

**MULTISPECIES ASSESSMENT IN CORAL REEF FISHERIES
USING HIGHER TAXONOMIC CATEGORIES AS UNIT STOCKS,
WITH AN ANALYSIS OF AN ARTISANAL HAEMULID FISHERY**

**UNE EVALUATION DES ESPECES CAPTUREES
DANS LES PECHERIES TROPICALES EN MILIEU RECIFAL,
EN UTILISANT COMME UNITE DE STOCK
LES PLUS HAUTES CATEGORIES TAXONOMIQUES;
ANALYSE D'UNE PECHERIE ARTISANALE D'HEMULIDES**

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ABSTRACT

In tropical reef fisheries, species data are often lumped together in catch statistics at the familial or generic level. By treating the species group as a unit stock, quantitative assessments using such data may be possible. Two lines of argument support this statement. First, empirical studies on the relationships between population parameters (particularly the von Bertalanffy parameters k , W_{∞} , and L_{∞} and natural mortality M) indicate that their variability within related groups is low, and that this variation is constrained by specific mathematical functions, i.e. within a predictable range, a particular combination of such parameters will be characteristic of a specific group. Thus, related species have similar quantitative life-history attributes. Second, related species of reef fish often approximate an ecological guild. Members of a guild exploit resources in a similar manner. As such, one species can substitute for another without much ecological impact. A stock of related species, termed a species cluster, is in many respects similar to a unispecies stock with size-selective mortality: smaller individuals grow faster but have a higher rate of mortality. Fishing pressure would initially reduce the number of larger individuals, but total cluster productivity would increase as smaller, more productive individuals increased in relative abundance. General unispecies concepts may therefore be applied in the analysis of some species clusters. As an example, the haemulid (grunt) fishery off La Parguera, Puerto Rico is analyzed. This species cluster contains 11 species, four of which dominate. Catch and effort were used to estimate population abundance and to derive two surplus-production models. Results were consistent between methods and in comparison to other studies. The fishery was found to be overexploited, with the level of current exploitation being 250% greater than that predicted for maximum yield.

RESUME

Les données sur les espèces capturées par les pêcheries tropicales en milieu récifal sont souvent analysées statistiquement au niveau de la famille ou du genre. Une évaluation quantitative peut être faite en utilisant ce genre de données si le groupe d'espèces est traité comme unité de stock. Cette affirmation s'appuie sur deux arguments distincts. Premièrement, les études pratiques des relations entre les paramètres de Von Bertalanffy tels que k , W_{∞} et L_{∞} , ainsi que la mortalité naturelle M , indiquent que leur variabilité à l'intérieur d'un même groupement est faible et que cette variation est limitée par des fonctions mathématiques spécifiques; c'est à dire, qu'à l'intérieur d'un domaine prévisible, une combinaison particulière de ces paramètres sera caractéristique d'un groupe précis. Ainsi, des espèces possèdent, du point de vue quantitatif, des paramètres biologiques semblables. Deuxièmement, certains peuplements de poissons récifaux peuvent être assimilés à une guildes écologique. Les membres de cette guildes exploitent les ressources de manière semblable. C'est ainsi qu'une espèce peut se substituer à une autre sans avoir un impact écologique important. Un stock d'espèces liées, désigné par "species cluster" ressemble en beaucoup de points à un stock monospécifique où la mortalité est proportionnelle à la taille des individus: les poissons de petite taille croissent plus vite, mais ont un taux de mortalité plus élevé. L'effet des captures devrait initialement se traduire par une réduction du nombre de gros poissons, mais la productivité totale du groupe d'espèces liées devrait augmenter en même temps que l'abondance relative de poissons plus petits, mais plus productifs. Les concepts monospécifiques peuvent être alors appliqués à l'analyse de certains groupes liés. La pêche des Hémulides (gorettes) dans les eaux de la Parguera, Puerto-Rico, est analysée à titre d'exemple. Le groupe d'espèces liées est constitué de 11 espèces dont 4 sont dominantes. Capture et effort de pêche ont été utilisés pour estimer l'abondance de la population et pour établir deux modèles de production des surplus. Les résultats sont cohérents entre des méthodes différentes ainsi qu'avec ceux d'autres études. Cette pêcherie est en surexploitation, avec un niveau de 250% au-dessus de celui prévu par une bonne gestion.

