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REPORT OF THE SECOND SOUTHEAST FISHERIES STOCK ASSESSMENT WORKSHOP
June 4-8, 1984

By

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June 4-8, 1984

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INTRODUCTION

The Southeast Fisheries Center sponsored its second Stock Assessment Workshop in Miami, June 4-8, 1984. The Fishery Analysis Division of the Center's Miami Laboratory organized and hosted the Workshop to present the most current information on the status of fishery/marine resource stocks within the purview of the Center, including the Gulf of Mexico, southwestern Atlantic and Caribbean. This second Stock Assessment Workshop was a continuation of the Fishery Analysis Division's efforts to provide a forum for discussion of stock assessment research and documents progress since the first Stock Assessment Workshop in August of 1982 (Report of the Southeast Fisheries Center Stock Assessment Workshop, August 3-6, 1982. J.E. Powers, ed. NOAA Technical Memorandum NMFS-SEFC-127). The report which follows summarizes current scientific advice for use by management agencies and institutions which have interest in these resources.

As in the previous Workshop, the Fishery Analysis Division had four primary objectives in hosting this Workshop. The first objective was to provide the current management advice needed by the regional Fishery Management Councils and national and international commissions and agencies.

The second purpose of the Workshop was to provide a timely forum for critical review of the stock assessment research being done by the Fishery Analysis Division and other research groups in the Center and in the Southeast. The documents presented to the Workshop are the most current updates of analyses, given available data and available models.

The third objective of this Workshop was to improve future stock assessment research and scientific advice by providing direction for data collection and research programs.

The final objective was to promote scientific interchange between stock assessment researchers working on the fishery resources of the Southeast. The Workshop provided an excellent opportunity in the Southeast for formal and informal discussions of ongoing research. This was particularly effective in transferring knowledge about analytical techniques, population models and statistical procedures from researcher to researcher and institution to institution.

The Workshop was attended by more than fifty people representing individual laboratories within the Southeast Fisheries Center, the Northwest and Southwest Fisheries Centers, state agencies of the southeastern United States, Puerto Rico and the US Virgin Islands, the three Fishery Management Councils within the region (South Atlantic, Gulf of Mexico and Caribbean) and various academic institutions. More than sixty stock assessment reports and documents were submitted to the Workshop by participants. These were reviewed during the Workshop by working groups covering: (1) Groundfish and Coastal Pelagics; (2) Marine Mammals and Sea Turtles; (3) Menhaden and Coastal Herrings; (4) Reef Fish and Reef Resources; and (5) Shrimp. Note that Oceanic Pelagics (billfish,swordfish, bluefin tuna and sharks) were not discussed during the June, 1984 Workshop. Development of current assessment advice on these resources was done during the summer and fall of 1984 by several independent Center and Council sponsored review panels and through the Standing Committee on Research and Statistics of the International Commission for the Conservation of Atlantic Tunas. However, reports of those results are not included with these proceedings.

As can be seen, these marine resources are geographically distributed through a wide area and are extremely diverse in their biological, ecological and fishery characteristics. The charge of the assessment scientists in this Workshop was to address that complexity and provide succinct updates and reviews on the status of the resources. This report represents those efforts.

Joseph E. Powers
Chief, Fishery Analysis Division
Chairman, Stock Assessment Workshop

GROUNDFISH AND COASTAL PELAGICS (GCP)

KING MACKEREL

I. DESCRIPTION OF FISHERY
I.1. Areas, Seasons and Gears

King mackerel occur from the Gulf of Maine to Brazil including the Caribbean and the Gulf of Mexico. King mackerel are not target species of commercial or recreational fisheries in waters north of North Carolina. Annual landings of over one million pounds of king mackerel have been reported fairly consistently by Brazil, Mexico, the United States and Venezuela between 1970 and 1980 (SAW/82/GCP).

Because of their migratory behavior, king mackerel are only seasonally available to recreational and commercial fisheries in many areas. Recreational fishing for king mackerel in the United States occurs along the Atlantic and northern Gulf coasts during the warmer months, along the southern Florida coast mainly from late fall through early spring, and along the Louisiana coast throughout the year. Commercial fishing for king mackerel in U.S. waters is concentrated in south Florida especially during the fall and winter months. Commercial fishing for king mackerel has recently begun off North Carolina and Louisiana during the fall and winter. Commercial and recreational fisheries for king mackerel also occur off the Mexican coast, off Puerto Rico and the U.S. Virgin Islands. In the latter two areas, king mackerel are caught primarily from November to April; little is known about the seasonality of the Mexican fisheries. Off northwest Brazil, king mackerel are caught in greatest quantities from December to February (SAW/82/GCP).

The U.S. recreational harvest is entirely by hook and line and is obtained using a variety of baits, jigs, and lures throughout the fishing range (SAW/82/GCP/3). Most of the king mackerel landed by commercial fishermen in south Florida in recent years have been caught by runaround gill nets or by hook and line. These nets measured 360 to 640 meters in length and about 22 meters (200 meshes) in depth, had a stretched mesh of 12.1 centimeters and were fished in water depths as great as 21 meters. Since the early 1960's, spotter aircraft have been frequently used to assist fishermen in locating schools of fish and to direct the setting of nets. In the commercial hook and line fishery lines with spoons or feathered jigs, sometimes with strips of mullet or squid, have been trolled behind boats. Lines are retrieved manually or with hydraulic or electric reels; planers or weights are often used to fish the lures deep.

