Assessment of Annual Relative Abundance and Mean Length of Six Marine Fishes in Texas Coastal Waters

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Abstract: Standardized fishery independent gill net and bag seine monitoring programs in 8 Texas bays from 1976 to 1982 demonstrated significant differences among annual indices of relative abundances of spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), sheepshead (*Archosargus probatocephalus*), southern flounder (*Paralichthys lethostigma*), and Atlantic croaker (*Micropogonias undulatus*) populations. These programs provide a more complete assessment of the fish populations than do commercial landings data because of the selective fishing inherent in commercial fisheries. The impacts of management decisions based on optimum sustained yield concepts, effects of catastrophic events, and stock-recruitment relationships can be enhanced by using measures of relative abundance based on fishery independent monitoring programs.

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Commercial and recreational fishermen in the United States have increased fishing pressure on marine finfish stocks in recent years (Anderson and Power 1957, U.S. Dep. Comm. 1982). Landings of marine fishes by commercial fishermen increased from 2.04 billion kg in 1955 to 2.95 billion kg in 1980. The number of recreational saltwater anglers tripled during the same period (U.S. Dep. Int. 1956, 1982). Fisheries management has become more complicated because to a large degree, commercial and recreational fishermen utilize the same species.

Optimum sustained yield (OSY) is used to allocate and regulate harvest to all user groups. Estimates of finfish abundance are required to allocate resources based on OSY projections. Generally, fishery dependent indices from commercial data (catch rates, landings, etc.) are used because they are the easiest to obtain (Cushing 1970, Gulland 1977). However, fishery independent indices of relative abundance are preferred to reduce biases in OSY projections which are caused mainly by gear modifications, species size selection, and inadequacies in the reporting of commercial landings (Cushing 1970, Radovich 1975, Williams 1977, Matlock 1982*a*). The importance of relative abundance indices to managers require fishery independent sampling programs be designed to be sensitive to changes in fish populations in general but less sensitive to changes arising from local conditions affecting a small portion of the population.

Estimation of recruitment is essential to understanding changes in fish stocks and the prediction of abundance (Cushing 1970, Gulland 1977, Ricker 1977). Standardized fishery independent monitoring programs can be used to estimate recruitment and to detect changes in the sizes of fishes in the populations.

The Texas Parks and Wildlife Department (TPWD) initiated a standardized fishery independent monitoring program to assess the relative abundance of finfish in Texas bays. Studies were initiated with gill nets in November 1975 and with bag seines in October 1977 (Hegen 1983). Gill net sets made during spring (15 Apr–15 Jun) and fall (15 Sep–15 Nov) and bag seine samples obtained monthly provide a statistically consistent and cost efficient method for obtaining information on adult, sub-adult, and juvenile fish populations (Matlock et al. 1978, Matlock 1982*b*, Matlock et al. 1982). Random selection of sampling sites in the TPWD monitoring program minimized the chance that 1 site would cause data to be interpreted as a general trend when there was only a change in a small area which was not true for the entire bay. In fall 1980, TPWD increased the number of gill net samples taken during periods of consistently high catch rates (spring and fall) to provide a more representative sample within each bay and to improve the precision of estimates (Hegen et al. 1983).

The objectives of this study were to determine if there were significant differences among mean: 1) gill net catch rates in fall or spring, 2) bag seine catch rates, and 3) total lengths of 6 fish species commonly caught in gill nets and bag seines in 8 Texas bays from 1975 to 1982.

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Methods

Monofilament gill nets (183 m long; 1.2 m deep with separate 45.7-m sections of 7.6-, 10.2-, 12.7-, and 15.2-cm stretched mesh tied together) and bag seines (18.3 m long; 1.8 m deep with 1.3-cm stretched nylon multifilament mesh in the central bag) were used in 8 Texas bay systems (Galveston, East

Matagorda, Matagorda, San Antonio, Aransas, Corpus Christi, and upper and lower Laguna Madre) from September 1975 to November 1982. Sites for setting gill nets during fall (15 Sep–15 Nov) and spring (15 Apr–15 Jun) and for sampling with bag seines (monthly) were randomly selected from approximately 100 areas in each bay system. During each season, 45 gill nets were set overnight and, during each month, 10 bag seine samples were collected in each bay system (Hegen 1983). Data collected during fall 1975 and spring 1976 were excluded from all analyses because of differences in sampling methodology.

Catch rates for spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), sheepshead (*Archosargus probatocephalus*), southern flounder (*Paralichthys lethostigma*), and Atlantic croaker (*Micropogonias undulatus*) were calculated by dividing the total number of fish caught by the total hours fished (gill nets) or hectares sampled (bag seines) in each sample.

