampling variability of gillnet and trammel nets when used under different net lengths and soak times.

STUDY AREA AND METHODS

The study was conducted on Maragarita reef, a shallow reef adjacent to La Paraguera, Puerto Rico (Figure 1). Two sections of the reef were selected for the experiments. The net length experiments were conducted on the deep fore reef, which represents that part of the reef that lies seaward and adjacent to the offshore sand or mud substrate (Kimmel, 1985). The substrate was composed of encrusting corals, sponges and gorgonians. The soak time experiments were conducted in the back reef. The substrate consisted of sand, mud, seagrass, sponges and reef patches.

Two types of experiments were run. In one, varying lengths of net (100, 200, and 300 fathoms) were set for 24 hours (approximately from 12:00 noon to 12:00 noon the next day). In the other, 100 fm of net was set for varying lengths of time (approximately 3, 6, 10, 15, and 20+ hours, beginning at 12:00 noon). For the net length experiment, the nets were set parallel to the reef along the same depth contours. The nets were tied together as a single net with a maximum length of 300 fm. The setting locations of the net were randomly assigned along the reef.

The gillnets were constructed of #208 monofilament webbing. The mesh size was 2.5 inches (stretched mesh) and hung on a one-half (two lengths of stretched mesh to one length of float line). Each net was approximately 100 fm long and 1.0 to 1.2 fm high. The trammel nets were constructed of #208 multifilament webbing with a mesh size of 2.5 inches for the inner net and 8 inches for the outer net, and hung on one-half basis. Mesh sizes and hanging ratios used on these experiments are representatives of the standard gear used in the study area. The nets were rented from gillnet and trammel net fishermen from the study area.

