

## Size structures of demersal catches in a multispecies multigear tropical fishery

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### Abstract

The overall size structure of catches was studied in the multispecific, multigear, demersal fishery of Martinique (Lesser Antilles). The results show that the fishery is presently based not only on small-sized species, but also on small- or medium-sized individuals of these species. Most of the catch is made up of species able to withstand its selectivity and effort, with larger species having been eliminated through overfishing. An exponential decrease of length frequencies for aggregated catches or samples was observed in the 2 years sampled, and could be due to some inherent size structure of the fish community. Such integrated analyses are useful complements to single-species assessment approaches inadequate to describe the dynamics of highly multispecific resources such as reef fish communities.

### Introduction

Size-dependent processes have long been recognised as important for the structure and production of marine systems and resources, but in recent decades some major advances have taken place in two main directions: improvement of length-based methods for fish stock assessment and development of size-structured models of whole marine ecosystems.

The effects of processes such as recruitment, growth, mortality, and exploitation on the shape of monospecific length frequencies have been exploited, since Petersen's pioneering works a century ago, by a number of length-based methods, reviewed by Jones (1984) and Pauly and Morgan (1987) among others. This important advance was motivated by the need for age-independent methods in tropical regions and made possible by the increased availability of microcomputers, but the advantages of length-based over age-based approaches have also been pointed out (Pauly and Morgan, 1987).

Physiological and ecological studies highlighted the role of size at various levels of organisation: individual organisms (Paloheimo and Dickie, 1966),



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fish schools (Fréon, 1984), species (Fenchel, 1974; Blueweiss et al., 1978), communities or whole ecosystems (Sheldon et al., 1972; Dickie, 1976). At the latter scale, these works lead to a better understanding of production processes and of ecological efficiencies in marine ecosystems, at least in the pelagic domain, where the trophic chain is made up of very distinct levels.

The use of size-structure data is quite difficult for the assessment of reef fish resources where high numbers of species are exploited. The first approach (population dynamics) is of limited application because it is monospecific and its extension to a resource comprised of tens of species is unrealistic; furthermore, it describes reliably only the recruited phase of the population, whereas recruitment processes play an important role in the structure of reef fish communities (Sale, 1991). The second approach (functional ecology) is more attractive because it integrates all the interactions between individuals and between species, but so far it seems applicable mostly to pelagic resources (Moloney and Field, 1985), and it covers a much wider range of organisms than the exploited fish resource alone. However, this does not mean that the large amount of information contained in the size data is useless in multispecific contexts. This intermediate scale of analysis (between species and ecosystem) has been explored by Pope and Knights (1982) and more recently by Murawski and Idoine (1992) who proposed an analytical framework for the modelling of multispecies length-frequency distributions. This approach deserves special attention in tropical fisheries, as it could be a promising way to overcome the problems related to the assessment of highly multispecific resources. The objectives of this paper are to show how taking into account the length structure of reef fish catches can provide a global interpretation of the fishery, and to discuss some possible areas for future research.

## Methodology

### *Presentation of the fishery*

Martinique ( $14^{\circ}\text{N}$ ,  $61^{\circ}\text{W}$ , Lesser Antilles) has only a narrow shelf, exploited by a variety of artisanal fishing gears down to its edge, around 80 m. An estimated yield of 1171 t of finfish was landed in 1987 by the demersal gears: antillean Z traps (62% of the catch), trammels, gillnets, small short-soak baited traps, handlines, bottom longlines and spearing (Gobert, 1989a). In these catches, 182 species were identified, the most abundant accounting for only about 5% of the total. The legal minimum mesh size for traps is 31 mm; most fishermen comply with this regulation, sometimes using even larger mesh sizes, but in some areas smaller meshes are still used. There is no minimum landing size for any finfish species.

### Data collection

From February 1987 to January 1988, intensive sampling was conducted at nearly all the landing sites of the island.

A first level of sampling dealt with catch and effort data in the 25 main landing sites and the 106 secondary sites, comprising number of trips, fishing effort, catch by species groups, etc. (Gobert, 1988, 1989b; Chevaillier, 1990). More than 5000 records of fishing activity were obtained, and 7090 trips were sampled; this allowed the estimation of catches by gear, species group, and time-space stratum (Gobert, 1989a).

A second level of sampling dealt with identification and length measurement of fish and lobsters landed in the main sites (Table 1). The following families were considered of major interest for the length-frequency sampling: Holocentridae, Serranidae, Acanthuridae, Scaridae, Mullidae, Palinuridae, Lutjanidae, Haemulidae, Sparidae. According to the time available for sampling a given catch, the measurements were done for all the individuals of one species and extended to other species then to other families until, when possible, all fish present in the catch were identified and measured. As often as possible, the list of species captured was recorded. In 1986, length-frequency sampling alone took place, without any well-defined sampling plan. Total sample sizes for demersal fishes were 13 944 in 1986 and 29 062 in 1987. Fish were measured in total length (*TL*) to the nearest centimetre, except for the large carangid species, measured in fork length (less than 1000 fish).