Total lengths (nearest 1 mm) of fishes caught in gill nets were obtained for the first 19 individuals of each species caught in each mesh size each week. Mean fish lengths in gill nets were calculated for each of the 4 mesh sizes in each sample. A weighted mean length for the combined meshes was calculated by weighting the mean lengths in each mesh size by the proportion of fish caught in each mesh. Total lengths (nearest 1 mm) for fishes caught in bag seines were obtained from a random sample of no more than 19 individuals of each species in each sample.

Fall and spring gill net catch rates and bag seine catch rates for each species were examined for significant differences ($P \leqslant 0.05$) among years using a 2-way analysis of variance allowing for unequal cell size (Overall and Spiegel 1961). All data were partitioned by year and bay system. However, since the primary interest was relative abundance among years, the data were blocked by bay system to increase the power of the test among years (Snedecor and Cochran 1971, Steel and Torrie 1960). Catch rates were generally transformed to reduce unequal variances using a reciprocal transformation:

$$t_i = \left[\frac{1}{x_i + 0.05}\right]^b$$

where t_i = value of the ith catch rate after transformation,
x_i = catch rate of the ith sample,
b = an exponent determined by computer iteration as the one minimizing unequal variances.

Bartlett's test was used to test for unequal variances. When a transformation could be found that would substantially reduce the unequal variances, the data were transformed and the results of the analysis using transformed data were used. If a transformation was not needed or an appropriate transformation was not found, the analysis was conducted using raw data.

Annual bag seine monthly catch rates were examined graphically to determine months of highest catch rates for each species. The time period selected for spotted seatrout was September to November; for red drum, November to March; for black drum and sheepshead, June to July; and for southern flounder and Atlantic croaker, February to May. Data from these periods were then selected for the analyses after all fishes with mean total lengths >150 mm were eliminated from the data sets. This procedure eliminated the infrequent and fortuitous catches of adults in bag seines and insured that analyses were accomplished with juvenile fishes. Determination of significant differences ($P \leqslant 0.05$) in mean total lengths for each species and for each gear type among years was accomplished using a 1-way analysis of variance. Data were not partitioned by bay systems because of the extent of missing data.

Statistics which had been computed from transformed data were back transformed for graphical presentation (Sokal and Rohlf 1981). A-posteriori comparisons of mean catch rates and mean lengths among years were made by calculating unweighted coastwide means and corresponding 95% confidence intervals. Significant differences were inferred whenever confidence limits failed to overlap.

Transformation significantly reduced the level of unequal variances in gill net and bag seine catch rates. All analyses were completed with transformed data except for southern flounder caught in gill nets. None of the analyses comparing mean fish lengths used transformed data because no appropriate transformation was found.

Results

Gill net catches within each season differed significantly ($P < 0.05$) among years for each species except for southern flounder caught in spring and fall and for sheepshead caught in fall. Spotted seatrout catch rates declined linearly from 1976 to 1979 (Fig. 1). Spring spotted seatrout catch rates began increasing in 1980 and by 1982 were equal to 1976 levels. Fall spotted seatrout catch rates also increased in 1980; however, they have consistently remained intermediate to the high of 1976 and the low of 1979. Red drum catch rates in spring were greater from 1980 to 1982 than from 1977 to 1979 (Fig. 2). Fall red drum catch rates decreased from 1976 to 1978, increased in 1979, and then decreased through 1982. Black drum catch rates decreased from 1976 to 1979 (Fig. 3). Catch rates from 1980 to 1982 were similar to catch rates observed from 1976 to 1978. There have been no significant changes ($P > 0.05$) among annual gill net catch rates for southern flounder from 1976 to 1982 (Fig. 4). Spring catch rates for sheepshead were low from 1977 to 1979, increased in 1980, but then decreased again in 1982 (Fig. 5). Atlantic croaker spring catch rates for 1977 were higher than any other year (Fig. 6). The fall catch rates were lowest in 1979 and highest in 1982.