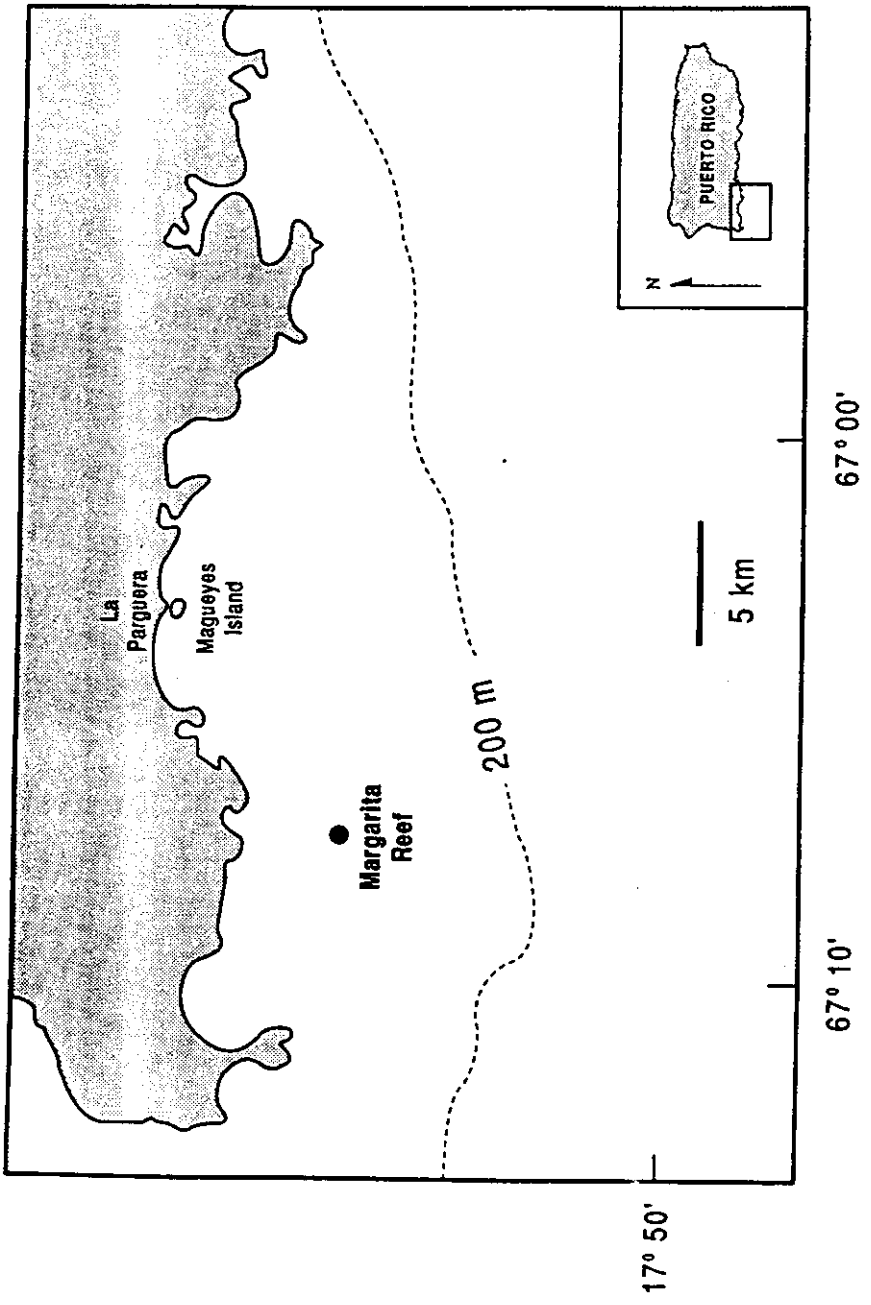

Figure 1. Map of La Parguera, Puerto Rico

For the net length experiment, fish were removed from the nets approximately four hours after soak time. The total number of each species, including damaged specimens, was counted. Length (cm) and weight (g) were recorded for all species. For the soak time experiment, the nets were visually checked every five to six hours, and all fish caught were counted. Fish were removed after the 24th period expired.

To facilitate the analysis of the catches, the replicate experiments were conducted for the same areas of the reef and during the same moon period (crescent phase). To compare the effiency of the nets, an analysis of variance (ANOVA) was carried out for a number of fish caught and CPUE of the catches.

RESULTS

Net Length

Gillnet. A total of 444 individuals, representing at least 32 species (not all species of Ostraciidae and Holocentridae were identified to species), were caught by gillnets during the study (Table 1). The ten most abundant species comprised 89% of the total catch. Out of these, redband parrotfish, *Sparisoma aurofrenatum*, accounted for 46% of the catch, followed by queen parrotfish, *Scarus vetula*, comprising 11% of the total catch. Catch per unit length of 100, 200 and 300 fm, ranged from 3 to 106 individuals, from 6 to 25 species from 16 to 60 kg, respectively (Table 3). The analysis of variance showed no significant differences in the number of individuals caught, nor the CPUE ($p > 0.05$) for any of the three net lengths studied.

Trammel net. A total of 566 individuals, representing 45 species, were caught by trammel nets. The ten most abundant species comprised 83.5% of the total catch. Out of these, stoplight parrotfish, *Sparisoma viride*, accounted for 48.2% of the catch. The rest of the catch was evenly distributed among the other species. The catch per net length ranged from 11 to 201 individuals, from 5 to fifteen species and from 22 to 127 kgs (Table 3). The analysis of variance showed a significant difference among the number of individuals caught by the three net lengths. A t-test statistic was used to identify which net was influencing the catch. The results indicated that a significant difference ($p < 0.05$) occurred when comparing the mean number of individuals caught by the nets of 200 and 300 fm versus the 100 fm net.

The effect of the increase of net length on the catch is illustrated in Figure 2. Longer net lengths exhibited an increasing mean catch, which tends to be proportional to the increase in net length. The higher mean catch observed by the trammel net of 200 fm in Figure 2 is due to the capture of a large aggregation of stoplight parrotfish on one occasion. If this observation is removed from the analysis, the results will be similar to those obtained by gillnets. No significant differences in CPUE were observed ($p > 0.05$), indicating that the three net lengths have the same relative effectiveness.

Table 1. Species and number of fish caught in gillnets for the net length and soak time experiments.