### Data processing

The species composition of catches (by weight) within main families or species groups was estimated from samples where all fish of the family or

Table 1  
Size of samples in 1986 and 1987 for the seven demersal gears

Gear type	Number of trips 1987 (1st level)	Number of finfish measured	
		1987 (2nd level)	1986
Traps	2171	16243	9589
Trammels	325	2248	707
Gillnets	493	6672	2380
Handlines	312	1688	21
Spearing	357	484	132
Longlines	70	570	431
Small baited traps	1157	684	
Total	3843	29062	13944

Table 2

Sample sizes of species-gear components taken into account for the 1987 stratified estimation of total length frequency

Species	Gear <sup>1</sup>						
	TR	TM	GN	TL	HL	LL	SP
<i>Scaridae</i> (175.5 t, 93.8%)							
<i>Sparisoma chrysopterum</i>	1102	46	40	-	-	-	-
<i>Sparisoma rubripinne</i>	400	146	70	-	-	198	-
<i>Sparisoma radians</i>	254	-	-	-	-	-	-
<i>Sparisoma aurofrenatum</i>	781	-	-	-	-	-	-
<i>Sparisoma viride</i>	454	56	-	-	-	-	-
<i>Serranidae</i> (122.9 t, 91.0%)							
<i>Paranthias furcifer</i>	91	-	26	-	166	-	-
<i>Alphestes afer</i>	326	42	37	684	-	144	69
<i>Epinephelus fulvus</i>	567	-	69	234	68	-	-
<i>Epinephelus guttatus</i>	232	-	23	-	47	-	-
<i>Epinephelus adscensionis</i>	35	33	-	-	-	-	-
<i>Epinephelus cruentatus</i>	88	-	-	-	-	-	-
<i>Lutjanidae</i> (115.0 t, 90.5%)							
<i>Lutjanus synagris</i>	96	-	181	-	28	57	-
<i>Lutjanus vivanus</i>	211	-	-	-	37	-	-
<i>Lutjanus buccanella</i>	174	-	-	-	63	-	-
<i>Lutjanus mahogoni</i>	74	-	32	-	-	-	-
<i>Luthanus apodus</i>	78	-	-	-	-	-	-
<i>Lutjanus analis</i>	19	-	-	-	-	-	-
<i>Rhomboplites aurorubens</i>	216	-	38	-	-	-	-
<i>Ocyurus chrysurus</i>	458	-	25	-	892	70	-
<i>Haemulidae</i> (113.0 t, 93.0%)							
<i>Haemulon album</i>	18	-	28	-	-	-	-
<i>Haemulon sciurus</i>	60	25	73	-	-	-	-
<i>Haemulon flavolineatum</i>	350	-	-	-	-	-	-
<i>Haemulon chrysopterum</i>	515	-	-	-	-	-	-
<i>Haemulon aurolineatum</i>	390	-	345	-	-	-	-
<i>Haemulon carbonarium</i>	308	88	40	-	-	-	-
<i>Haemulon plumieri</i>	729	179	189	-	-	-	-
<i>Holocentridae</i> (109.8 t, 96.1%)							
<i>Myripristis jacobus</i>	806	-	1530	-	-	-	-
<i>Holocentrus ascensionis</i>	1637	-	156	-	-	-	-
<i>Holocentrus rufus</i>	1283	-	212	-	-	-	-
<i>Mullidae</i> (56.5 t, 98.8%)							
<i>Pseudupeneus maculatus</i>	877	-	101	-	-	-	-
<i>Mulloidichthys martinicus</i>	768	-	167	-	-	-	-
<i>Acanthuridae</i> (53.2 t, 95.0%)							
<i>Acanthurus bahianus</i>	1760	436	58	-	-	-	-
<i>Accanthurus chirurgus</i>	61	24	-	-	-	-	-
<i>Acanthurus coeruleus</i>	219	94	-	-	-	-	-

Species	Gear <sup>1</sup>						
	TR	TM	GN	TL	HL	LL	SP
<i>Mugilidae</i> (35.4 t, 99.7%)							
<i>Mugil</i> spp.	30	–	32	–	–	–	–
<i>Carangidae</i> (32.6 t, 56.2%)							
<i>Caranx latus</i>	25	–	26	–	–	–	–
<i>Caranx crysos</i>	24	–	12	–	34	–	–
<i>Caranx ruber</i>	180	101	223	–	–	–	–
<i>Priacanthidae</i> (22.7 t, 91.5%)							
<i>Priacanthus arenatus</i>	43	–	23	–	–	–	–
<i>Priacanthus cruentatus</i>	65	274	1003	–	–	–	–
<i>Malacanthidae</i> (2.5 t, 37.9%)							
<i>Malacanthus plumieri</i>	–	–	–	–	42	–	–

<sup>1</sup>TR, traps; TM, trammels; GN, gillnets; TL, small baited traps; HL, handlines; LL, bottom longlines; SP, spearing.

Family names are followed by the weight of the catch taken into account and the proportion it represents of the total catch of the family.

species group had been measured, converting lengths into weights with relationships available in the regional literature or obtained with data collected previously in the French Antilles (P. Chevaillier, unpublished data, 1984). For the least important families or groups (morays, for instance), a very crude estimation of species composition was obtained from qualitative data (frequency of presence of the species).