Bag seine catch rates differed significantly ($P < 0.05$) among years for

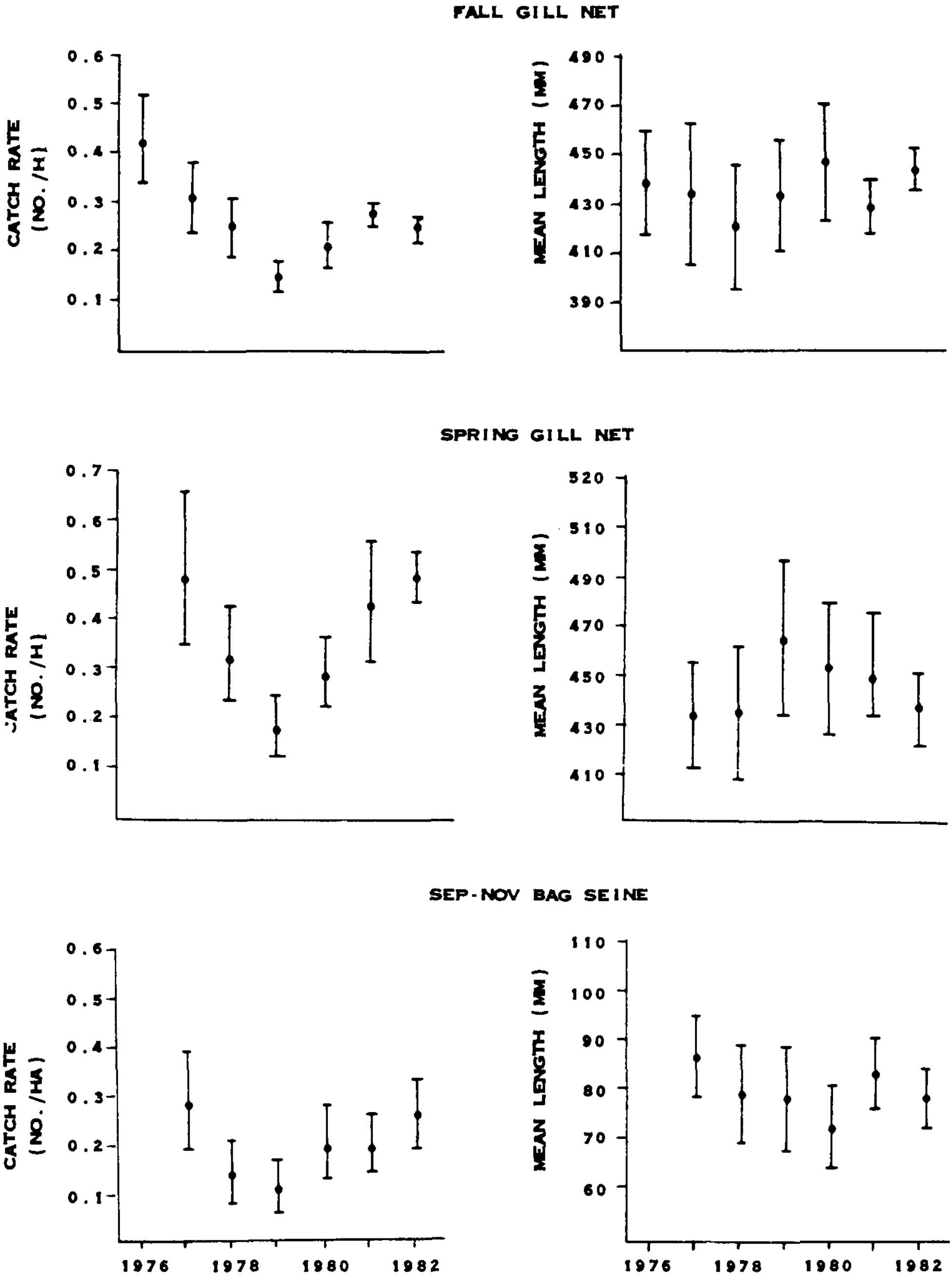

Figure 1. Coastwide mean catch rates and mean lengths (and 95% confidence intervals) for spotted seatrout (*Cynoscion nebulosus*) caught in fall and spring gill net sets and bag seine samples from 1976 to 1982.