INTRODUCTION

In tropical coral reef systems, characterized by high species diversity, typical unispecies assessment methodologies are difficult to apply because data are often lacking. Analytical methods are needed which can utilize data as commonly encountered in tropical fisheries. One typical characteristic is the lumping of species in fisheries statistics, usually at the familial or generic level. For example, in Hawaii 11 species of carangids are grouped together as *ulua* (Parrish, 1980); in Puerto Rico all species of haemulids (grunts) are reported as *boquicolorado* (Weiler and Suarez-Casbro, 1980).

The analysis of lumped-species data is not new, either in theory or in practice. Royce (1972), Kesteven (1973) and Lackey (1974), for example, all explicitly define unit stock to include multiple species when necessary, although the exact methods of quantitative assessment are often left to the imagination of the reader. Lackey (1974) gives several examples where lumping species might be justified. He based an ecological unit stock on the general behavior of exploited species, such that fishing pressure would likely be more uniform within similar ecological groups than between, e.g. dividing a lake fishery into demersal, littoral and pelagic stocks. An aggregate unit stock was defined when statistics of growth, mortality and recruitment could be assumed not to vary substantially between different species, and as such, serious errors in analysis would probably not occur, e.g. Graham's (1935) analysis of the North Sea demersal stock.

In practice, lumped-species data have been used to study trends in abundance, often with interesting results (e.g. Pauly, 1979a; Pope, 1979), but they have rarely been used for practical stock assessment (for an exception see Ellis, 1969). In all cases, though, the suitability of using such groupings is poorly addressed; one must assume the basis lies on the unstated premise that closely related species are morphologically and ecologically similar.

This paper presents bases for using higher taxonomic groupings (e.g. genera or families) as units in stock assessment, with particular reference to coral reef fishes. The arguments below are presented in four parts. The first two discuss the empirical and ecological bases, respectively, of using higher taxonomic groupings in stock assessment. The third considers the nature of such stocks, primarily through analogy to unispecies systems, followed by a demonstration of an assessment using a segment of the Puerto Rican haemulid fishery. The methods to be presented should not be considered as a substitute for single species assessment, but primarily as a way of utilizing lumped data to obtain useful information when no other recourse is available.

EMPIRICAL BASIS FOR GROUPING BY TAXONOMIC STATUS

Extending the earlier work of Beverton and Holt (1959) and others, Pauly has derived empirical relationships between k and W_{∞} , and L_{∞} , the von Bertalanffy growth parameters (Pauly, 1979b; 1980a), and between these parameters and M , the natural mortality rate (Pauly, 1980a,b). The relationship between growth parameters is demonstrated on an auximetric grid, plotting $\text{Log}_{10}k$ against $\text{Log}_{10}W_{\infty}$ (Fig. 1). The plotted parameters are clustered by stocks within species

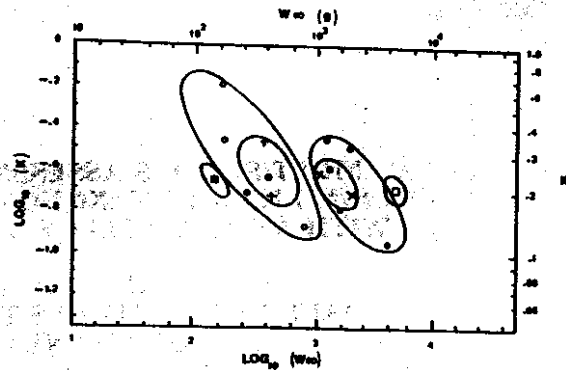


Figure 1. An auximetric grid plot of growth parameters for the Haemulidae. Values for each species are enclosed in an ellipse whose major axis has a slope of $-2/3$. Data are from Table 1.