Incidental catches of small king mackerel are made by shrimp trawls in South Carolina but are usually recorded as Spanish mackerel (SAW/82/GCP). Other incidental catches of king mackerel have occured with shrimp trawls (SAW/82/GCP). A small bycatch of king mackerel also occurs in the Florida gill net fishery for Spanish mackerel (0.08%· SAW/82/GCP). However, fishermen report that catches of small king mackerel can be substantial in the Spanish mackerel fishery when small kings are abundant (Mark Godcharles, personal communication.

Recently, there has been expansion of the commercial fishery, northward to North Carolina (SAW/84/GCP/11; SAW/84/GCP/5) and westward to Louisiana (SAW/84/GCP/5; SAW/84/GCP/13; SAW/84/GCP/15).

I.2. Catch Trends

Commercial landings in the Gulf of Mexico and the south Atlantic coast of the United States are summarized in Table GCP-1. The highest landings in the Gulf occurred in 1974. Landings declined somewhat in the Gulf since 1980-81. Louisiana landings contributed over one million pounds to the total Gulf in 1983 which was much greater than had occurred in any year previously. Conversely, landings in the south Atlantic were at their highest level in 1982 primarily due to expansion of fishing northward into North Carolina (Table GCP-1).

Recreational catches in 1979 and 1980 (the most recent estimates available to the Workshop) were summarized in SAW/84/GCP/1. The 1979 data are preliminary. However, they indicated recreational catches were 4.2 and 5.9 million pounds in the south Atlantic and Gulf of Mexico, respectively (10.1 million combined). Recreational catches increased in 1980 to 11.8 million in the Gulf and to 23.6 million for the Gulf and south Atlantic combined.

I.3 Effort Trends

An historical time series of detailed effort is not available for this fishery. However, total fishing effort was estimated in SAW/84/GCP/2 based upon a single charter boat's catch per unit effort in northwest Florida and upon three assumptions about the level of recreational catch from 1970-82. The three assumptions were: 1) constant recreational catch; 2) constant recreational effort; and 3) constant ratio of commercial and recreational effort. For all three scenarios, the conclusion was that there was an increasing trend in effort seen from 1970-82 with 1981 and 1982 having the highest effort levels observed (Table GCP-2).

SAW/84/GCP/12 estimated standardized effort for the Florida commercial fishery for 1969 through 1980 (excluding 1978 and 1979). This effort index increased continually throughout the time series except for a small decline from 1969 to 1970. Effort levels in 1980 were the highest on record, approximately 9 percent higher than 1977 and 42 percent higher than in 1975 (Table GCP-2).

II. STOCK STRUCTURE

Results of the previous Stock Assessment Workshop (SAW/82/GCP) and the most recent assessment documents (SAW/84/GCP/1; SAW/84/GCP/23; SAW/84/GCP/4; indicated that the available data is not sufficient to define more than one genetic stock. However, the mixing rates appeared to be sufficiently low such that separate management strategies may be required. Thus, two migratory groups were defined for which allowable biological catch could be estimated (SAW/84/GCP/2). The basis for separating these groups were: 1) tagging data indicated low mixing rates; 2) fishing mortality rates appeared to be substantially different between the two groups; and 3) historical fishing patterns on the Groups were different. The two Groups are the Atlantic Migratory Group and Gulf Migratory Group. However, new data suggest (1) separate genetic stocks may exist within the Gulf and (2) that there are substantial differences in migration patterns within the Gulf Group.

Biochemical analysis using high pressure liquid chromotography (SAW/84/GCP/15) suggest that Texas/Louisiana fish are genetically similar, East Florida/Carolina fish and Mexican fish are genetically similar and that Texas/Louisiana fish are different from Florida/Carolina fish. However, samples have been very limited with none coming from the northeastern Gulf and the west coast of Florida. Also, the samples are not sufficient to quantify size, sex and seasonal affects on these analyses. More work needs to be done before these analyses can be conclusive.

Available tagging results suggest different migration patterns within the Gulf Migratory Group east and west of the Mississippi River (SAW/84/GCP/4). Tagging data (SAW/84/GCP/4) show recaptures of Texas-tagged fish in Florida to be about equal to returns in Texas, while only a small portion of fish tagged in Florida are recaptured in Texas. Given the high fishing effort in Florida, a greater fraction of Texas fish should be recaptured in Florida unless a significant portion of the Texas fish do not migrate to Florida. Tagging data also show migration between Mexico, Texas and Louisiana (SAW/84/GCP/13), but these limited data have not shown migration between the Northeast and Northwestern Gulf.

Although further subdivisions of the Gulf Migratory Group are not justified by these preliminary results, there are at least two possible hypotheses which merit further investigation. The first hypothesis is that there may be two subgroups, the first ranging from Mexico in the winter to the northern Gulf in the summer and the second subgroup ranging from Florida in the winter to the northern Gulf in the summer. The second hypothesis is that there is a third group of larger fish (15 lbs and greater) which have changed migratory habits and remain in the northwestern Gulf.

However, at this point in time, the Workshop could not determine which, if either, of these two hypotheses is more likely to be correct. More importantly, we cannot determine the biological importance of the hypothesized sub-groups to recruitment and biological viability of the Gulf Group as a whole. We do not know if one sub-group is of integral importance to the survival of another or not. Therefore, present assessment should be based upon Atlantic and Gulf Migratory Groups previously defined.

III. STATUS OF THE STOCK

III.1 Population Parameters

III.1.1. Mortality Rates

Natural mortality rate estimates were reviewed in SAW/84/GCP/1 and SAW/GCP/2. Estimates were based upon indirect relationships of natural mortality rates to growth parameters. The range of estimates of the instantaneous rate of natural mortality (M) was 0.3 to 0.45. The best estimate (M = 0.4) may not be much more likely to occur than the end points of the range, i.e., there is considerable uncertainty within this range what actual mortality rates are.