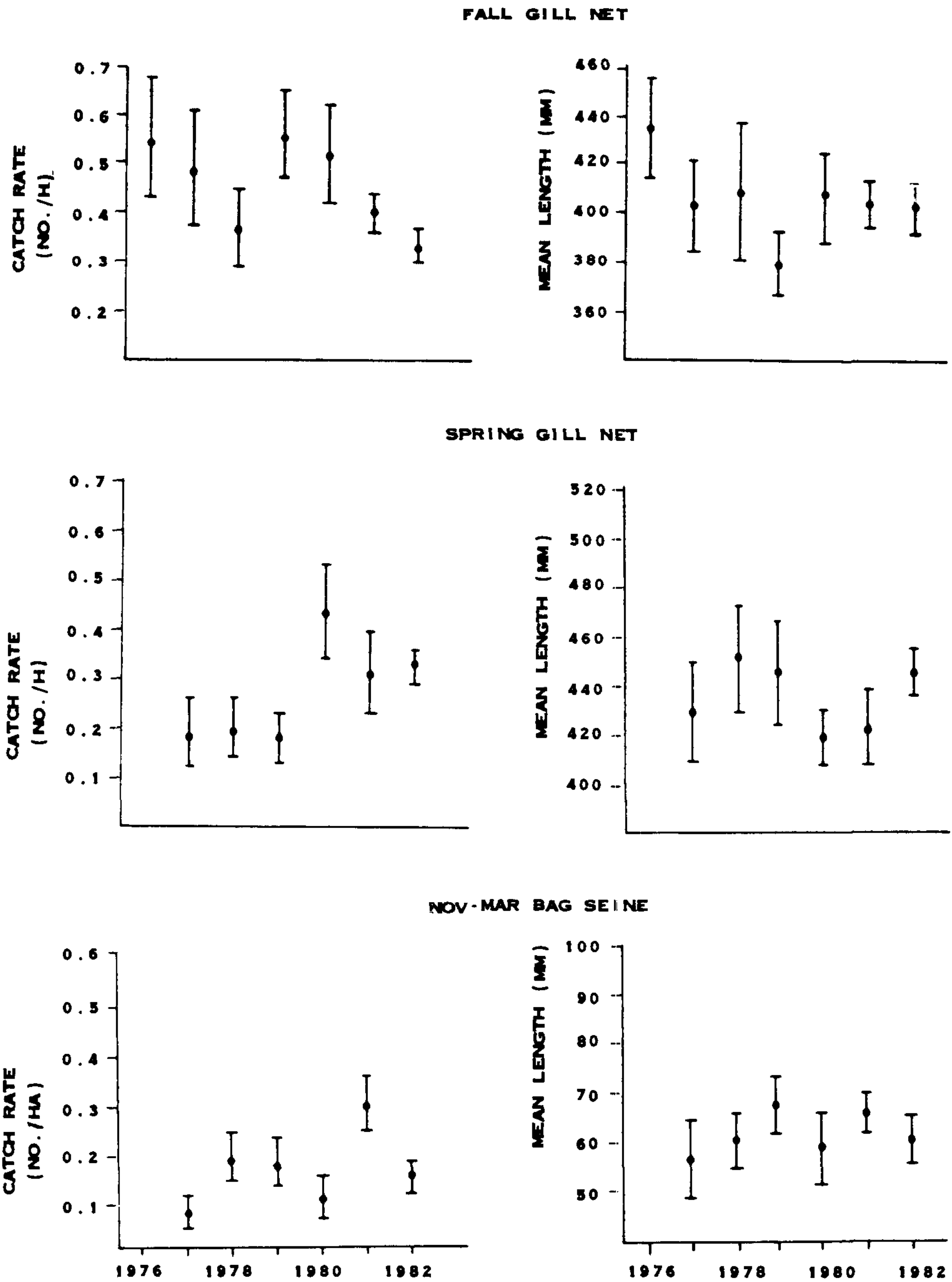

Figure 2. Coastwide mean catch rates and mean lengths (and 95% confidence intervals) for red drum (*Sciaenops ocellatus*) caught in fall and spring gill net sets and bag seine samples from 1976 to 1982.

