Analysis of Usage Patterns in Shared Stocks: The Red Grouper Fishery from the Continental Shelf of Yucatan

VICTOR MORENO, FRANCISCO ARREGUÍN-SÁNCHEZ, MARTÍN CONTRERAS, and ROGERIO BURGOS
Centro Regional de Investigaciones Pesqueras de Yucalpetén
Instituto Nacional de la Pesca. Apdo.
Postal 73, Progreso,
Yucatán, México
Centro de Investigación y de Estudios Avanzados del IPN Apdo.
Postal 73-CORDEMEX, 97310
Mérida, Yucatán, México

ABSTRACT

When a given stock is exploited by several fleets, the knowledge of differences in fishing patterns is important to understand the whole and individual contributions to fishing mortality, and the interdependences between fleets. In this paper a single equation is used to analyze the fleet's usage patterns assuming that when fleets operate within the same area at the same time, the catch composition must be similar as well as fishing patterns, showing a complete overlap. The case study selected was the red grouper (*Epinephelus morio*) fishery from the continental shelf of Yucatan, México, where three fleets operate: two from México, the artisanal (art) which fish until 12 fathoms (ft), and the technified (tec) from the coast to 40 ft; and the Cuban fleet (cub) between 12 to 60 ft. The three fleets are technologically different. For the analysis cath-at-length data were used. Results indicate that the overlap between art and tec is 65% to 69%; tec and cub, from 53% to 60%; and art and cub, around of 20%.

INTRODUCTION

Analysis of the partial contribution of several fleets to fishing mortality is a very important task in population dynamics because their individual contributions affect the whole fishing mortality (Pope and Shepherd, 1985; Megrey, 1989). Part of the main problem is to understand how the fleets are interacting, if their partial contribution can be simply added, or if there is any kind of interdependence like in sequential fisheries. It is especially important when differences in accessibility exist between fleets, and some assumptions must be taken for modeling the exploitation phase of the fishery.

When several fleets operate within the same area, and they have similar fishing gears (although the fishing power could be different), and the fishing, by and between fleets, is not targeted to some specific sizes, it should be expected that catch composition by length or age must be similar.

In this contribution, a simple equation to estimate fleets' overlapping as a comparison of fishing (or usage) patterns is applied to the red grouper (*Epinephelus morio*) fishery from the Campeche Bank, Mexico.

The red grouper is a multifleet fishery where three fleets operate; two from Mexico, the artisanal (art) and technically advanced (tec) fleets; and the technified fleet from Cuba (cub). The art fleet works along the coast to 12 fathoms (ft) depth; the tec fleet from the coast to 45 ft, while the cub between 15 to 60 ft (Arreguín-Sánchez *et al.*, 1987). The red grouper population show seasonal movements along the continental shelf of Yucatan apparently associated with reproductive behavior and the influence of seasonal upwelling (Arreguín-Sánchez *et al.*, 1990), and fleets follows these seasonal changes in population density. Some authors (Seijo, 1986; Arreguín-Sánchez *et al.*, 1987) have suggested an important influence (through fishing mortality) of the artisanal fleet whose catches are composed mainly of preadults and young adult fishes; however, although more recent studies (Arreguín-Sánchez *et al.* 1990; Contreras *et al.*, in press) show the art fleet is not affecting the population growth rate, it is evident that it probably is the case of a sequential fishery.

MATERIALS AND METHODS

In order to understand trends in fishing patterns between fleets a test could be performed on the base of the null hypothesis (H_o):

H_0: all fleets have similar pattern of resource usage.

To test the null hypothesis it was assumed that two fleets have similar exploitation patterns when no-differences exist in their respective catch-compositions. Then, the test is developed under the null hypothesis of complete overlap; not for `no-overlap' or `some overlap'. Differences can be interpreted in terms of accessibility and fishing strategies.

In order to compare catch compositions between fleets, catch-at-length data from each fleet were considered, but as catch per unit of fishing effort, to eliminate possible bias due to relative differences in fishing power. When catch-at-length data are used, catches are separated in several length intervals ($L_1, L_2, \ldots L_n$), and the relative use of specific sizes between fleets can be measured as the degree of overlap between the respective catch compositions.

Specific overlap (SO) per fleet (f) (= $S_f O$) can be obtained as the specific overlap by j-th fleet onto k-th fleet as follows (adapted from the niche overlap measurement discussed by Petraitis, 1979) :

$$S_f O_{j,k} = \exp^{E_{j,k}} \quad (1)$$

$$\text{where } E_{j,k} = \sum_{L=1}^{n} [(C_{j,L} / {}_{L}C_{j,L}) Ln (C_{k,L} / {}_{L}C_{k,L})] - \ldots$$

$$\ldots - \sum_{L=1}^{n} [(C_{j,L} / {}_{L}C_{j,L}) Ln (C_{j,L} / {}_{L}C_{j,L})]$$

where L represents the length interval , C is the catch in number (or catch per unit of fishing effort if the fishing power between fleets are different), and $C_{j,L}$ represents the abundance of fishes within the length interval (L) for the j-th fleet.