Total mortality rates were estimated from tagging data, 1975-79 (SAW/84/GCP/1; SAW/84/GCP/2; SAW/84/GCP/4) using several methods. Since detailed fishing effort data were not available, the tag returns were not adjusted for variation in recapture probability. The results (summarized in Table GCP-3) indicate that the estimates do not differ much between methods. Also, the results show that total mortality was higher in the west coast/Key West Area of Florida and in the winter east coast of

Florida (Gulf Migratory Group) as compared to the Carolinas and summer east coast of Florida (Atlantic Migratory Group) (SAW/84/GCP/4; SAW/84/GCP/2). The total instantaneous mortality rate (Z) averaged approximately (1.1) for the Gulf Migratory Group and 0.5 for the Atlantic Migratory Group during 1975-79 (SAW/84/GCP/2). This is equivalent to fishing mortality rates (F's) of approximately 0.7 and 0.1 for the two Groups, respectively in 1975-79.

Fishing mortality rate estimates are not available for 1980 to the present. However, commercial annual landings in North Carolina have more than doubled since 1979 (SAW/84/GCP/11) indicating effort and fishing mortality has probably increased in the Atlantic. Additionally, the commercial landings of the Atlantic Migratory Group have increased (Table GCP-4). On the other hand, Gulf Migratory commercial landings have declined since 1980, even with large Louisiana catches in 1982-83 (Table GCP-5). It is unlikely that catches of this Group in 1983-84 will exceed 3 million pounds. Also, effort on the two Groups combined (Table GCP-2) based upon a CPUE index on the Gulf Group was likely to have been high in 1981 and 1982. The implication is that Atlantic Group fishing mortality has probably increased since 1980; whereas Gulf Group fishing mortality may have declined somewhat in 1983-84, but still remains at high levels.

III.1.2 Growth Estimates

Several estimates of growth parameters are available and have been reviewed (SAW/84/GCP/2). It appears that growth rates differ between sexes. In addition, sizes of fish sampled, area from which samples were taken, method of ageing and method of curve fitting all affect the resulting parameter estimates. Estimates generated from tagging (SAW/84/GCP/4) in which sexes were combined were consistent with some previous backcalculation estimates. SAW/84/GCP/4 showed that the relative growth rates (i.e., growth rates without absolute age parameters) were very similar between investigators, and also showed that yield per recruit results were robust to the choice of the growth model. However, estimating catches by age are most often done using a growth model. Therefore, the appropriate growth relationship will have to be defined in order to develop catch at age models in the future.

III.2. Catch Per Unit Effort Trends

Catch per unit effort (CPUE) from a single charter boat in northwest Florida (SAW/84/GCP/2) were reported (Fig. GCP-1). These data show a decline in CPUE from 1970 to 1982 with peak years in 1975 and 1980 (1972 data were not available). The 1981 and 1982 CPUE values were approximately 20 to 25 percent of those in 1970 and 1971. Additionally, 1981-82 was 16-20 percent of the 1980 level. However, these data only represent a single boat operating out of northwest Florida.

CPUE from commercial vessels in Florida was also calculated (SAW/84/GCP/12). Based upon standardized commercial boats, there was a decline in CPUE from 1969 to 1980 (1978 and 1979 data were not available). Peak years were 1974 and 1977 (Fig. GCP-2).

More comprehensive samples of charter boat CPUE have been taken in 1982, 1983 and continuing into 1984 (SAW/84/GCP/5, SAW/84/GCP/14). These samples were distributed by month and by area (Texas to Florida Keys and Florida Keys to North Carolina), therefore, the data are more representative of the population dynamics of king mackerel. However, these data have not yet been standardized such that they can be compared to the historical CPUE's discussed above. There was no consistent change in CPUE between 1982 and 1983 in all areas (Table GCP-6). However, the catch per hour in northwest Florida was low (0.72 per hour in 1982 and 1.37 per hour in 1983), comparable to catch rates in northwest Florida in 1977-78 and 1981-82 periods (Fig. GCP-1). Charter boat CPUE in northern Texas was consistently greater than in south Texas and any other area in 1982-83 except northwest Florida (Table GCP-6, SAW/84/GCP/14). However, differences in CPUE between areas may reflect different availability and vulnerability rather than differences in abundance.

III.3 Stock Assessment Analysis
III.3.1 Production Model Analysis

The king mackerel fisheries have been examined by two production model analyses. The first used an effort index based upon commercial fishing (both hook and line and net) in Florida (SAW/84/GCP/12). The second used a recreational charter boat effort index (SAW/84/GCP/2). Results of both showed that yield has appeared to decline with increasing effort in recent years (Figure GCP-3). The maximum sustainable yield of the Atlantic and Gulf Migratory Groups combined using 1979-80 recreational data and the charter boat effort index was 26.2 million lbs (range 21.9 to 32.0) (SAW/84/GCP/2). Several different scenarios about historical recreational catch/effort and errors in the CPUE index were tested in SAW/84/GCP/2. The maximum sustainable yield estimate was relatively insensitive to these assumptions. However, the estimate of present fishing mortality rate relative to the rate which produces MSY is more uncertain. Therefore, we are less certain of the degree of reduction in sustainable yield that has occurred. If the recreational catch is added to the commercial based effort analysis (SAW/84/GCP/12) then similar MSY estimates will result.