Catch length-frequency distributions by species and by gear were obtained from all collected samples, taking into account the sampling rate within each catch. The method was based on a ratio estimator (Cochran, 1977), defined as the ratio of the number of fish of the species in a given size-class to the weight of the family or species group to which the species belonged (Chevaillier, 1990).

### Definitions and terminology

Two kinds of size structures are defined in this study.

At the level of species, the size structure is based on the maximum length reached by the species, which are thus grouped into classes (i.e. species reaching 10–20 cm, 20–30 cm, etc.). Values of maximum length were taken from Randall (1983) and Fisher (1978). It was found that 1107.5 t (94.5% of the demersal fish catch) could be distributed among size classes. This 'species size structure' was used to study the distribution of catches (in weight and in numbers) and the class-specific length-frequency distributions of fish.

At the level of fish, the size structure is the usual length-frequency distribution, either for individual species, for groups of species, or for the whole catch. In these latter cases, the estimation procedure was either stratified (using catch estimations by gear and species) or non-stratified (raw summation of samples). The stratified estimation was possible only for the best sampled species-gear components (Table 2); this subset represents 90.9% of the catch of the 11 families involved, 78.9% of the catch of all species reaching less than 80 cm, and 71.6% of the total demersal finfish landings.

The data sets used to study multispecific length frequencies are the 1987 subset defined in Table 2 ( $N=24940$ ), processed with and without stratification, and the whole data sets for 1986 ( $N=13944$ ) and for 1987 ( $N=29062$ ), both processed without stratification.

## Results

### *Species size structure of catches in weight and in numbers*

The distribution of 1987 catches in weight according to classes of maximum length of species shows that half of the total weight is made of species reaching less than 40 cm (Fig. 1); the class 30–40 cm alone accounts for 36.4% of the total, with very common species or genera such as *Holocentrus* spp., *Acanthurus* spp., *Epinephelus fulvus*, *Alphistes afer*, etc. Classes above 50 cm all contribute less than 10% of the total catch, especially for classes 80–90 cm and 90–100 cm, whose yield is very low. Species reaching more than 100 cm

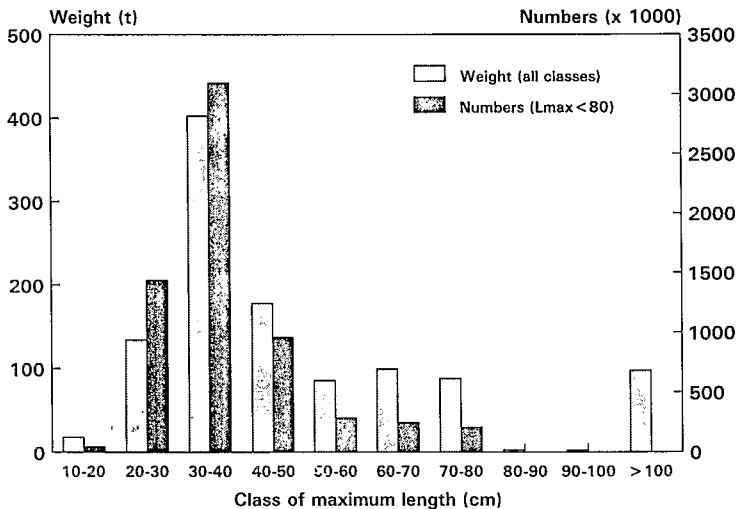


Fig. 1. Distribution of 1987 demersal catches in weight (for all classes) and in numbers (for classes lower than 80 cm) according to classes of maximum size of species.

in length were placed together in a single class and are all situated at a high trophic level: morays (59.9% of the class weight), sharks (28.5%), barracudas (4.5%) and other predators (groupers, jacks, needlefishes: 7.5%).

Because it depends on monospecific length-frequency samples, reliable estimation of the distribution of 1987 catches in numbers according to classes of maximum length is not possible for all species, but only for the subset of 41 species belonging to 11 families (Table 2), which is considered to be representative of species not exceeding 80 cm. Within this subset, the 30-40 cm size class still dominates in weight, but even more so in numbers (Fig. 1); more than 70% of the fish caught belong to species reaching between 20 and 40 cm. In weight as well as in numbers, the three larger classes of this subset (50-60, 60-70, 70-80 cm) are of roughly equal importance.

### Multispecific length-frequency distribution

The overall length-frequency distribution of fish belonging to the 1987 subset ( $N=24\ 940$ ) is unimodal, with a mode of 17 cm, a mean of 19.8 cm, and standard deviation of 5.62 cm (Fig. 2). Ninety-four percent of the fish within this subset are less than 30 cm in length: the fishery is thus based not only on medium-sized species, but also on small- or medium-sized individuals of these species, with respect to their potential maximum size. The smooth aspect of the ascending arm of the distribution (Fig. 2) reflects the selection in the fishing gears, and particularly of traps. The height of 50% retention ( $H_{50}$ ) in the selection curve is 4.9 cm for the main mesh size used for traps in Marti-