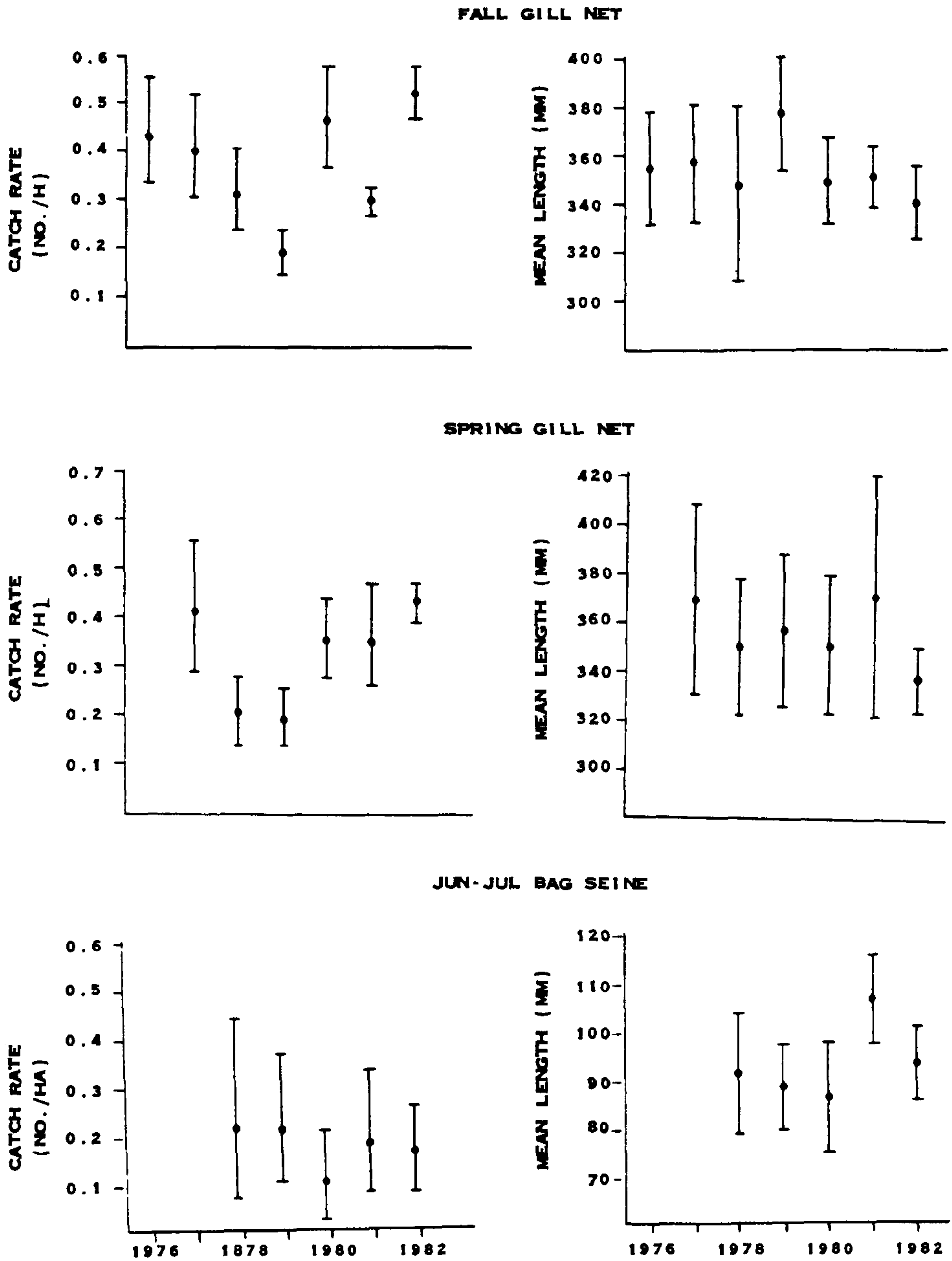

Figure 3. Coastwide mean catch rates and mean lengths (and 95% confidence intervals) for black drum (*Pogonias cromis*) caught in fall and spring gill net sets and bag seine samples from 1976 to 1982.