III.3.2 Yield Per Recruit Analysis

Yield per recruit analyses were performed using several growth relationships and both Ricker and Beverton-Holt yield per recruit models (SAW/84/GCP/1; SAW/84/GCP/2; SAW/84/GCP/4). Results showed that there was no appreciable potential for increasing yield by increasing the size (age) at first capture. Using the Ricker model (which does not depend on absolute age, only age relative to recruitment), SAW/84/GCP/4 showed that yield per recruit was very robust to the growth model and the method of aging (Table GCP-7), indicating that the difference in growth models may be differences in aging in the early portion of the fish's life prior to when it is significant in terms of yield per recruit.

There is a small potential for increasing yield per recruit in the Atlantic Group by increasing fishing mortality (Fig. GCP-4) based upon 1979 mortality estimates (SAW/84/GCP/2). However, expansion of fishing on this Group may have already realized that potential. Yield per recruit of the Gulf Group would not be improved measurably by increasing the fishing mortality rate (Fig. GCP-4).

III.3.3 Recruitment Indices

The percent size composition of winter Florida commercial catches indicate that recruitment of fish 725 mm fork length and less was high in the three periods 1969, 1975-76 and 1980-81 (SAW/84/GCP/4). The percent of these small fish declined from 1980 to 1983; however, 1983-84 size frequencies indicate that a stronger year class than in the recent past may be entering the fishery. This is corroborated by the fall 1983 size frequencies from the northeastern Gulf recreational fishery (SAW/84/GCP/6) in which smaller fish occurred at a higher frequency. The recreational fishery tends to catch smaller fish in the Gulf, so it has been suggested that recreational CPUE may have potential as an indicator of recruitment strength and thus a predictor of future commercial catch success (SAW/84/GCP/1).

No conclusive evidence on relative recruitment strength is presently available for areas other than the northeastern Gulf and the Florida winter fishery.

III.3.4. Other Indices

It was noted in several documents (SAW/84/GCP/6; SAW/84/GCP/13; SAW/84/GCP/5; SAW/84/GCP/4) that there is a concentration of larger king mackerel, (15 lbs and greater) off

Louisiana. These larger fish are predominately female and may represent a large source of potential fecundity for the Gulf. However, the contribution of these fish to the total recruitment of the Gulf Migratory Group is unknown at this time.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

The commercial hook and line quota in the present FMP of 3.9 million pounds was reached in 1982-83. However, due to delays in notification and the actual limitation on total catch was minimal and what effect it did have was probably on the Atlantic Migratory Group, i.e., the Group that is not stressed by the fishery. It is unlikely that the present quota will be reached in 1983-84. In addition, the recreational allocation of the quota cannot be monitored within a year. Therefore, it has had no affect in reducing mortality. SAW/84/GCP/3 suggests a bag limit as a mechanism to reduce recreational fishing mortality. The regulatory system that is presently in place does not appear to have had any affect on reducing mortality in 1982-84 and its potential in the future is likely limited only to the commercial sector.

V. RECOMMENDATIONS

V.1. Data Needs

1) Detailed effort data by area, gear, month, including number of anglers per charter boat and their individual catches.

2) Timely estimates of recreational catches.

3) Size frequencies from all sectors of the fishery by gear, area, month and sex and assemble a consolidated catch at length and size frequency data base for use in virtual population assessment.

4) Cooperative sampling procedures for collecting and exchanging biological samples for use in biochemical studies for stock indentification. The biological samples should include fish stratified by area, season, size and sex.

V.2. Research Needs

1) Develop stock identification research methods including tagging of small fish and biochemical discrimination methods. Establish accuracy and precision of biochemical techniques for discriminating stocks and apply techniques to well designed sample.

2) Thorough examination of charter boat CPUE to get standardized effort and abundances indices using appropriate statistical techniques which will provide proper weighting between factors.

3) Increase ability to estimate current fishing mortality rates through age-specific CPUE and virtual population assessment techniques. These techniques require indices of abundance and catch at length (age), the data needs for which were discussed in the previous section.

4) Investigate appropriate ageing procedures by verification of growth models, modal analysis and other appropriate techniques such as tetracycline tagging. Also, develop sampling procedures for determining age-length keys which vary over time.

5) Investigate methods of indexing annual recruitment including recreational CPUE, ichthyoplankton surveys, and shrimp bycatch CPUE.

V.3. Management

Assessment results indicated that abundance levels of king mackerel have declined with increasing fishing mortality rates, primarily on the Gulf Migratory Group. Reductions in the fishing mortality rate on this Group could be imposed to return the abundance to previous levels. There is considerable uncertainty about the level of reduction and the rate at which the abundance level would return. Assessment results were based primarily on data through 1980. Since 1980, there are indications that Gulf Group catches have declined with no large reductions in effort indicating further declines in the abundance. Conversely, 1983 may have been a stronger recruitment year than in the recent past, indicating some recovery. However, the balance of this new evidence would indicate that mortality rates on the Gulf Migratory Group have remained high since 1980, which will delay the rate at which abundance returns to previous levels. Therefore, further reductions in take are expected to increase the rate of recovery of abundance levels.

Although fishing mortality rates on the Atlantic Migratory Group have been low, recent expansion of the fishery on this Group indicate that the fishery may be quickly reaching its maximum potential. Therefore, the status of this Group should be closely monitored.

The Gulf Migratory Group may be composed of more than one subgroup. However, insufficient information is presently available to define the subgroups or to determine the biological (recruitment and migration) relationships between the subgroup. Nor would it be possible with existing information to establish separate biologically allowable catch levels and biological management regimes for these subgroups.