and by species within genus or family, though to a proportionally lesser extent. The clusters take the shape of an ellipse. Pauly (1979b) showed the major axis of an intraspecific ellipse to define the following relationship: $\text{Log}_{10}k = a - 2/3 \text{Log}_{10}W_{\infty}$. Similar results were obtained using $\text{Log}_{10}L_{\infty}$ (Appeldoorn, 1982). Within an interspecific ellipse the parameters remain linearly related (Fig. 1; Pauly 1979b: Fig. 5; 1980a: Fig. 2), but the major axis differs from that above. A predictive linear regression on 63 pairs of growth parameters presented by Pauly (1979b; 1980a) yielded the following relationship: $\text{Log}_{10}k = a - .1908 \text{Log}_{10}W_{\infty}$ (for these data $a = .0847$; $p < .01$). The major point is that positions on the grid can "be used to define taxa, such as families" (Pauly, 1980a: 158); knowledge of one member of a group can be related to all members. The lower the taxonomic level considered, the lower the variability. In the present context variability would be reduced further because the species considered would inhabit the same environment, particularly with respect to temperature, i.e. extreme points of high k , low W_{∞} and vice versa, resulting from

Table 1. Literature values for von Bertalanffy growth parameters for species of Haemulidae (*Haemulon* & *Pomadasys* (= *Rhoniiscus*)). W_{∞} is in grams. S = literature source.

Species	W_{∞}	k	Location	S
<i>H. plumieri</i>	1357	.345	Jamaica	1
	1752	.157	Jamaica	3
	2007	.328	Cuba	3
	4112	.108	N. Carolina	4
	1357	.26	Puerto Rico	6
	<i>H. aurolineatum</i>	188	.35	Jamaica
740		.138	Cuba	3
165		.664	Campeche	2
266		.184	Campeche	2
<i>H. sciurus</i>	402	.220	S. Atl. Bight	2
	1114	.24	Jamaica	1
	2063	.189	Cuba	3
<i>H. flavolineatum</i>	374	.35	Jamaica	3
	476	.179	Jamaica	3
<i>H. alban</i>	5297	.2	Jamaica	1
<i>P. striatus</i>	142	.229	Red Sea	5

Sources: (1) Billings and Munro, 1974; (2) Darcy, 1983; (3) Hartsuijker, 1982; (4) Manooch, 1976; (5) Pauly, 1979b; (6) Stevenson, 1978.

extremes of high and low temperature respectively, would be eliminated.

Beverton and Holt (1966) observed that M/k remained fairly constant within families. Pauly (1980a,b) has correlated natural mortality to the above growth parameters and temperature. (Again, temperature will be uniform for a given environment so its effect here can be incorporated into a constant.) From this relationship it can be concluded that if k and W_{∞} or L_{∞} are similar among related species, then the values that M can assume will also be limited. The result is a suite of related species having similar growth and mortality parameters, the values conforming to specific relationships.

ECOLOGICAL BASIS FOR GROUPING BY TAXONOMIC STATUS

Theoretical support for grouping similar species comes from the study of ecological guilds. A guild is "a group of species that exploit the same class of environmental resources in a similar way" (Root, 1967: 335). The grouping of species within a guild is independent of taxonomic status, but because of genetic similarities, guilds are often highly correlated to taxonomic divisions. Indeed, many classifications employ at least some characters which reflect interspecific patterns in ecology. Some workers also have used guilds to develop "functional taxonomies" to aid construction of ecological models (Bahr, 1982).

Guilds of coral reef fish have been studied by Gladfelter and Johnson (1983), Williams (1983) and others, but the most detailed work has been that of Sale on a guild of territorial, herbivorous damselfish (see Sale, 1980 for references). His results showed that member species had similar requirements for habitat and space; territories were defended against all intra- and interspecific guild members. Recruitment was essentially random, limited to the number of vacant sites available, and for a given species, proportional to its abundance in the pool of colonizers. Functionally, one species could be substituted for another without much ecological change. That guild members belonged to the same family is not uncommon (Sale, 1977: Table 1).

NATURE OF A SPECIES CLUSTER AS A UNIT STOCK

Stock assessment on a higher taxonomic unit is based on the premise that such a unit can be treated in many respects as a single species. From the above empirical relationships it is known that, between related species, growth and mortality will have limited variability, with the nature of this variability being constrained by these relationships. On an ecological basis there is good support for considering a guild to behave functionally as a single species, and that guilds often form along taxonomic lines. It is not necessary that the species involved form a true and complete guild, but obviously the closer a group of related species, termed a "species cluster", approximates a true guild, the greater will be the validity and reliability of the analysis.