A similar expression can be obtained for specific overlap by k-th fleet onto the j-th fleet as:

$$S_f O_{k,j} = exp^{E_{k,j}} \quad (1a)$$

Then, to test if the null hypothesis the statistic X (for equation 1) is computed as below, which is distributed as chi- square with n-1 degrees of freedom.

$$X_{j,k} = -2 U_j Ln S_f O_{j,k} \quad (2)$$

and, for equation (1a)

$$X = -2 U_k Ln S_f O_{k,j} \quad (2a)$$

where U is the sum of the abundance of fishes over all the length intervals for the jth fleet

For catch-at-age composition, equations (1) and (2) could be applied with (L) representing age groups.

From these estimations, and following the time tendencies of the S_f O indices it is possible to understand quantitatively how fishing patterns for each fleet and between them have operated.

For red grouper fishery length-composition data were used for annual periods; for the tec and cub fleets data from 1975 to 1987 were available; and from 1987 for the art fleet. With these data equations (1) and (2) were applied.

RESULTS AND DISCUSSION

Figure 1 show tendency of specific and total overlap among tec and cub fleets. Both fleets show the same trend, but variation is slightly higher for tec fleet, specially for 1980 and 1981. This behavior could be associated with a fall in recruitment in 1980 (Arreguín-Sánchez *et al.*, 1990; Contreras *et al.*, in press)

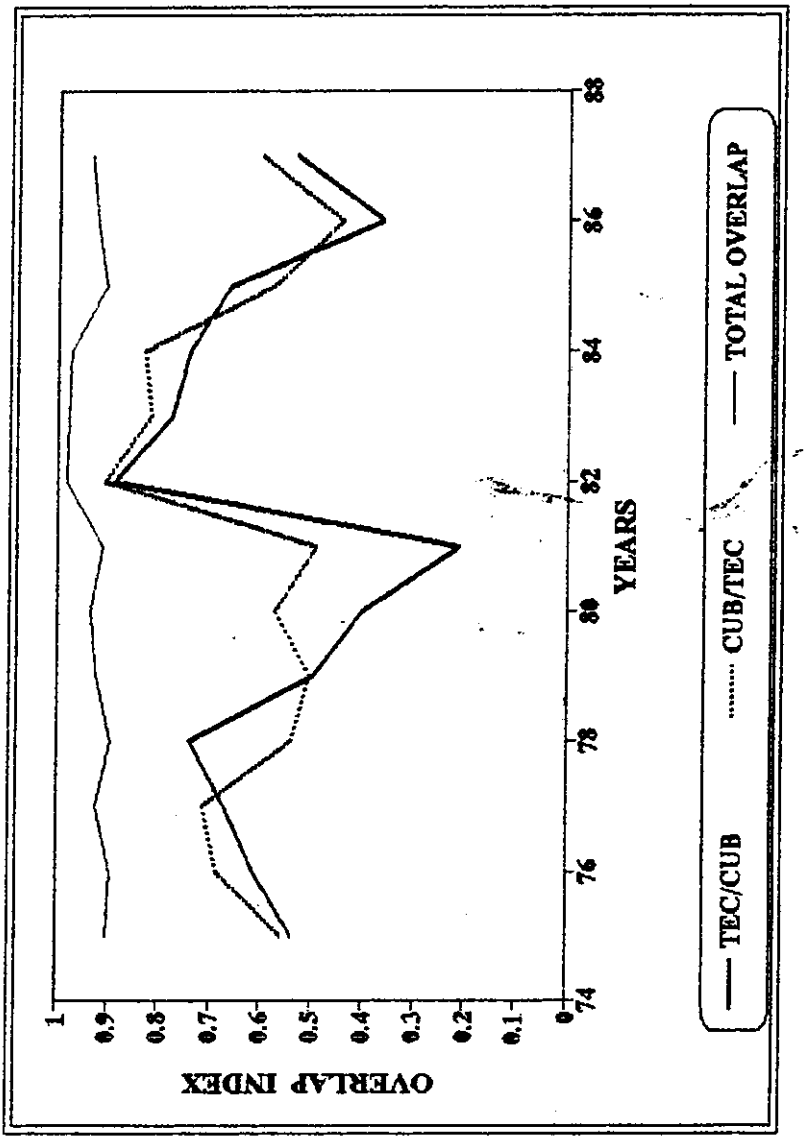

Figure 1. Annual trends of the fleets overlap between the technified fleets of Mexico and Cuba.