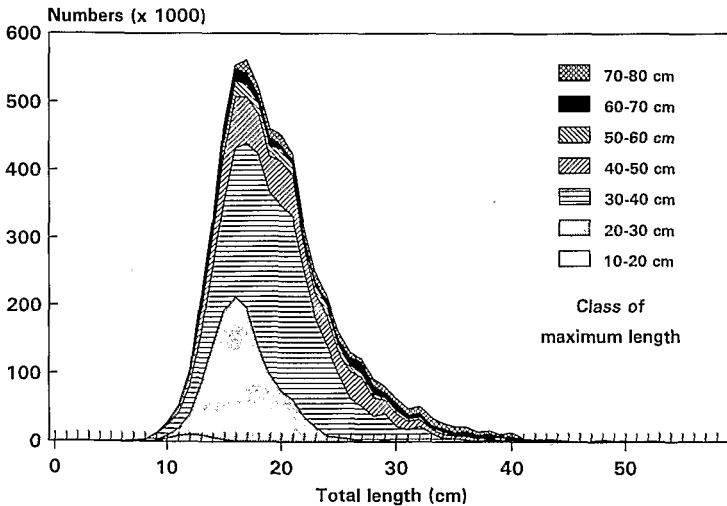


Fig. 2. Overall length structure of catches, for species reaching less than 80 cm TL (stratified estimation of numbers).

nique, corresponding to a total length ( $L_{50}$ ) ranging from 15 to 22 cm for most of the species studied (Chevaillier, 1990), but the other selectivity patterns involved (other trap mesh sizes and other gears), as well as the species differences in body shape, account for the overall selection process.

### *Length distributions by classes of maximum length*

The impact of the present fishing practices on the different classes of species are shown by the descriptive statistics of their catch length frequencies: i.e. the mean, standard deviation, and range (Fig. 3). The minimum length is lower than 10 cm in all classes (owing to the generally common selection process by traps and nets), which means that fish belonging to large species can be caught from about 10% of their maximum length. The catch is made of fish of decreasing relative size as larger species are considered: small species (10–30 cm) are exploited close to their maximum lengths, medium-sized ones (30–50 cm) contribute to the catch with fish of intermediate length, and large species (more than 50 cm) provide mostly relatively small fish.

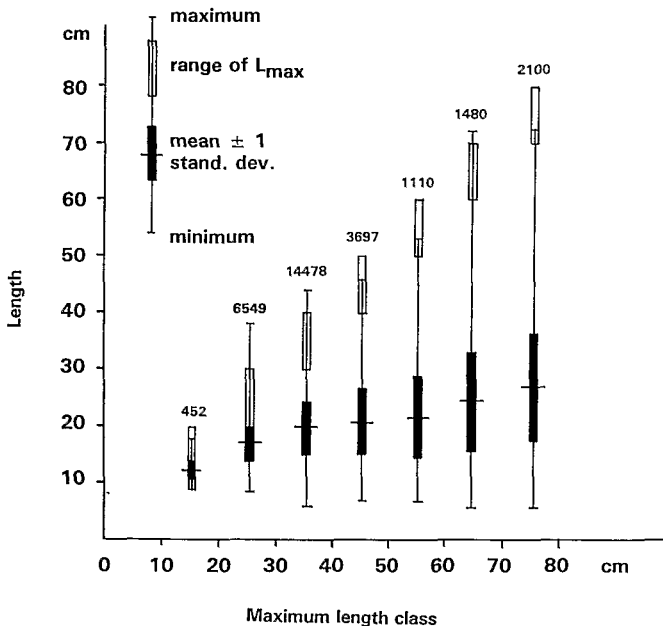


Fig. 3. Descriptive statistics of length structures of catches in each class of maximum size (numbers indicate sample sizes).



### Shape of the multispecific length distributions

The descending arm of the overall length-frequency distribution for stratified 1987 data shows a monotonic decrease with an exponential general shape (Fig. 2). This is confirmed by the  $\ln(N+1)$  transformation of frequencies, where the linear trend is obvious, at least up to about 60 cm (Fig. 4); a linear regression fitted to the interval where the variance of residuals can be considered as constant (20–40 cm) accounts for almost all the variance (Table 3).

In order to study the generality of the exponential decrease of length frequencies, data were plotted for lower levels of species aggregation (individual species, species groups) and for different whole data sets. For most individual species, fitting a linear regression to length frequencies is inappropriate because either the length range is too narrow, or the residual variance is not constant, or a curvilinear trend of residuals is obvious. Overall length fre-

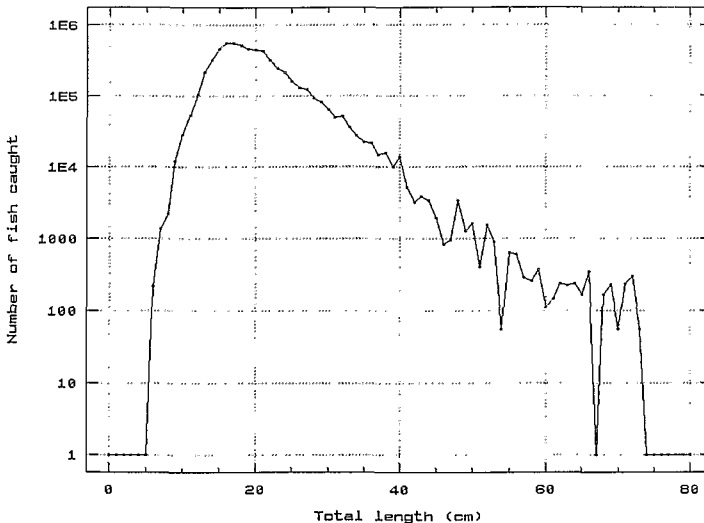


Fig. 4. Logarithmic plot of the length structure of 1987 catches (stratified estimation for species reaching less than 80 cm TL).