To comprehend the nature of a species cluster consider a single species population with size-selective mortality. It has been shown that within a population (Gerking, 1957; Ricker, 1968) and in interstock comparisons (Beverton and Holt, 1959; Pauly, 1980b), fast growing individuals suffer a higher mortality; hence k and M are positively correlated. Faster growing individuals

are also known to reach a smaller final size, so that k and L_{∞} or W_{∞} are negatively correlated (Gallucci and Quinn, 1979). The same is true within a species cluster; there exist groups of individuals (species) with moderately varying values of M , k , and L_{∞} or W_{∞} , with k correlated to M and to the inverse of L_{∞} and W_{∞} . The difference between a single species with size-selective mortality and a species cluster is that the range of parameter variability is greater within a cluster. However, the treatment of either system should be similar.

Ricker (1969) reviewed the effects of size-selective mortality on growth, production, and yield estimates. With respect to productivity and yield estimates, ponderal mortality rates should be used when size-selective mortality is operating. For von Bertalanffy growth computations, Ricker showed that population growth rate differed from the required true growth rate, the latter yielding a higher value of k and a lower value of L_{∞} and W_{∞} . Within a cluster, an analogous change would move the values of k and W_{∞} toward the center of the ellipse on the auximetric grid. Indeed, if the spread of points within the ellipse is small, average values of k and W_{∞} might be suitable, as a first approximation, to describe the cluster. However, Ricker found the effect of such changes in growth coefficients on yield-per-recruit computations to be unpredictable, and called for a separate study to address this point. Such a study will not be attempted here, but rather attention will be focused on surplus-yield type models. In reality, it is more likely that, for the fisheries being considered, catch and effort data alone would be available rather than the detailed information required for yield-per-recruit analysis.

The effects of fishing pressure on a species cluster generally can be shown, again, through analogy to a unispecies stock. In such a stock equilibrium mean individual size decreases as fishing pressure increases. At moderate pressure this results in greater productivity since the fish are maintained at a smaller, more rapidly growing stage. Within a species cluster, the same effect should occur. Increasing fishing pressure will remove relatively more of the larger species thus reducing equilibrium mean size. If lottery recruitment operates, higher mortality on larger species would not result in greater productivity within those species (Sale, 1982b). However, an increase in total cluster productivity would be expected since remaining smaller species would have higher individual (k) and higher population (r) growth rates (Banse and Mosher, 1980). An important difference here between a single species and a species cluster is that all members of a cluster cannot interbreed. Hence, within a cluster it is theoretically possible to drive large individuals to extinction under heavy fishing pressure. However, Sale (1982a) has shown that, under lottery recruitment, extinction is unlikely even when member species differ substantially with respect to mortality (but cf. Abrams, 1984).

Theoretical support for modeling a species cluster using surplus-yield equations comes from the analysis of mixed-species fishery dynamics (Pope, 1976; 1979; Kirkwood, 1982). Pertinent general conclusions from these studies are: (1) if the component species are weakly interacting, there is a broad range of fishing mortalities wherein the mixed fishery exists, and (2) if the ratio of fishing mortalities on component species

is restricted, total effort can be used to model the fishery. The first conclusion is consistent with Sale's (1982a) analysis of species stability within a lottery-type recruitment system. Competition occurs at settlement, with success being random. After settlement few, if any, competitive interactions exist. As to the second conclusion, there is good reason to believe that within a species cluster the ratio of fishing mortalities will be restricted. It can be assumed that typically no directed fishery exists for any species within the cluster, since no effort is made to single out species in the market or in catch statistics. Fishing might be directed toward the entire cluster, or the cluster may be by-catch from fishing directed toward other preferred species. If all species within the cluster behave similarly, an encounter with a unit of fishing gear by any species will be random, and frequency of encounter will be determined by species abundance. In a nonselective fishery there would be no way to actively alter the ratio of fishing mortalities.