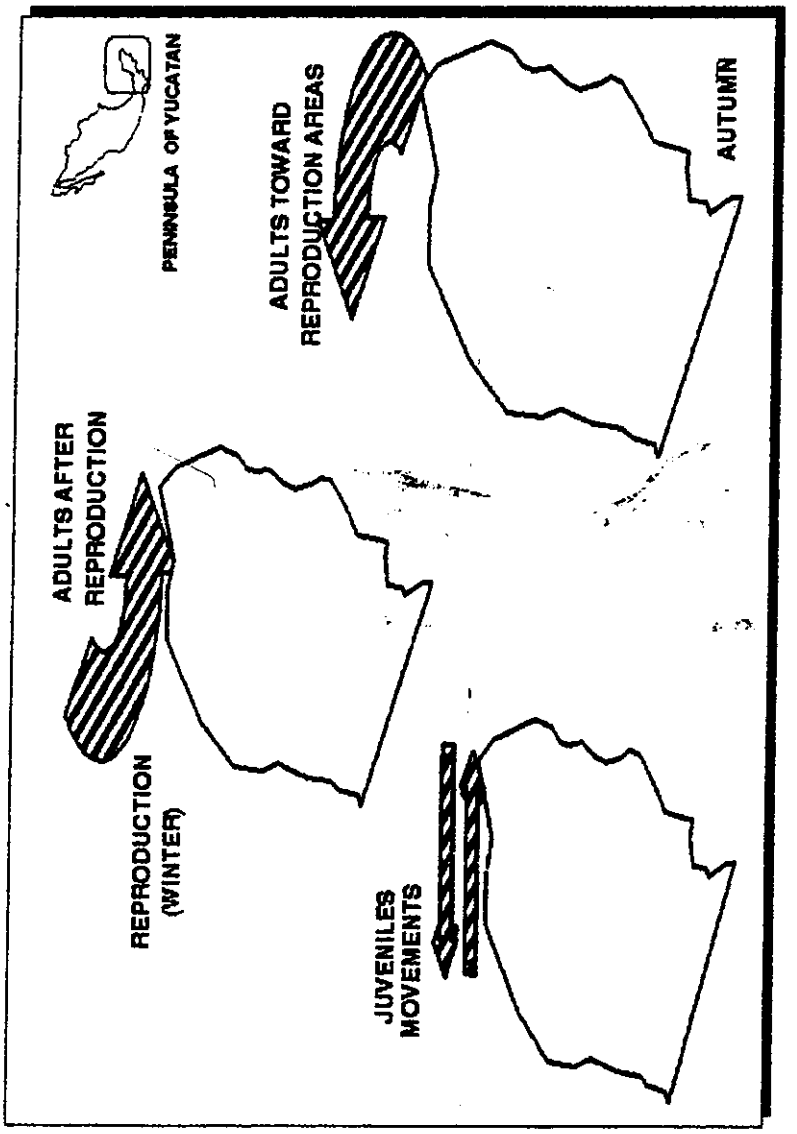

Figure 2. Patterns of seasonal movements of the red grouper (*Epinephelus morio*) population in the continental shelf of Yucatan.

which probably caused changes in the fishing strategy. For art there only is one data which show an overlap. A summary of results could be given as follows:

$S_f O$	OVERLAP PROPORTION	AVERAGE RANGE OF FISHING DEPTH (fathoms)
art and *tec*	65% to 69%	from coast to 12
tec and *cub*	53% to 60%	from COAST to 40
art and *cub*	18% to 20%	from 15 to 60

Fleets' fishing strategies are based on changes of population abundance and their spatial distribution. Both processes are contributing in population and specific fish-sizes accessibility, which could be computed as catchability differences between fleets.

Figure 2 show the mean fish concentration areas which respond to seasonal patterns linked with population behavior and dynamics. In the late spring and summer an aggregation of adults occurs in deeper waters at reproduction time, then, after this event dispersion of larger fishes occurs, but in late autumn and winter, new recruits are incorporated to exploited stock as a result of previous reproduction seasons. Small and juveniles fishes are distributed along the northern coast of Yucatan in deep waters. Then, fleets follow this concentration. For art fleet, boats autonomy limits fleet's movements to deeper waters far to the coast remaining in fishing areas close to the coast. Then, its particular accessibility to smaller fishes is higher than other fleets. Instead, cub fleet is limited to deeper waters because legal limitations restrict fishing to beyond 12 miles from the coast (around of 15 ftm.), but this fleets access fishes on deeper waters than tec because technical characteristics of the boats give it advantages. This could explain differences between fleets mentioned above. Finally, tec fleet has the highest access to the range of fish sizes because it can fish on most of the fishing areas, and differences with other fleets are mainly given by the fishermen's preference; that is, during spawning seasons the fleet moves to deeper water, later returns close to the coast at recruitment time. At times between these events fishing effort is dispersed on the continental shelf with tendency to remain close to the coast (apparently linked with economic convenience due to lower operation cost) and partially oriented to other resources (as octopus in early autumn).

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