But there are risks associated with treating the Gulf as a single management entity. If more than one group exists in the Gulf, and there is one regulatory measure, then it would be possible to overfish one group and underfish the other.

Conversely, there are risks in separating the Gulf management. If the Gulf is composed of only one Group and two or more separate management regimes are imposed, then the fishing area with the more restrictive regulations would be limited to the benefit of the fishing area with the less restrictive regulations.

Although there appear to be differences in migratory patterns within the Gulf Migratory Group, we are unable to clearly define these differences or further biologically subdivide the Gulf Migratory Group.

SPANISH MACKEREL

I. DESCRIPTION OF FISHERY

I.1 Areas, Season and Gears

The Spanish mackerel, Scombermorus maculatus, a member of the family Scombridae closely related to the king mackerel, S. cavalla, the cero, S. regalis, and the Brazilian mackerel, S. brasiliensis. All except the latter are widely distributed throughout the western Atlantic with centers of abundance in Florida. The Spanish mackerel supports important commercial and recreational fisheries in the United States south Atlantic, and Gulf of Mexico. It is prized as a food item and as a highly desirable recreational fish (Trent and Anthony 1979).

Because of their migratory behavior, Spanish mackerel are only seasonally available to recreational and commercial fisheries in many areas. Recreational fishing for Spanish mackerel in the United States occurs along the Atlantic and northern Gulf coasts during the warmer months and along the Southern Florida coast mainly from late fall through early spring. There is a distinct "run" of Spanish mackerel in April and May from Florida through Texas and return migration in the fall. It is unknown whether substantial numbers of Spanish mackerel overwinter in areas outside Florida.

Commercial fishing for Spanish mackerel in United States waters is concentrated in south Florida and occurs primarily in December and January. Formerly, commercial landings were spread rather evenly from November through April. There is a small spring and fall fishery for Spanish mackerel from northwest Florida through Louisiana. Similarly, there is a modest summer fishery for Spanish mackerel in North Carolina. A commercial fishery for Spanish mackerel also occurs off the Mexican coast (Doi and Mendizabel 1979), and in Brazil by trolling and gill net (Berrien and Finan 1977; Sturm 1978).

Initially, in the United States trolling and pound nets accounted for most Spanish mackerel catches although mackerel were taken in gill nets (anchored, staked, drifting, and runaround), haul seines trammel nets, hand lines, and otter trawls (Berrien and Finan 1977). By 1920, when the center of the Spanish mackerel fishery had shifted from chesapeake Bay to south Florida, the gill net had become the principal capture gear (Schroeder 1924). From 1950 to 1974 the average percentages of total landings of Spanish mackerel were: gill nets, 87; haul seines, 6; lines, 5; trammel nets, 1; and other, 1 (Trent and Anthony 1979). Presently, the majority of Spanish mackerel are taken by gill net in the commercial fishery.

Recreational anglers catch Spanish mackerel from boats while trolling or drifting, and from boats, piers, jetties, and beaches by casting, livebait fishing, jigging, and drift fishing. Lures and baits less than five inches long are usually used (Trent and Anthony 1979).

Since 1950, over 92% of the total United States commercial catch has been taken in Florida (Trent and Anthony 1979). In recent years that percentage has been increasing.

I.2 Catch Trends

The Spanish mackerel commercial and recreational fisheries in the southeastern United States from 1880 to 1976 were described by Trent and Anthony (1979). Table GCP-8 shows commercial landings of Spanish Mackerel for the South Atlantic and Gulf of Mexcio from 1950 to 1983. Total landings averaged 7.69 million pounds from 1950 to 1967; reached a plateau from 1968 to 1975 when they average 10.94 million pounds; peaked in 1976 and 1977 with an average of 15.82 million pounds; and have much more erratic since then with average annual landings of 7.84 million pounds from 1978 to 1983.

FLorida continues to dominate total commercial landings (Table GCP-9), but landings have varied considerably between the east and west coast of Florida (Table GCP-8). Landings on the west coast have declined considerabley since 1976; whereas, landings on the east coast have been lower since 1980.

The timing of commercial landings differs according to geographic location. In Georgia and South Carolina Spanish mackerel are primarily a bycatch of shrimp fishermen and most landings occur May through September. In North Carolina Spanish mackerel are landed May through Novebmer with peak landings occurring August through October. In Alabama, Mississippi, and Louisiana most Spanish mackerel are landed March through May with some fish taken throughout the year.

Trent and Anthony (1979) reported that most commercial landings in Florida in the Forr Pierce and southwest area occurred between October and May; whereas, in the northwest area most landings occurred during April and May and September and October. The landings pattern in northwest FLorida closely mimics those in Alabama, Mississippi, and Louisiana.

Landings in the eastcoast of Florida from 1966-67 through the 1973-74 fishing seasons were spread throughout the November through April time period (Table GCP-10). When the fishery increased during the mid-1970's, landings were compressed in the December through March period. Since the 1979-80 fishing season approximately two-thirds of annual landings have occurred in one month, either December or January.

Recent estimates of recreational catch (Table GCP-11) are lower than formerly believed (GMSAFMC 1983). Commercial landings in 1979 and 1980 in the South Atlantic greatly exceeded recreational (Table GCP-11). Conversely, in the Gulf of Mexico recreational catches were greater than commercial.

II. STOCK STRUCTURE

The existing FMP (GMSAFMC 1983) for mackerels assumes that there is one stock of Spanish mackerel in the southeastern United States. However, limited tagging and biochemical information derived after development of the FMP suggests that there may be a more complicated stock struture. Available information is summarized below.