It may be useful to look at a multispecies fishery where the above conditions are not particularly applicable: the South African pilchard-anchovy reduction fishery. These species are quite similar ecologically, and may be thought to constitute a species cluster. An analysis of the fishery by Pope and Harris (1975) showed the species to be highly interactive, and the probability of maintaining a mixed species fishery was low. However, the total maximum sustainable yield did not vary significantly regardless of species composition. Therefore, since neither species was particularly favored in the market, this species cluster could be managed as a unit by employing an overall total catch quota. Such a quota, in fact, has been the most important management regulation applied to the fishery (Newman and Crawford, 1980).

ASSESSMENT OF A PUERTO RICAN HAEMULID FISHERY

Among reef fishes, the haemulid catch represents the second largest in weight and third greatest in value for Puerto Rico (Weller and Suarez-Caabro, 1980), yet species-specific catch

data are not reported. This fishery will be analyzed to demonstrate how a simple assessment of a species cluster might proceed. The particular area to be considered is centered around the town of La Parguera, P.R. Eleven haemulid species are taken in the local fishery (Table 2); 9 are *Haemulon*, of which 4, *H. flavolineatum*, *H. aurolineatum*, *H. plumieri*, and *H. sciurus* are ubiquitous, very abundant, and comprise the majority of the catch (Anon., 1979). Hence, the analysis will necessarily concentrate on these four species, which should reduce the degree of interspecific variability.

The initial step is to determine how closely the species cluster approximates a guild. Fortunately, much information on grunt life-histories is available. Early juveniles, up to 40 mm SL, show similar pigmentation and morphologies, which may reflect early ecological similarity among species. Heterotypic schools can occur as early as 9 mm SL (Lindeman, 1984) and are commonly observed by 30 mm (Ogden and Ehrlich, 1977). Most species often are found in or near grass-bed areas, moving out to reefs as they grow older. Although differences in habitat preference are discernable, older juveniles and adults of the major species are fairly ubiquitous and often overlap in distribution on the reef (Billings and Munro, 1974; Davis, 1967). Almost all species (the exceptions are not appreciably taken in the fishery) are generalized macroinvertebrate foragers, feeding nocturnally over grass beds and sand flats (Randall, 1967). Some preferences exist in feedings areas and prey among major species. However, these preferences vary between studies and are secondary to the degree of overlap in both area and diet (cf. Billings and Munro, 1974; Davis, 1967; Randall, 1967). Because of this high degree of overlap in distribution, diet and behavior, the potential exists for species substitution within the group without great ecological effect. Hence, it appears that this species cluster reasonably approximates a guild.

Methods

The La Parguera fishery was selected for three reasons. First, it is solely an inshore fishery, so fishing statistics are not affected by the

Table 2. Haemulid species (*Haemulon* and *Anisotremus*) found off La Parguera, Puerto Rico. L_{max} is the approximate maximum length (cm) taken from Randall (1968)¹. Comments on distribution and abundance were derived primarily from data in Kimmel (1985)².

Scientific Name	Common Name	L_{max}	Distribution & Abundance off La Parguera, P.R.
<i>H. plumieri</i>	White grunt	41	Ubiquitous distribution; very common; moderately abundant
<i>H. sciurus</i>	Bluestriped grunt	39	Very common on reefs; moderately abundant
<i>H. flavolineatum</i>	French grunt	30	Very common & abundant on reefs, especially inshore
<i>H. aurolineatum</i>	Tomtate	25	Ubiquitous dist.; moderately common & abundant inshore
<i>H. album</i>	Margate	65	Uncommon; very low abundance
<i>H. carbonarium</i>	Ceasar grunt	36	Common with low abundance on reefs
<i>H. parri</i>	Sailor's choice	41	Uncommon with very low abundance on inshore reefs
<i>H. macrostomum</i>	Spanish grunt	43	Moderately common, especially inshore; very low abundance
<i>H. chrysargyreum</i>	Smallmouth grunt	23	Moderately common on inshore reefs; low abundance
<i>H. striatum</i>	Striped grunt	28	Rare (found offshore & not prone to trap capture)
<i>H. bonairiense</i>	Black grunt	28	Rare; not found in trap catches
<i>H. melanurum</i>	Cottonwick	33	Rare; not found in trap catches
<i>A. virginicus</i>	Porkfish	30	Moderately common on reefs; low abundance
<i>A. surinamensis</i>	Black margate	60	Uncommon with low abundance on reefs

¹Randall, J.E., 1968. Caribbean reef fishes. T.F.H. Publications, Inc. Ltd. Hong Kong. 318p.