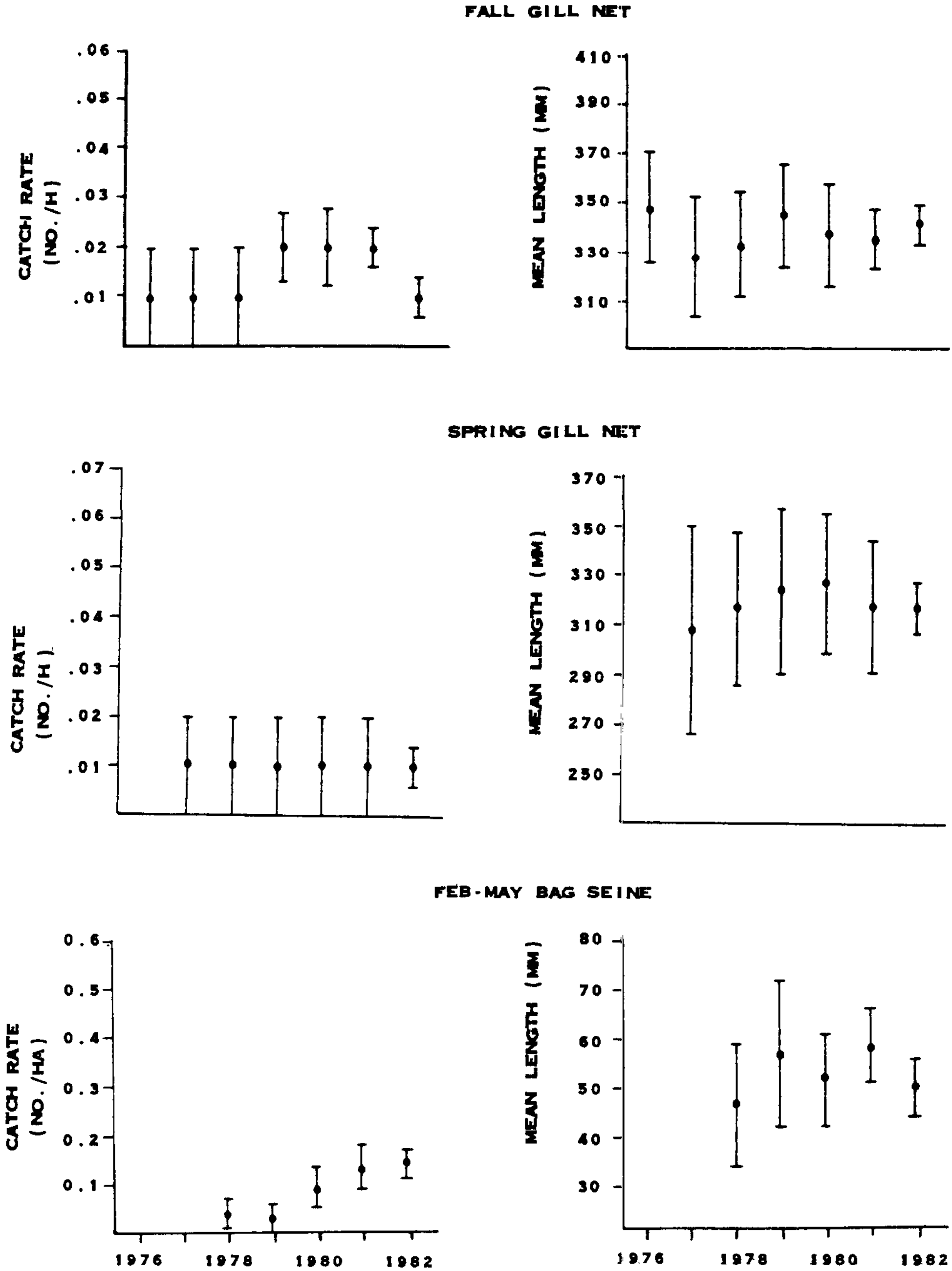

Figure 4. Coastwide mean catch rates and mean lengths (and 95% confidence intervals) for southern flounder (*Paralichthys lethostigma*) caught in fall and spring gill net sets and bag seine samples from 1976 to 1982.

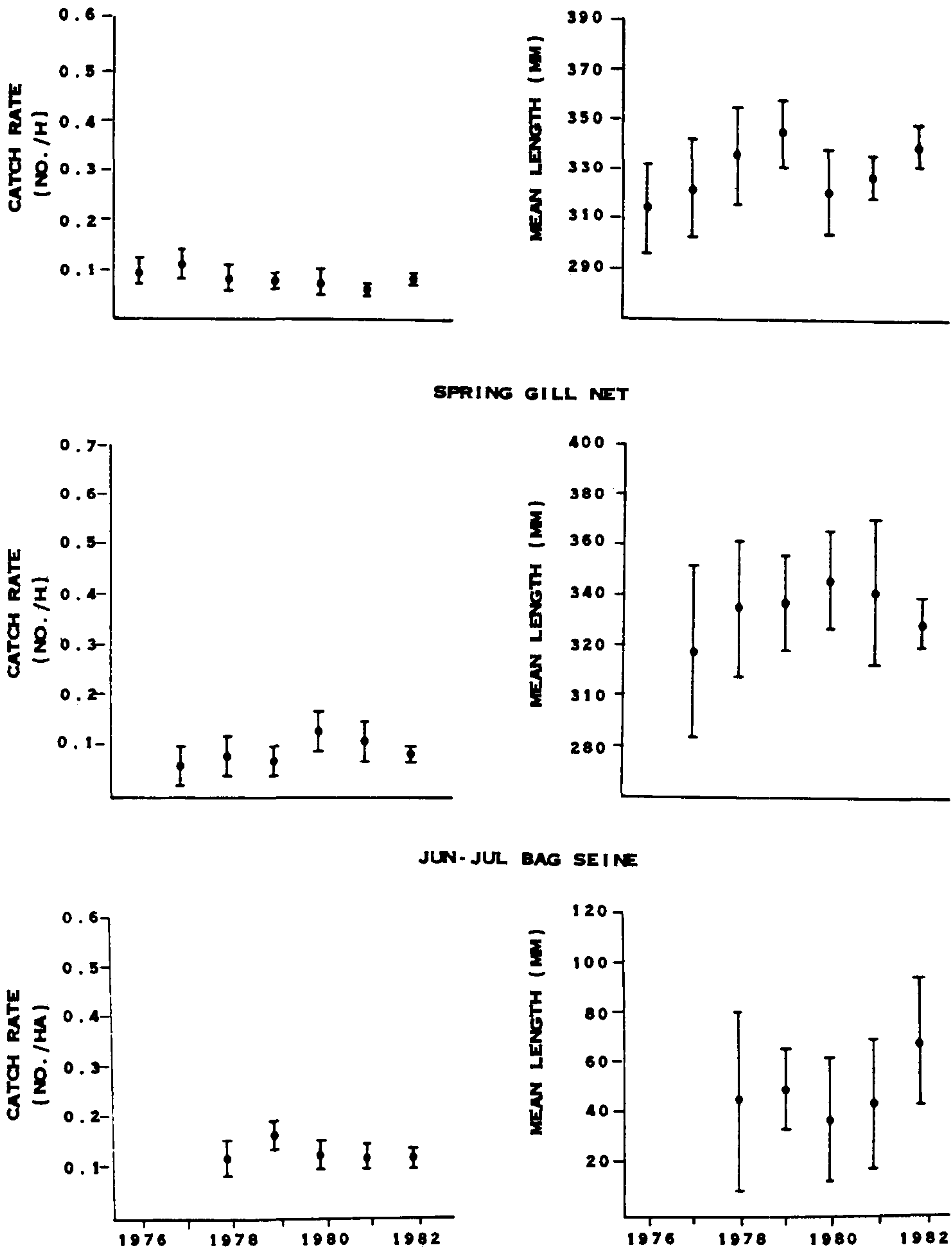

Figure 5. Coastwide mean catch rates and mean lengths (and 95% confidence intervals) for sheepshead (*Archosargus probatocephalus*) caught in fall and spring gill net sets and bag seine samples from 1976 to 1982.