SPECIES	NET LENGTH	SOAK TIME
Sparisoma aurofrenatum	202	28
Scarus vetula	47	3
Haemulon plumeri	35	9
Caranx ruber	31	12
Sparisoma viride	28	6
Gerres cinereus	17	7
Haemulon sciurus	13	3
Lutjanus synagris	10	19
Scarus taeniopterus	8	-
Acanthurus bahianus	7	4
Sparisoma chrysopteum	5	1
Lutjanus analis	4	4
Ocyrus chrysurus	4	3
Acanthurus coerulus	3	5
Sparisoma rubripinne	2	3
Epinephelus guttatus	2	1
Calamus bajonado	1	8
Holocentrus ascensionis	1	3
Lutjanus jocu	1	3
Pseudopeneus maculatus	-	4
Haemulon album	-	2
Dasyatis american	-	2
Echeneis naucrates	-	1
Balistes vetula	-	1
Scarus coeruleus	1	-
Scarus sp.	1	-
Haemulon carbonarium	4	-
Lutjanus vivanus	1	-
Cephalopholis fulva	2	-
Lacthophys trigonus	2	-
Cantherhinus pullus	1	-
Bodianus rufus	3	-
Tylosurus crocodilus crocodilus	3	-
Priacanthus cruentatus	2	-
Scomberomorus regalis	1	-
Lutjanus mahogani	1	-
Selar crumenophtalmus	1	-
TOTAL	444	132

Table 2. Species and number of fish caught in trammel nets for the net length and soak time experiments.

SPECIES	NET LENGTH	SOAK TIME
Sparisoma viride	273	16
Sparisoma aurofrenatum	38	23
Scarus vetula	19	1
Haemulon plumeri	6	17
Caranx ruber	6	-
Gerres cinereus	12	-
Haemulon sciurus	33	8
Lutjanus synagris	-	3
Scarus taeniopterus	8	-
Acanthurus bahianus	24	8
Sparisoma chrysopteum	4	4
Ocyrus chrysurus	10	-
Acanthurus coerulus	40	-
Sparisoma rubripinne	8	1
Calamus bajonado	6	2
Calamus calamus	2	-
Calamus pennatula	1	-
Holocentrus ascensionis	8	-
Epinephelus guttatus	3	-
Lutjanus jocu	3	-
Dasyatis american	1	1
Balistes vetula	2	-
Scarus coeruleus	1	-
Haemulon carbonarium	4	-
Haemulon chrysargyreum	2	1
Haemulon striatus	1	-
Haemulon flavolineatum	1	-
Lutjanus vivanus	1	-
Mulloidichthys martinicus	2	-
Lacthophys trigonus	3	-
Cantherhinus pullus	16	1
Bodianus rufus	5	-
Albula vulpes	9	-
Lutjanus apodus	5	-
Acanthurus chirungus	2	-
Kyphosus sectatrix	2	-
Ephippidae	1	1
Acanthostracion polygonious	1	-
Halichoeres radiatus	2	-
Ginglymostoma cirratum	-	1
Myripristis jacobus	-	1
Diodon hystrix	-	1
Holocanthus tricolor	1	-

Table 2. Cont.

SPECIES	NET LENGTH	SOAK TIME
Chaetodon striatus	1	-
Chaetodon capistratus	1	-
Rypticus saponaceus	1	-
Lacthhophyrs bicandali	1	-
Anisostremus viginicus	1	-
Aulostomus maculatus	1	-
TOTAL	566	90

Table 3. Total number of fish caught (#Indivs.), weight of fish caught [WT (kg)] and CPUE for gill net and number of individuals for trammel nets in the two experiments (NET LENGTH and SOAK TIME) conducted.