Table 3  
Regressions of  $\ln(N+1)$  on  $LT$  over the 20–40 cm length range

Data set	$R^2$ (%)	$a$	$b$	Fish measured
1987 subset (stratified)	98.97	16.8674	-0.1925	24940
1987 subset (non-stratified)	99.74	11.1530	-0.1802	24940
1987 whole sample	99.63	11.2328	-0.1754	29062
1986 whole sample	98.59	10.1595	-0.1709	13944

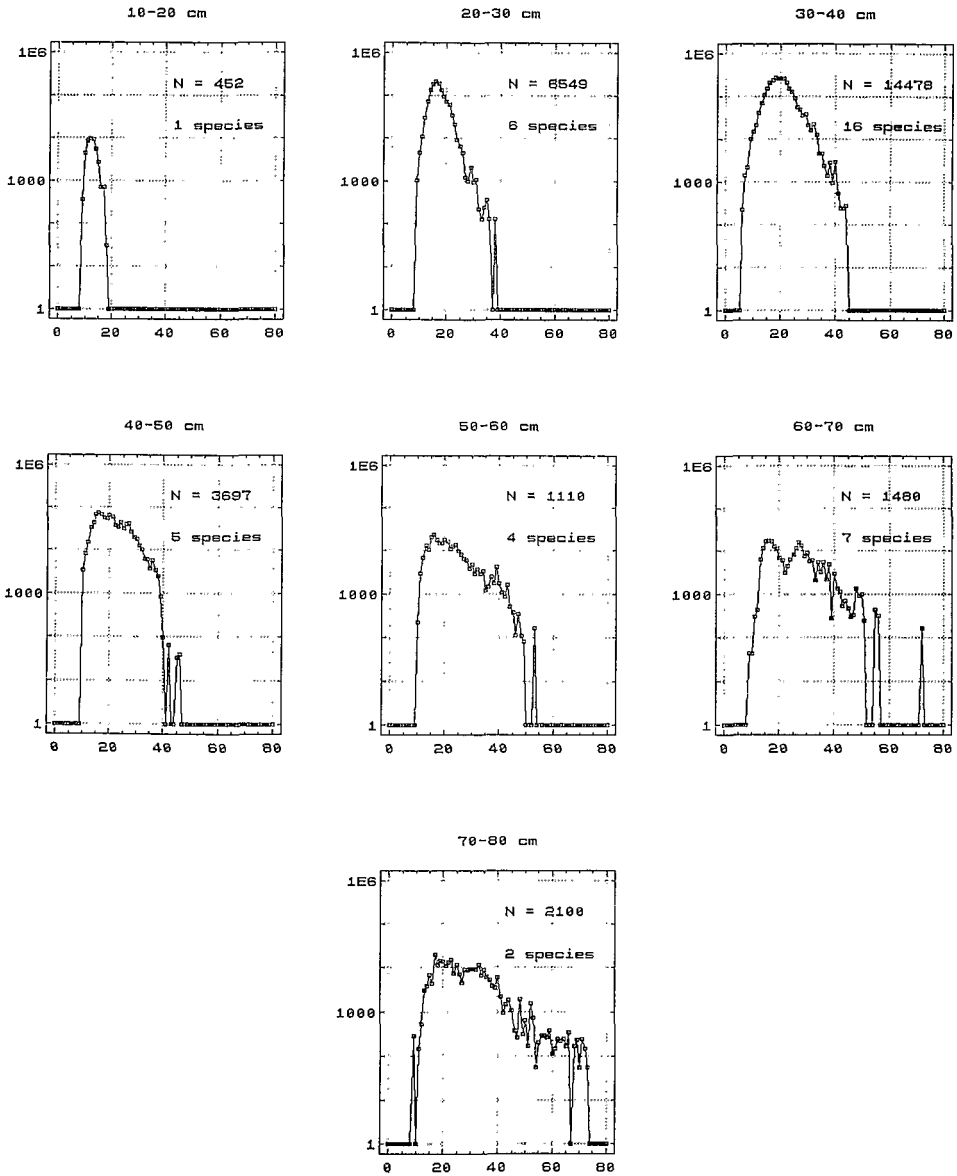


Fig. 5. Logarithmic plots of the length structures of 1987 catches for each class of maximum size (stratified estimations).

quencies within classes of species all show some linear trend after  $\ln(N+1)$  transformation (Fig. 5), but the regression analyses lead to rejection of the linear relationship in all cases except the 30-40 cm class, mainly because the residuals are clearly not randomly distributed over a major part of the seem-

ingly linear length ranges. Length-frequency plots of the 1987 non-stratified subset, of the 1987 whole data set, and of the 1986 data, all show the same general aspect, with a clearly linear first part of the descending arm, and a more variable second part (Fig. 6). The stratified and non-stratified plots of the 1987 subset (41 species) are very similar, reflecting the spreading of data collection over the sampled population. Compared with the non-stratified subsample, the total 1987 sample (more than 150 species) differs in the higher frequencies of large species which could not be incorporated in the stratification, but the first parts of the distributions are similar. With an overall size about half of those of 1987, the 1986 sample differs mainly by the lack of large fish.