Sutherland and Fable (1980) on the basis of migratory behavior and tagging returns suggested that there may be eastern and western stocks of Spanish mackerel in the Gulf of Mexico. They reported that there were known wintering grounds of Spanish mackerel in South Florida and Campeche-Yucatan. Further, mackerel from both areas migrate to the northern Gulf during spring and summer months along the respective coasts. The degree of mixing of adult fish in the northern Gulf is unknown.

Spawning is protracted and occurs throughout the southeast (Wollam 1970; Dwinell and Futch 1983; McEachren and Finucane 1979). The location of spawning grounds is unknown at this time, thus, the degree of mixing of eggs and larvae in the Gulf of Mexico is unknown. Mixing of eggs and larvae between western Gulf and Atlantic coast fish is likely to be minimal; however mixing between eastern Gulf and Atlantic fish may occur.

Skow and Chittenden (1981) examined hemogloben patterns of Spanish mackerel taken off Beaufort, North Carolina and Port Aransas, Texas and concluded that these fish were genetically separated. They also reported that preliminary findings of morphometric and meristic studies by Collette and Russo indicated significant differences between fish from the Gulf of Mexico and the southeast coast of the United States.

Preliminary findings of an electrophoretic study of Spanish mackerel collected from Louisiana to North Carolina indicate that fish along the Atlantic coast may be distinct from those of the eastern Gulf (A. Johnson, personal communication). No western Gulf fish were available for examination in that study.

The available data are far from conclusive. However, these new studies indicate that the hypothesis that there are at least two stocks cannot be rejected and further study should be done to resolve this issue.

III. STATUS OF STOCKS
III.1 Population Parameters
III.1.1 Mortality rates

Sturm (1978) estimated the total mortality rate (Z) of Brazilian mackerel in Trinidad in the early 1970's for beach seine and gill net gear (Table GCP-12). The FMP (GMSAFMC 1983) reported estimates of Z that varied from 0.71 to 1.25 depending upon the data source and the method of calcualting Z. Although no precise estimate of the fishing mortality rate (F) and the natural mortality rate (M) exist for United States Spanish mackerel, it was suggested in GMSAFM (1983) that the most likely values for M varied between 0.50 to 0.80 and for F from 0.20 to 0.50.

III.1.2 Growth Estimates

Fable et al. (In Press) have sumarized available growth information for Spanish mackerel in United States waters. Major points of their report include:

1. Females live longer than do males.

2. There is a wide range of lengths within an age group for both males and females.

3. Annulus formation in the fish studies occurred in March, April, or May; whereas, Powell (1975) had reported mark formation in May, June and July, and

4. Back calculations showed a great variation in mean fork lengths at age from area to area and year to year. In general, the fastest growing fish were taken in south Florida, and the slowest growing in Louisiana.

Validation of otoliths for aging Spanish mackerel has not been completed. Aging of juvenile Spanish mackerel in South Carolina by counting "apparent" daily growth rings is being attempted and may increase our confidence in using otoliths for aging purposes.

Several sets of Von Bertalanffy growth parameters have been estimated for Spanish mackerel (Table GPC-13). An inspection of the growth parameters reveals that values for females are reasonably consistent; however, values for males are not. The reason for this is unknown.

III.2 Catch Per Unit Effort Trends

Nominal effort data for Spanish mackerel are not available and it si uncertain how many vessels actually participate in the fishery.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

The current FMP was implemented on February 4, 1983. The FMP established an optimum yield of 27 million lbs which was not to be exceeded and minimum size limit of 12 inches. The level of landings from 1979 to 1983 indicate that total landings of Spanish mackerel are approximately one-half of the optimum yield. Total commercial landings peaked in 1976 and 1977 and have declined since. Because the present quota is approximately twice the level of observed landings, it is highly unlikely that the fishery will be affectd by the quota. Thus, current management measures appear to have a minimum impact at the present time.

V. RECOMMENDNATIONS

V.1 Data Needs

Fishing effort and size composition data are needed, especially for the Florida commercial fishery. Size composition and effort indices are needed for the recreational fishery. More timely recreational catch estimates are needed and selected age samples are needed, especially for the Florida commercial fishery because that fishery appears to account for the majority of total landings.

V.2 Research

Research is needed on stock identification, age and growth characteristics, mortality rates, recruitment phenomena, and stock assessment.

V.2.1 Stock Identification

The stock structure of Spanish mackerel is unknown although there is biochemical evidence that there may be more than one stock. Tagging and biochemical methods can be employed to determine stock structure of Spanish mackerel.

V.2.2 Age and Growth

The several growth curves which have been fitted to male and female Spanish mackerel differ in their estimates of growth parameters. A study examining "apparent" daily growth rings of juvenile Spanish mackerel in South Carolina should enhance our understanding of growth. Once these results are known, published growth estimates should be re-examined in order to account for differences. Tetracycline marking techniques may also provide useful information.

V.2.3 Mortality

Mortality rates are poorly known for Spanish mackerel. Improved catch and effort statistics, size information, and selected tagging experiments will provide better data. Charter boat CPUE should be done examined for its potential in estimating trends and mortality rates.

V.2.4 Recruitment

Recruitment patterns are unknown for Spanish mackerel. Because the resource appears to be concentrated in South Florida during the winter and because the winter commercial fishery appears to be the greatest source of fishing mortality, careful monitoring of the winter fishery would allow researchers to estimate recruitment to the resource. Monitoring information would include catch and effort statistics, size information and selected tagging experiments. In addition, abundance of pre-recruit Spanish mackerel could be monitored by summer trawling surveys along the Atlantic coast in order to test the feasibility of establishing a recruitment index based on the relative strength of pre-recruits. Such an index, if it could be developed, would provde valuable recruitment information approximately one year before recruitment to the fishery.