²Kimmel, J.J., 1985. A characterization of Puerto Rican fish assemblages. Ph.D. Diss. Univ. Puerto Rico, Mayagüez, P.R. 106p.

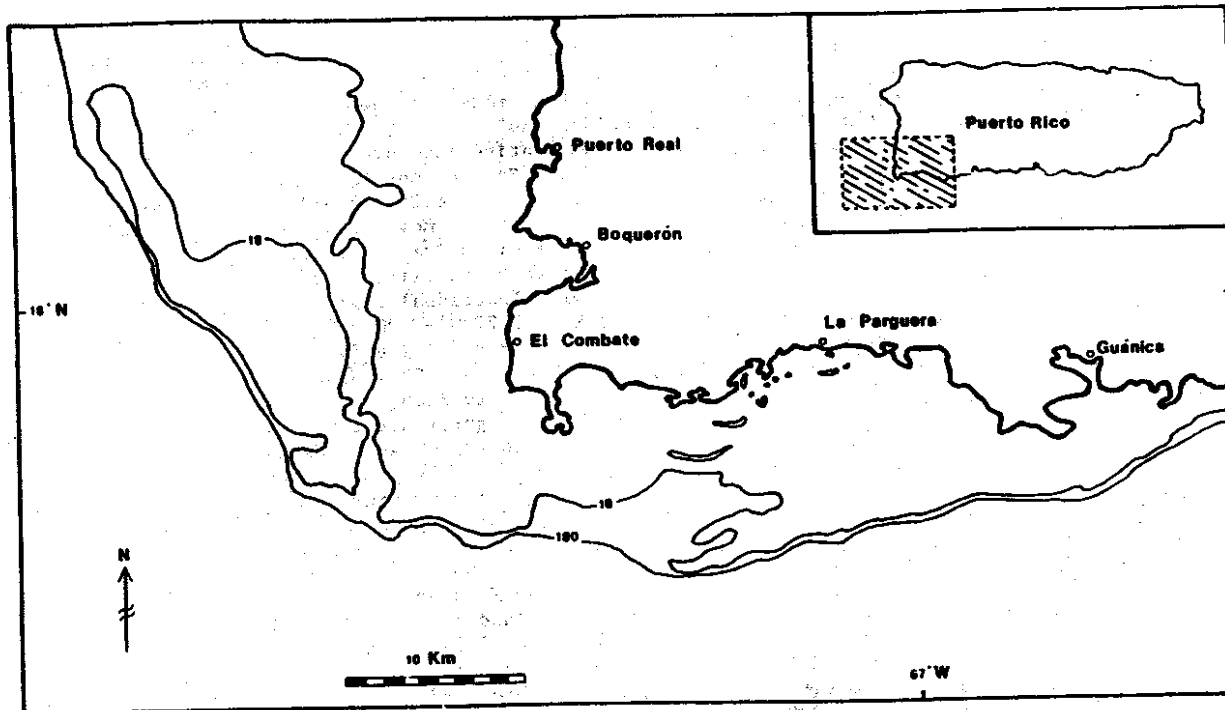


Figure 2. The southwest insular shelf of Puerto Rico. Depth contours are in meters.

deeper-water fishery which developed elsewhere in the 1970's (Suarez-Caabro, 1976). Second, La Parguera and the surrounding shelf are somewhat isolated (Fig. 2), so little of the area catch is landed elsewhere. Third, although many different types of gear are used, the Antillean fish trap accounts for the vast majority of the catch. Therefore, use of trap number as a measure of effort is not strongly affected by changes in relative abundance and use of various gears.

Monthly catch data (lbs) were obtained from the P.R. Commercial Fisheries Laboratory of CODREMAR. Effort was measured as number of traps reported in use during a year. Data were obtained as above and from published reports (Table 3). In some years complete data sets were not available, and average monthly catches were used to fill in missing points. Analysis of monthly data showed no seasonal trends that would affect this procedure. Annual data are presented in Table 3.