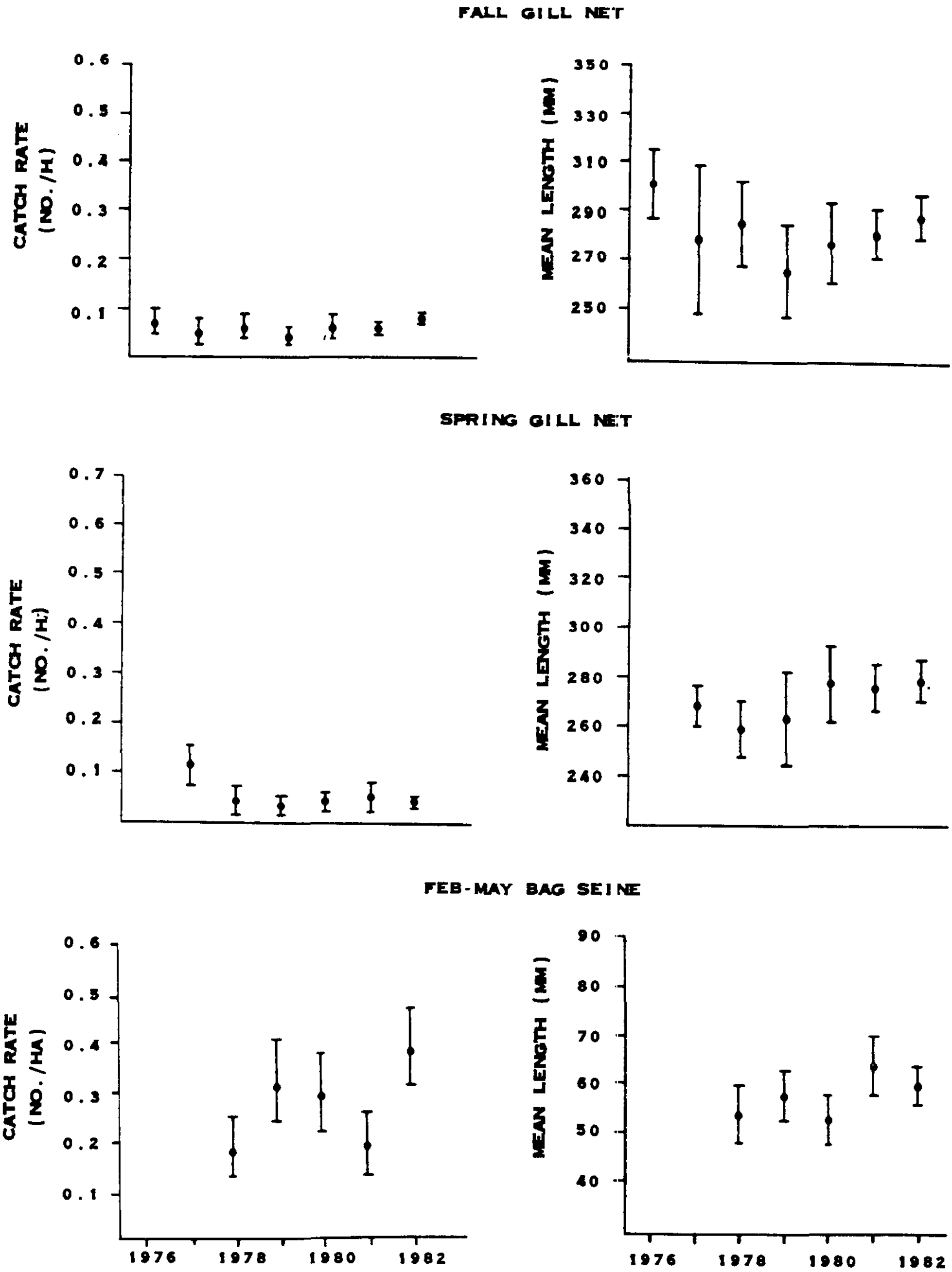

Figure 6. Coastwide mean catch rates and mean lengths (and 95% confidence intervals) for Atlantic croaker (*Micropogonias undulatus*) caught in fall and spring gill net sets and bag seine samples from 1976 to 1982.

each species except for black drum and sheepshead. Spotted seatrout mean catch rates declined linearly from 1976 to 1979 (Fig. 1). Catch rates then increased from 1980 to 1982 to the level seen in 1976. Red drum mean catch rates were greatest in 1981 and lowest in 1977 (Fig. 2). Southern flounder mean catch rates were lowest in 1978 and 1979 (Fig. 4). Catch rates then increased in 1980 and by 1981 and 1982 they were 3 times higher than 1978 and 1979. Atlantic croaker catch rates were highest in 1982 and lowest in 1978 and 1981 (Fig. 6).