	GILL NET			TRAMMEL NET		
NET LENGTH (Fathoms)	#Indivs.	WT (kg)	CPUE	#Indivs.	WT (kg)	CPUE
100	66	16	0.049	75	21.7	0.054
200	136	40.2	0.05	348	127.1	0.158
300	244	59.5	0.049	137	55	0.06
SOAK TIME (Hours)						
3	4					
6	34			27		
10	27			34		
15	84			48		

Soak Time

Analysis of variance showed no significant differences among the number of individuals for different soak times for both types of gear (same conclusion could be drawn from using the weight data). The high proportion of dead fish and the degree of spoilage increases as the soak time increases. These factors precluded the accurate estimation of the actual weight of the catch and also the computation of CPUE. The species composition showed similar results for both sets of gears. Twenty-eight fish species were captured during this experiment using both gears. Differences in species composition and relative abundance

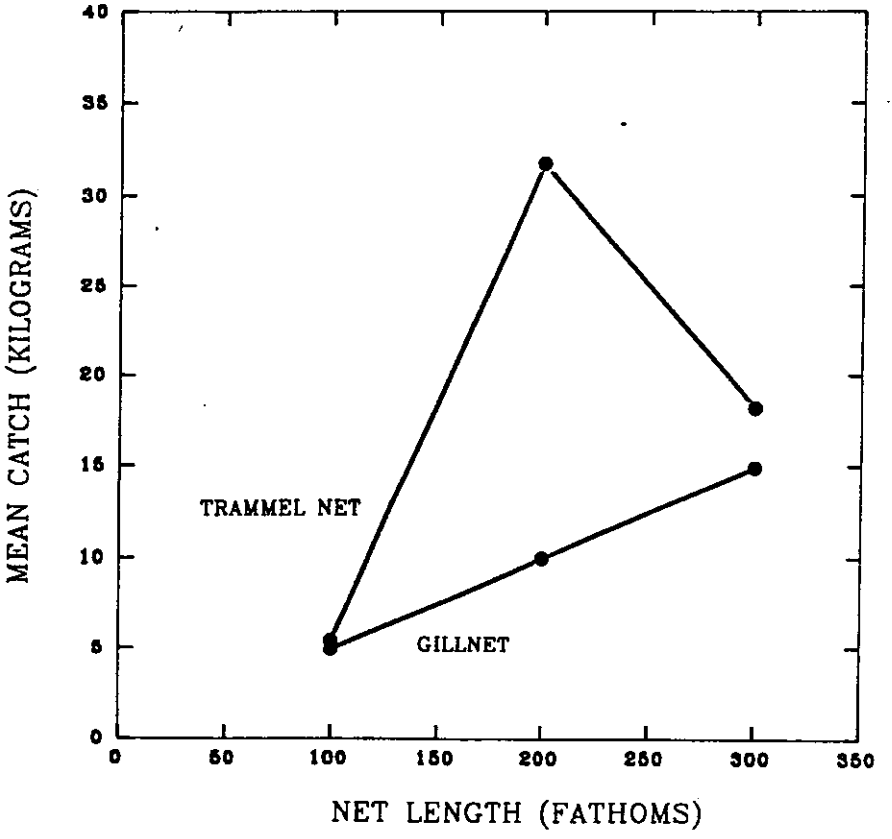

Figure 2. Effort of net length on catch.

between the two gears were consistent with the results obtained on the net length and soak time (Tables 1 and 2).

The results for both experiments also indicated that the number of species increases with the net length and soak time (Figures 3 and 4). These results demonstrated that net length and soak time have an effect of total catch and species composition generated from these gears.

DISCUSSION

The catches in gillnets aand trammel nets that were hauled daily varied considerably during different times of the day and at different days, even when they were fished under apparently similar conditions. The sources of these variations are not clear, but some might be attributable to gear design, habitat and behavioral differences among fish species. Initial inspection of the results might lead one to believe that the trammel net and gillnet catches had virtually the same characteristics, because CPUE was not significantly different between the two gears ($p > 0.05$). However, when examining the catches, a fundamental difference became apparent. These differences may have been caused by behavioral responses of the smaller fish species to the gear. The main species caught by gillnets was the redband parrotfish which had smaller mean size (21.8 cm) than stoplight parrotfish (31.0 cm), the most abundant species caught by trammel nets. These results are a consequence of the selective aspects of these gears. The facility with which a fish gets caught in a trammel net is generally a result of its momentum, which is the product of velocity and mass of the fish as it increases with size.