In Puerto Rico, records of catch and effort are obtained through voluntary reporting by fishermen and commercial buyers (Anon., 1979; Weiler and Suarez-Caabro, 1980). As such they are susceptible to errors and misreporting. Conversations with local fishermen

indicated that some intentional misreporting did indeed occur. However, the degree of misreporting was felt to be low and, more importantly, to be similar from year to year, i.e. the errors induced represented small but apparently constant fractions of total catch and effort. Hence, in a relative sense the data are consistent among years, and analyses based on these data should not be significantly affected.

Three models were applied to the data: Chapman's open population modification of the Leslie method for abundance estimation (Chapman, 1970), and two production models. It is realized that these methods should be applied to a complete stock, which is not the case here. Generally, most haemulids do not appear to migrate significantly after recruitment, which would rule out emigration and immigration. However, reproductive input from other areas needs to be addressed. Here it is assumed that the La Parguera fishery is representative in the amount of fishing effort and consequent stock status, so that reproductive input equals reproductive loss. Reported catch and effort statistics for Puerto Rico generally support this assumption.

Chapman's method yields population size for the first year of data (1975). This requires estimating $r-M$, values of which were obtained for the four main *Haemulon* species by applying the empirical relationships of Blueweiss et al. (1978) as modified by Pauly (1982), which related size to r , and of Pauly (1980b), which relates growth parameters and temperature to M . Subsequent species-specific values of $r-M$ were linearly related to weight on a logarithmic basis. Therefore, a single estimate for the cluster was taken from the mean of the common logarithms of these values ($r-M = .960$).

Production model parameters were calculated using the methods of Gulland-Fox (Ricker, 1975:

Table 3. Catch (lbs) and effort (traps/year) data for haemulids from La Parguera, Puerto Rico.

Year	Catch	Effort	Year	Catch	Effort
1975	43,023	512	1979	50,062	596
1976	59,788	512	1980	40,388	641
1977	30,186	460	1982	23,206	741
1978	34,002	551	1983	29,197	1447

Sources: Abreu Volmar (1978); Suarez-Caabro and Abreu Volmar (1976); Weiler and Suarez-Caabro (1980); Calderon, CODREMAR (pers. comm.).

section 13.8.3), and of Schnute (1979: eq. 17). The former method estimates only maximum sustainable yield (MSY) and corresponding effort (E_{msy}) and catch-per-effort (U_{msy}); the latter method also yields the catchability coefficient (q), fishing mortality (F_{msy}), stock biomass (B_{msy}), virgin biomass (B_{max}), and r . Schnute's method assumes a parabolic relationship between yield and effort, while the method of Gulland-Fox assumes an asymmetric one with an extended right-hand limb. Although the Gulland-Fox method yields less information, it is considered more appropriate when yield is used instead of catch, and when equilibrium assumptions may not hold.

Results and Interpretations

Results of the three analyses are shown in Table 4. There is good agreement between the various methods. The Gulland-Fox and Schnute methods yielded almost identical estimates of E_{msy} , and similar estimates of MSY; U_{msy} values differed slightly. Some of this difference is no doubt due to the variability inherent in the analysis of small data sets. Using the formula: $B = B_{max}(1-qE/r)$, biomass (B) for 1975 can be estimated using the Schnute parameters and E for that year. The result, 38,100 lbs, closely matches that of the Chapman analysis, 40,020 lbs.

The results, especially of the Schnute method where $MSY > B_{msy}$ and $F_{msy} = 1.31$, indicate a higher rate of productivity than one might have expected for grunts. However, these values depend upon the estimate of q , the accuracy of which may be affected by the small sample size used, the questionable suitability of a parabolic yield function, and particularly the violation of equilibrium assumptions. When effort is increasing, q will tend to be overestimated, with corresponding overestimation of F and underestimation of equilibrium biomass.

Comparison of the results to the data listed in Table 3 indicates that the haemulid cluster has been overfished since 1978-1979, and that the current level of exploitation is four times greater than that predicted to achieve MSY. Because the data used were few and variable, one should use caution in interpreting results or making predictions. Thus, while the evidence for significant overexploitation is clear, the degree of overexploitation may differ from that predicted.