V.3. Management

The analysis of the status of the Spanish mackerel resource contained in the Coastal Migratory Pelagic FMP (GMSAFMC 1983) was prepared in 1978. Since then, commercial and recreational landings appear to have declined and present landings appear to be one-half of the optimum yield estimate in the FMP. Further, more than one stock may exist within the Gulf of Mexico and South Atlantic areas. Therefore, the resource should be closely monitered until additional data can be examined to assess the status of the resource.

GROUNDFISH

Groundfish species considered in the 1982 Stock Assessment Workshop were described in SAW/82/GCP and included the Atlantic croaker (Micropogonias undulatus), the groundfish species of principal commercial and recreational importance. In the present Workshop spotted seatrout (Cynoscion nebulosus) and red drum (Scianenops ocellatus) were added. New data were available on croaker for the north-central Gulf of Mexico (Louisiana and Mississippi) and the southwestern North Atlantic (North Carolina). Limited information on spotted seatrout and red drum was available for the north central Gulf of Mexico (Louisiana), and the southeastern Gulf of Mexico (Everglades National Park, Florida).

ATLANTIC CROAKER

I. DESCRIPTION OF THE FISHERIES

I.1 Gulf of Mexico

There are two distinct directed commercial fisheries for croaker in the northern Gulf of Mexico - the petfood fishery, which harvests croaker and associated species for processing, and the food fishery, which harvest larger croaker for the fresh fish market. Croaker landings for petfood are approximately five times the weight of croaker food fish landings. Croaker is becoming a more sought-after recreational species, particularly near Grand Isle, Louisiana, where large croaker are caught near oil rigs. A more complete description of commercial and recreational fisheries for croaker was given in SAW/82/GCP. An update on landings data for food croaker and the recreational fishery is given in Table GCP-14. Landings data for 1980 through 1983 are not available for the petfood fishery due to confidentiality of the data.

Although detailed data on catch rates are not available since 1977, the catch rates of the petfood fishery are believed to have declined from a peak in 1974 until 1983, when increases were reported by the industry (N. Mavar, Mavar Boat Co., Biloxi, Mississippi). Processors have adjusted to decreased catch rates by changing their operating strategy. Now fewer of the large groundfish vessels are deployed during the June-November fishing season and more smaller vessels (shrimp vessels) are employed during the December-May season. This strategy has kept the canneries operational despite an apparent decreased availability of croaker from June through November.

I.2 Southwest North Atlantic

The principal fisheries for croaker in the southwestern North Atlantic are in North Carolina. A description of these fisheries is given in SAW/82/GCP. Commercial landings of croaker in North Carolina peaked in 1980 at 9,592 metric tons (Table GCP-14) and has declined since. A large majority of the drop in landings occured in the offshore winter trawl fishery.

II. STOCK STRUCTURE

II.1 Gulf of Mexico

There is no evidence for more than one stock of croaker in the Gulf of Mexico. The north-central Gulf, where maximum densities and maximum biomass of croaker occur, may be a major spawning area for croaker from the western Gulf (SAW/82/GCP). No new information on stock identification in the north-central Gulf of Mexico was presented at the Workshop.

II.2 Southwestern North Atlantic

The North Carolina Division of Marine Fisheries recently completed an electrophoretic study of croaker. Eleven protein systems were examined for variability. Four: transferrin, hemoglobin, parvalbumin, and phosphoglucose isomerase, were variable and showed potential as possible markers for gene pools. Detailed investigation of these four systems in up to 2,166 fish collected from Chesapeake Bay to Cape Fear River, North Carolina, throughout the year produced no evidence of the presence of more than one stock or population in the region.

III. STATUS OF STOCKS

III.1 Gulf of Mexico

III.1.1 Fishery-Independent

Estimated fall density (number per unit area), biomass (weight per unit area), and average weight of croaker from resource surveys conducted in the north-central Gulf of Mexico (from Perdido Bay, Florida to Pt. Au Fer, Louisiana) were made for 1972 through 1983 (SAW/84/GCP/8). Results indicated a statistically significant (alpha $<$ 0.1) downward trend in biomass and average weight of croaker. Although the density (number) of croaker appeared to decrease, a statistically significant downward trend was not indicated (Figure GCP-5).

III.1.2 Recruitment Indices

Atlantic croaker spawn in the Gulf of Mexico in the fall and winter. Larvae move into estuaries and the waters of adjacent tidal marshes, where they grow rapidly. Then they move offshore.

Peak upstream (into marsh) movements of small young-of-the-year croaker occur from November through February in Louisiana at a modal length of 15.0 - 19.9 mm standard length (Figure GCP-6). Peak downstream (out of the marsh) movements of larger young-of-the year (50-60 mm SL) fish occurred from late March to early May in 1980-82 (Herke et al. 1984a). Peak trawl catches in marsh waters occurred from February through May. Length frequency distributions within samples were often bimodal, suggesting separate cohorts (recent and earlier arrivals).

SAW/84/GCP/9 estimated recruitment trends in Louisiana bays from estuarine survey data using a multiple regression technique. Results indicated that the method may be useful in estimating regional recruitment trends; however, estimates in each bay were variable. Tentative results indicated no long-term decline in abudance of croaker in anv of the bays.