Evidence of decreasing CPUE with the number of hours or nights that the gillnet is set had been revealed by several studies on gear saturation (Van Oosten, 1935; Kennedy, 1951; Benegal, 1972). The results of the soak time experiment reported here suggest that saturation effects in reef areas depends on the fish species and the availability of fish. Some species are more susceptible or vulnerable to capture by these gears. Visual census conducted along the nets indicated the availability of the fish in the area. Gillnets and trammel nets set in the afternoon (*i.e.* 13:00 hours) would tend to get filled with day-active fish early during the day, and night-active fish later at dusk or at night. A way in which the efficiency of the net can decrease with soak time is by the presence of captured fish, especially while struggling to escape, which may frighten other fish. We observed captured fish trying to escape from the net and conspecifics biting them.

Minns and Hurley (1988) examined the effects of varying net length and soak time for gill nets in Lake Ontario during 1983 and 1984. They found that there are net-length and set-time saturation effects, depending on fish species. Net length did not appear to affect CPUE for yellow perch, *Perca f lavescens*, but it did affect CPUE for white perch, *Morone americana*. The CPUE decreased

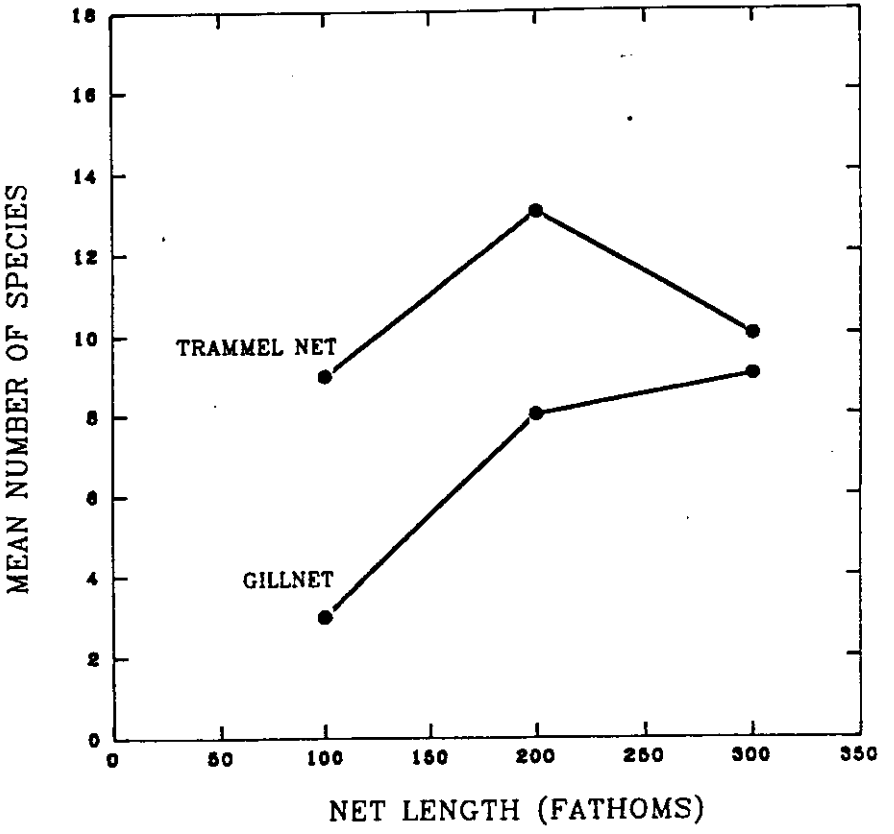

Figure 3. Effort of net length on number of species in the catch.