Table 4. Results of 3 analyses of the haemulid fishery of La Parguera, Puerto Rico. See text for explanation of terms.

	Method		
	Gulland-Fox	Schnute	Chapman
MSY	40,572	45,535	
E_{msy}	562	564	
U_{msy}	72.2	80.7	
q		.00231	
F_{msy}		1.31	
B_{msy}		34,886	
B_{max}		69,772	
r		2.61	
B_{1975}		38,100	40,020

However, in light of the possible over estimation of productivity, and given criticisms of production models in general (Pauly, 1979a; Marchesseault et al., 1976; Sissenwine, 1977), a conservative interpretation would be advised. For reasons given above, results obtained from the Gulland-Fox analysis are considered to be most reliable. From these results equilibrium yield-per-effort (Y/E) can be related to equilibrium effort (E) using the following functional regression equation: $\ln(Y/E) = 5.2789 - .001779E$ ($r^2 = .73$; $p < .05$).

Only two studies exist for comparison to present results. Stevenson (1978), on the west coast of Puerto Rico, found that *H. plumieri* may have been slightly overfished by 1973-1974. Fishing effort has increased considerably since then. Being one of the largest grunts and thus susceptible to fishing pressure over a greater portion of its life history, *H. plumieri* would be noticeably affected by overfishing before the haemulid cluster as a whole. Thus the time lag between overfishing *H. plumieri* on the west coast in 1973-1974, and the haemulid cluster in La Parguera in 1978-1979 is consistent.

A more precise comparison comes from Juhl and Suarez-Caabro (1973). For 1970 they reported a catch rate off La Parguera of 4.8 lbs/trap-lift, with 21.12% being grunts. The commercial fishery averaged two lifts/week yielding 105 lbs of grunts/trap-year. Using the reported effort in La Parguera for 1970 (376 traps: Juhl and Suarez-Caabro, 1971), the predicted catch rates are 107 and 101 lbs/trap for the Schnute and Gulland-Fox models respectively.

DISCUSSION

Sale (1982b) discussed reef fish community ecology with respect to fishing and fisheries management. In his opinion, the best ecology can offer at present is speculation and extrapolation. May (1984: 14) defends such practices: "the choice in many circumstances is not between perfect and imperfect advice to managers, but between crudely imperfect advice and none at all". The analysis of the La Parguera grunt fishery provides a case in point. The analysis conducted was clearly an "extrapolation" of the ecological and empirical arguments presented above. However, the analysis yielded results which were at least consistent between methodologies and in comparison to other studies. Even considering the inherent variability, the analysis provided a quantitative assessment, one that clearly indicated an overfishing problem.

How important can such an assessment be? Again, the analysis above provides a case in point. Present knowledge of the status of Puerto Rican reef fishes was succinctly summarized in Powers (1985): "the observation of disproportionate contributions of undersized fish to the catch, coupled with declining landings is...consistent with the hypothesis of marked local depletion of shallow water reef fishes". In other words, an overfishing problem is generally acknowledged, but quantitative assessments which could document this have not been conducted. The lack of quantitative assessments not only limits the ability of management agencies to make rational decisions, but in a climate where organized fishermen are prepared to legally contest proposed regulations, it can limit the agencies' ability to take any action at all. Thus, in this case, species-

cluster analysis served its purpose: supplying an assessment where no prior information existed.

The consistency of results above supports the arguments justifying the use of species-cluster analysis. However, support does not constitute proof, and considerably more research is necessary. With respect to the haemulid cluster, a first approach would be to see how future catches conform to model predictions. Unfortunately, local fishermen are currently withholding catch data in a dispute over a proposed marine sanctuary in the La Parguera area. A more general test would come from the analysis of a species cluster for which separate assessments of each member species are available for comparison. Another approach would be to develop more detailed methods, such as yield-per-recruit, for the analysis of a cluster that would elaborate specific life-history parameters. Previously developed unispecies methods (e.g. Ricker, 1969; Caddy, 1984) could be extended for use in such an analysis. However, to reiterate Sale (1982b), more research on the ecology of reef fish communities, especially with respect to fishing, is needed. It is a greater understanding of this ecology that, in the long-run, promises a more rational basis for fishery assessment and management.

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