A linear regression on the same length interval as on the stratified 1987 data (20–40 cm) provides a very good fit in all three cases (Table 3), with more than 98.5% of the variance accounted for and no trend in the residuals. These slopes are not significantly different ( $F=3.17$ , 2;57 d.f.), but their common slope ( $b=0.175$ ) differs significantly from that of the stratified regression ( $F=15.14$ , 1;76 d.f.).

In summary, the exponential decrease of length frequencies becomes clearer as higher levels of species aggregation are considered, and is equally obvious for all data sets involving the whole catches.

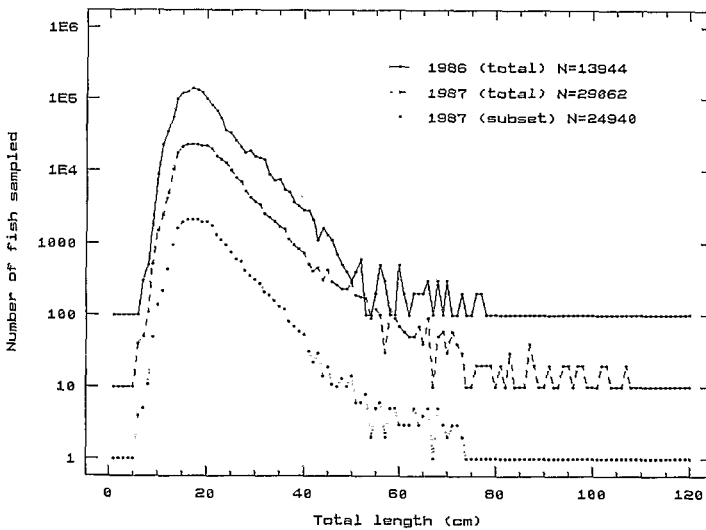


Fig. 6. Logarithmic plots of the length structures of the raw samples of 1986 and 1987 (for more clarity, the curves were spaced by a multiplicative factor of 10).

## Discussion

### *Species and size selectivity of the fishery*

The first point to discuss is to what extent the overall catchability pattern of the fishery is responsible for the observed distributions of catches among maximum size classes and among individual fish lengths. In other words, are large fish and large species rare in the catches because they are rare in the exploited fish community or because their catchability is low for the gears used by fishermen? In 1987, the demersal fishing effort was dominated by traps, which accounted for 62% of the landings (all species together); in the subset of species reaching less than 80 cm, 79% of the fish (in numbers) were caught by traps. The size selectivity of fish traps is usually described by a logistic model, with a constant catchability above the full retention length (Chevaillier, 1990); in reality, it is quite certain that catchability decreases for large fish, which are less likely to enter traps. This can be related to possible behavioural causes, about which little is known, and to physical constraints (trap volume, funnel width). The dimensions of the traps used in Martinique (often bigger than 2 m<sup>3</sup>) are such that only the largest individuals of large species could have a significant decrease in catchability. The other main demersal gears used in Martinique (which rank very far behind traps for landings) all show a marked decrease in catchability as fish length increases, in relation to mesh sizes for gillnets and trammelnets (with a more complicated pattern for trammelnets), to hook size and shape for handlines and bottom longlines, and to trap volume and entrance for the small baited traps. As far as species selection is concerned, some minor gears are quite selective (particularly handlines and bottom longlines), but the main ones catch a high number of species: 127, 118, and 107 species were identified in the catches of traps, trammelnets and gillnets, respectively, with only partial overlaps of dominant species (Gobert, 1992). Qualitatively, the reef fish fauna is quite well represented in the catches: out of 186 species described by Randall (1983) as reaching more than 20 cm, 124 have been identified in the catches, and those that are missing are often described as rare, either in the whole Caribbean region or in the Lesser Antilles. Some large species are also amongst those missing, and these were formerly caught by the same gears as are used nowadays (see below).

From a more general standpoint, it should be considered that the Martinican fishery operates in a context where access to technology and capital is seldom a limiting factor for fishermen. Furthermore, the market demand for fresh demersal fish is very high, thus generating high prices for all sizes of fish and species, and restraining discards, especially above a minimum size acceptable for consumers (the smallest, non-marketable fish are often kept for use as bait). There is some field evidence suggesting that the diversity of fish-

ing techniques and strategies used by fishermen in Martinique allows them to target most, if not all, significant components of the demersal resource, through the use of a variety of options such as gear dimensions and shape, mesh sizes, soak durations and periods, depths, baits, etc. (Gobert, 1989a; Pary, 1989). Therefore, it can be assumed that, although they are not absent, the overall species- and size-selectivity of the fishery contribute only to a limited extent to the observed length-frequency distributions of catch above the full retention length of the main gears.