Mean lengths for each species caught in gill nets within each season did not differ significantly ($P > 0.05$) among years except for red drum in spring and fall and sheepshead in fall. Mean lengths of red drum caught in spring appeared cyclic (Fig. 2). They increased from 1977 to 1978, decreased through 1980 and 1981, then increased in 1982. Mean lengths of red drum caught in fall decreased from 1976 through 1979 then increased to mid-1976 to 1979 levels from 1980 to 1982. Mean lengths of sheepshead caught in fall appeared cyclic (Fig. 5). They increased from 1976 through 1979, decreased in 1980, then increased through 1982.

Mean lengths for each species caught in bag seines did not vary significantly ($P > 0.05$) among years except for black drum and Atlantic croaker. The largest black drum caught were collected during 1981; mean lengths during all other years were similar (Fig. 3). Atlantic croaker mean lengths were generally lower from 1978 to 1980 than during 1981 and 1982 (Fig. 6).

Discussion

Estuaries are physically and biologically dynamic ecosystems and populations in estuaries often undergo unpredictable fluctuations (Miller and Dunn 1980). Annual fish recruitment may vary by a factor of 2 orders of magnitude (Cushing 1982). Catch rates (relative abundance indices) of most of the species in this study were found to have significant variations, although the ratio of the smallest to largest catch rate for any 1 species was <4 in all cases. The detection of significant differences in relative abundance using fishery independent sampling was possible. The significant decline of spotted seatrout catch rates in fall gill nets from 1976 through 1979 and the 2 declines found in gill nets for red drum in the fall (1976 to 1978 and 1979 to 1982) demonstrate that these monitoring programs can be used to indicate annual changes in fish populations.

Fishery independent measures of abundance can be used to assess the effects of management techniques such as harvest restrictions and stocking and to assess the effects of catastrophic events such as freezes on fish populations. In Texas, size limits on red drum and spotted seatrout were enacted and the sale of native red drum and spotted seatrout was prohibited because of the demonstrated decline in existing populations from 1976 to 1979 (Matlock 1982*a*). Spotted seatrout gill net and bag seine catch rates have increased and stabilized since the imposition of restrictive regulations which may be indicating some success in reducing fishing mortality. However, the full effect of the 1981 legislative banning of the sale of native red drum on existing populations may not be evident for 3 to 5 years because commercial fishing restricted recruitment by concentrating on sub-adults living in bays and this species does not spawn until 3 to 5 years of age.

Southern flounder gill net catch rates were 2 orders of magnitude lower than any other species. The low catch rates for this species, probably caused by low gear selectivity, may make this gear inappropriate to monitor southern flounder adult abundance. The flat body shape of the southern flounder and its habit of partially burrowing on the bottom contributes to its low susceptibility to gill nets (Hegen and Matlock 1980, Stokes 1977). In other fisheries of the world, flatfishes are routinely sampled with trawls (Gulland 1977). In Texas, adult southern flounder have not been commonly caught in fish or shrimp trawls (Matlock 1979, Matlock 1982*c*). However, Stokes (1977) reported catching substantial numbers of adult southern flounder in Aransas Bay, Texas, using a 13.7 m-trawl with 70 mm stretched mesh. Rotenone, a less selective toxicant, was an effective method for estimating abundance of many species including southern flounder in nearshore habitats. However, the expense and extensive manpower requirements precluded its use as a routine monitoring tool (Matlock et al. 1982).

Standardized fishery independent monitoring programs provide a tool for assessing changes in fish populations which are not subject to economic changes or to poorly defined gear types. Generally it has been impossible to tell whether changes in commercial catches have been the result of changes in the fish populations or whether it was the result of changes in economics, gear use or non-reporting of catch statistics (Matlock 1982*a*, Rothschild 1983). Managers utilizing only commercial catch data may incompletely assess the status of fish populations. Standardized monitoring programs which sample all available areas equally provide statistically consistent data on which to base management decisions.

Determination of the relationships between recruitment and subsequent adult abundance is a key fisheries management question and is dependent upon long-term information of fish populations (Cushing 1970, Gulland 1977). Bag seines and gill nets used on a long-term basis can provide data for many fish species from which stock-recruitment relationships can be estimated. If changes in year class strength are to be accurately predicted then standardized monitoring programs must be implemented and maintained.

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