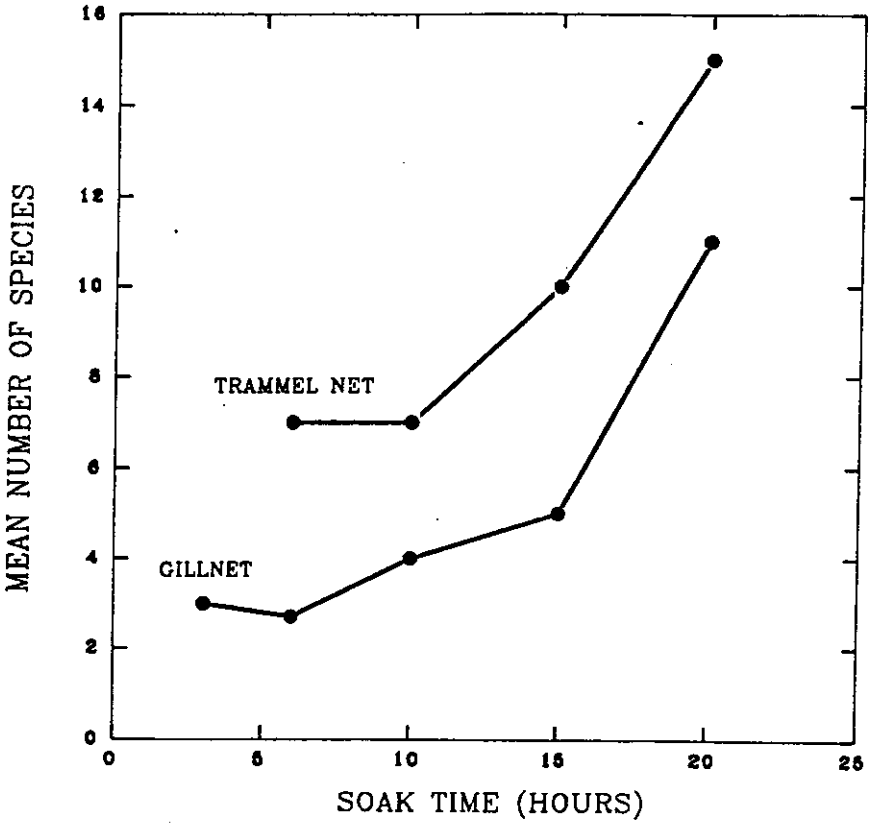

Figure 4. Effect of soak time on number of species in the catch.

with increasing set time for yellow perch, but it increased for white perch, which dominated total catches during 1984. These differences may be related to species variability in behavior and to the ability of different species to detect and avoid nets under different light conditions.

The evidence from the net length experiments reported here suggests that the mean catch per net length increases proportionally with increasing amount of webbing (Figure 2). The subject of fish reaction to nets is complex and has many implications in this kind of study. Biasing effects of leading behavior (fish following along the net before attempting to pass through) on sampling with net have been reported by other researchers (Davis and Schupp, 1987). The lack of significant differences of the number of individuals among the different nets, suggests that leading behavior may not be affecting the capture efficiency of the nets. Besides leading effects, schooling behavior and spawning aggregations may also play an important role. Overall, 61 species were caught by the two gears during the net length experiment, in contrast to 28 caught during the soak time experiment. Again, this big difference may be attributed to the same factors affecting the soak time experiment. The effects of net length and set time on total and species catch of gillnets and trammel nets have direct implications on the use of these gears to assess fish populations.

The results of this study revealed differences in species composition and relative abundance in catches made with the two types of nets. These lead us to suggest that the use of gillnet catches as indices of fish abundances must be validated for each species. Our results were consistent with the results obtained by Minns and Hurley (1988) in fresh water fishes. In general, it is not possible to determine the species composition of a community using passive gear because of their species and size selectivity (Allen *et al.*, 1960). However, the relative species composition generated by passive gear can be used to assess differences between communities and changes in a community over time.

Doubling the soak time at which the gillnets and trammel nets are lifted does not double the catch. This is an important factor to consider when detailed analyses of fisheries statistics for this gear are undertaken. Without experimentation to rule out the possible effects of gear saturation and fish behavior on catches, abundances may be overestimated when fish densities are low and underestimated when densities are high (Minns and Hurley, 1988). At high levels of availability, nets that are soaked for a few hours should yield the same or more per haul than nets that are soaked for longer periods. Similar results should be obtained by increasing the net length. With the methodology used in this study, an extensive number of tests would have to be conducted in order to obtain more acceptable levels of accuracy and precision. Sampling efficiency with these gears is strongly influenced by a variety of factors mentioned before which in many cases are unmeasurable and unrecorded.

Because of the limited scope of this study and the limited number of replicates, the above results and conclusions should be taken with caution.

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