### *Size-related interpretation of the fishery*

Consideration of the size distribution of the whole set of species sampled in the catch brought an understanding of the fishery which would not have been available with single-species analyses alone.

Reliable growth parameters and sufficiently large sample sizes were available for very few species only: *Haemulon plumieri*, *Haemulon flavolineatum*, *Ocyurus chrysurus*, *Mulloidichthys martinicus*, *Pseudupeneus maculatus*, and *Epinephelus fulvus*. Length-based pseudo-cohort analysis and yield-per-recruit simulations (Chevaillier and Laurec, 1990) applied to these species lead to conclusions ranging from clear under-exploitation to slight over-exploitation of growth potential, according to species and values assumed for the coefficient of natural mortality  $M$  (Chevaillier, 1990; Gobert, 1991a). In no case could strong indications of growth overfishing be found for fishes, as was the case for the lobster *Panulirus argus* (Gobert, 1991b). This result contrasts with the finding that the demersal fishery of Martinique is one of the most intensive of the Caribbean region (Munro, 1983; Gobert, 1990), and can be misleading if taken without consideration of the multispecific nature of the fishery. With the exception of *O. chrysurus*, all the species analysed fall into the small or medium size-classes ( $L_{\max}$  ranging from about 28 to 41 cm) and therefore are selected in the catches at moderately large relative lengths (Fig. 4), and consequently at ages allowing their populations to withstand the present fishing effort. However, this conclusion cannot be applied to smaller or larger species. The former are probably very lightly impacted upon by the fishery, with only the larger fish being caught. The latter are caught at very small relative lengths, and very likely undergo much higher exploitation rates than the 'optimum' they could withstand given the present selectivity pattern, suggesting that they are subject to severe growth overfishing and probably also to recruitment overfishing. This general interpretation is supported for large groupers by the results of a series of interviews with old fishermen, using a rigorous methodology (Gobert, 1993): some of the large grouper species (including *Epinephelus itajara*, *Epinephelus striatus* and *Mycteroperca venenosa*), now very rare, were much more common 30 or 40 years ago, before the generalisation of trap fishing, which replaced the more selective handlin-

ing on the Martinican shelf. Answers concerning large parrotfish species (*Scarus* spp.) also suggested, but less clearly, a decline in abundance; for methodological reasons at least, results for the large snappers (other than *O. chrysurus*) were inconclusive.

A size-related exploitation pressure of the multispecific resource (increasing from small to large species) thus appears in this fishery. However, consideration of a few examples shows that specific variations about this pattern are caused by differences in catchability (depending on habitat and behaviour), growth and natural mortality parameters, and in body height/length ratio. The yellowtail snapper, *O. chrysurus*, was not found to be suffering from growth overfishing in spite of its large size ( $L_{\max} \approx 75$  cm): assuming natural mortality to conform to the rule found by Ralston (1987) for tropical snappers and groupers, the fishing mortality due to traps should even be significantly increased in order to reach the maximum yield per recruit (Gobert, 1991a). *Ocyurus chrysurus* is an exception to the general pattern of demersal habits of Lutjanidae, with much less dependence on the bottom habitat for food and shelter (Parrish, 1987): this probably reduces its catchability by traps, thereby making the survival of the population possible, whereas other demersal species of the same size range have already been fished out. Although adequate data are lacking, one could also suspect that morays are much less vulnerable to growth overfishing than other large species, since they are caught at high relative lengths (about 60 cm for *Gymnothorax moringa*, whose  $L_{\max}$  is about 120 cm) because of their body proportions.

#### *Exponential decrease of multispecific length frequencies*

The exponential decrease of multispecific length frequencies was found for all samples and both estimation procedures (with and without stratification); the fit of a linear regression to log-transformed frequencies was always excellent between 20 and 40 cm, but the linear trend remained apparent to at least 50 cm, with more variability within and among samples owing to the very low numbers of fish measured (less than ten fish per length class above 50 cm). The increasing regularity of length-frequency distributions when individual species, then species groups, then the whole data set were considered, shows that the smoothing effect of sample aggregation contributes to the regular aspect of the overall distribution. However, the smoothed aggregated distribution could be of any shape, and this effect by no means accounts for the observed exponential decrease. As discussed above, this is also true of the overall selectivity of the fishery.

An exponential decrease in numbers is typical of age structures in steady-state populations when total mortality is constant, but the descending arms of length-frequency plots are normally not exponential, with a shape depending on growth and mortality parameters (Jones, 1984). Thus, it seems that

the interpretation of the shape of the overall catch length structure should be sought in some inherent feature of the resource. Although reef fish assemblages have been studied extensively, multispecies length structures in these communities have received very little attention from researchers (Sale, 1991). More generally, ecosystems often have properties which cannot be deduced simply from those of their constituting species (Odum, 1983): if confirmed in the exploited fish community, the exponential decrease of numbers would be such an 'emergent property', since it appears only at high levels of aggregation. The distribution of sizes of organisms (measured in equivalent spherical diameter) has been shown to be an emergent property of pelagic ecosystems, which have relatively predictable biomass spectra, from bacteria to whales (Sheldon et al., 1972). The importance of this size factor is related to ecological or physiological processes such as predator/prey ratio of body size, production/biomass ratios according to the size of species, etc. (Dickie et al., 1987). However, this model seems more suitable for pelagic ecosystems, where vertical trophic structure is dominant and degradation/remineralisation cycles are secondary processes, than on continental or insular shelves where trophic webs are much more complex. It is not clear to what extent the regularity of biomass spectra can be applied to coral reef ecosystems, where energy pathways and nutrient cycles are organised in a very different way with high turnover rates (Sournia, 1977; Longhurst and Pauly, 1987).

The observations presented here deal with fishery catches and with only a part of the biological spectrum of the reef ecosystem, and thus bring a limited

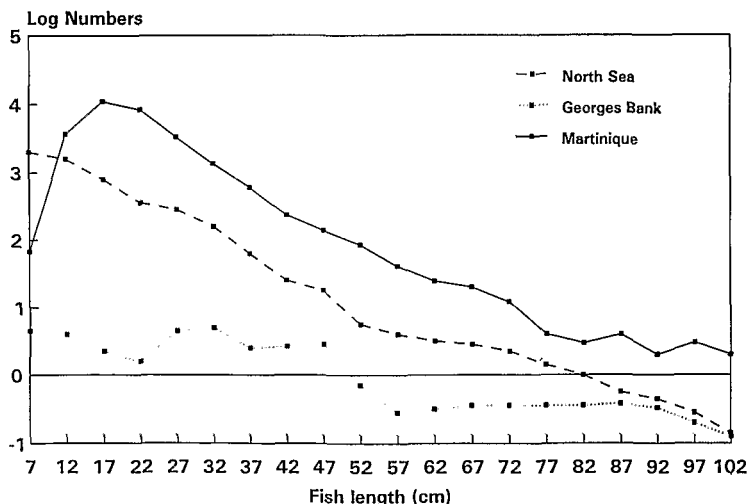


Fig. 7. Overall logarithmic length-frequency distributions of fish caught in the North Sea, on the Georges Bank (from Murawski and Idoine, 1992), and in Martinique. Numbers are average numbers per tow for the North Sea and Georges Bank, and total numbers caught for Martinique.

contribution to this ecological debate; however, emergent properties have been shown to have some potential interest in multispecies fisheries assessment and management, particularly with respect to stability of catch or biomass (Food and Agriculture Organisation, 1980) or of length structure (Pope and Knights, 1982; Murawski and Idoine, 1992). In the three regions compared by these authors (North Sea, Faroe, Georges Bank), the overall size structure of trawl catches remained relatively stable over more than 20 years in spite of large year-to-year fluctuations in species composition. The use of a smaller mesh size and a higher predation mortality on young fish were thought to explain the much greater slope found for the North Sea catch curve (Murawski and Idoine, 1992). Interestingly, the slopes of the log-transformed plots of North Sea and Martinique data are very close, compared with the Georges Bank data (Fig. 7), suggesting some similarity in the rates of energy transfer along the size spectrum of fishes. However, these two systems are so different, both from the fishery and ecology standpoints, that drawing any conclusion at this stage could be misleading. In the short term, very promising approaches for reef fishery assessment are (a) to test the overall size structure as a conservative property through studies of its evolution in selected reef fisheries, and (b) to test its usefulness as an indicator of exploitation levels through comparative studies of fisheries differing mainly in fishing effort or selectivity.

## Conclusions

As in many other tropical small-scale fisheries, the assessment of the demersal resource of Martinique is hindered by many factors, related both to the cost of collecting the basic information (catch and effort statistics, biological sampling, etc.), and to the inappropriateness of traditional single-species models for a highly multispecific stock exploited by a variety of fishing gears.

In addition to these classical approaches, the consideration of multispecies size structures allowed the use of all the costly information collected, and more important, ensured that misleading conclusions were not drawn from the use of single-species analyses only. Generally speaking, the multispecific scale of analysis is all the more necessary that even if data were available on a large number of species, the mere juxtaposition of single-species analyses would yield results applicable within only a small range of variation around the present state of the system (Dickie et al., 1987). In the case of the Martinican fishery, short-term management options were proposed, but assessing the long-term impact of larger changes in fishing effort or size selectivity was impossible, as the set of species sustaining the fishery would probably be different (Gobert, 1991a).

The data presented here do not allow any conclusions to be drawn about exponential decrease of length frequencies being an emergent property of the



reef fish community, and more ecological research is required on this topic. Without a sound understanding of how the overall length structure of the resource is determined, the observed length structure of the catch cannot be interpreted directly for fishery purposes, in terms of assessment of the exploitation level or status of the resource. However, such an approach is especially interesting for tropical reef fisheries, in complement to the traditional methods of fish stock assessment, such as short-term yield/recruit analyses or catch and effort time series. As stated by Pope and Knights (1982), comparative studies on multispecific size structures in fisheries having experienced different development and/or management policies are also a particularly promising perspective for research.

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