SAW/84/GCP/10 indicated consistent seasonal patterns of catch of young-of-the year by gear in Mississippi. Croaker from beam plankton trawl samples were taken almost exclusively from October through December (93.6% of the total BPL croaker catch). The 16-ft trawl operating near to the inner estuarine shoreline had the largest catch rates of young-of-the year croaker from January through June (90.4%). The 36-ft trawl catch rate for most years was bimodal, with one peak between May and July (38.2%) and the other between August and November (57.9% of the total 36-ft trawl catch). Peak catches could be followed from the BPL to the 16-ft otter trawl and to the 36-ft otter trawl. Regression analysis of nine years of data indicated a statistically significant relationship between the CPUE of the BPL from October through December and the mean CPUE in the 16-ft otter trawl from January through June ($\alpha < 0.05$). The later seasonal peak in the CPUE of the 36-ft trawl was correlated with the CPUE of the 16-ft trawl from January through June. These results indicate the feasibility of developing a method to predict recruitment to the offshore trawl fishery based on catch rates of young croaker in various gear in the Mississippi Sound.

Recruitment of juvenile croaker into Mississippi waters has varied from generally higher levels in the mid to late 1970s to low levels in 1981 through 1983. During the spring of 1984, large numbers of juvenile croaker were caught in Mississippi Sound and near-shore areas (Gulf Coast Research Laboratory, Ocean Springs Mississippi, unpublished data).

III.1.3 Other Indices

The harvesting of brown shrimp in Mississippi Sound has been shown to have a significant effect on the local density of juvenile croaker (Warren 1981). Fifteen stations throughout Mississippi Sound were sampled weekly in 1979, once during the day and once during the night. An 80% decrease in the mean weekly catch-per-unit-effort was noted immediately following the opening of the 1979 shrimp season (Figure GPC-7). In 1980 and 1981 sampling was reduced to nine day/night stations, visited once a week. Although the effect of the shrimp opening on juvenile croaker numbers was not as clear cut as in 1979, a 59% decrease was indicated in 1981 (Warren 1982). Shrimp harvesting was also shown to affect local croaker abundance in Barataria Basin, Louisiana (Rogers 1979).

SAW/84/GCP/8 demonstrated significant declines in fall resource survey estimates of croaker abundance with increased shrimp trawling (Figure GCP-8; Table GCP-15).

III.1.4 Current Status

Information presented at the Workshop suggests that shrimp trawling activity may influence the abundance of croaker in the north-central Gulf of Mexico. Although this may have had a detrimental effect on croaker catch rates in directed fisheries for croaker, there is no evidence that the long-term viability of the stock has been damaged. In fact, recruitment indices from both Mississippi Sound and Louisiana bays, though variable from year to year, show me long-term declines.

III.2 Southwestern North Atlantic

III.2.1 Fishery-Independent Surveys

There is presently no fishery-independent information on trends in abundance and biomass of Atlantic croaker in North Carolina fishery landings. The North Carolina Division of Marine Fisheries (DMF) currently is collection data on size and age composition, relative abundance, and seasonality of croaker in commercial long-haul seine, pound net, and offshore winter trawl catches. Using their recently acquired computer capability, DMF will use commercial catch data to monitor the status of all economically important groundfish species and to develop yield-per-recruit models for these species and will routinely monitor the status of the stocks in Pamlico Sound using fishery-independent surveys.

III.2.2 Recruitment

Since 1979, the North Carolina Division of Marine Fisheries has been monitoring relative abundance and size composition of age 0 croaker throught a statewide estuarine trawl survey conducted monthly from March through November at about 150 stations. Detailed analyses of this data to determine seasonal patterns, variation in recruitment, and the relationship of relative abundance to environmental factors and landings are forth coming.

About 30,000 late young-of-the-year croaker were tagged by DMF in both 1982 and 1983. The return rate has been about 0.5%. The fish, which were tagged primarily in western Pamlico Sound, moved toward deeper, more seaward portions of Pamlico Sound and to nearshore ocean waters and south along the coast during the fall and winter. Fish were recaptured primarily throughout Pamlico Sound (along the mainland side) and in lower Albemarle Sound in the summer following tagging.

III.2.3 Current Status

The current status of croaker in the southwestern North Atlantic is largely unknown. Landings data suggest that abundance may have declined in the last few years. Landings set records each year from 1977 to 1980 but have since ranged from about 50 to 65% of the record landings.

IV. EFFECT OF CURRENT REGULATIONS

No effects have been evaluated.

V. RECOMMENDATIONS

V.1 Data Needs

1. Establish mechanisms for collection of effort data. Explore the possible use of industry records to estimate a time series of CPUE data.

2. Identify areas major recreational fishing areas for Atlantic croaker and conduct one-year creel census studies in these areas to obtain information to fine-tune estimates of recreational croaker catches (and effort) from the National Recreational Survey.

3. Collect catch and length-frequency data on Atlantic croaker from recreational boats, in particular. Assemble catch-by-size data bases for use in virtual population assessments.

4. Continue efforts to estimate bycatch of groundfish in shrimp fisheries, both inshore and offshore (inshore should include recreational catch).

5. Investigate the data base from the <u>Albatross</u> cruises of the Northeast Fisheries Center for possible indices of abundance and biomass of Atlantic croaker offshore of North Carolina.

6. Cordinate the sampling design, data management, and data analysis of the estuarine resource surveys conducted by

Louisiana, Mississippi, and Alabama to improve the potential use of the data to estimate recruitment.

V.2 Research Needs

1. Continue to develop recruitment indices for croaker by utilizing available state and federal data bases.

2. Improve and validate ageing techniques for croaker. Apply the improved technique to samples collected over several years to determine annual variation.

3. Improve estimates of natural mortality of Atlantic Croaker.

4. Use available data to investigate trends in total mortality of groundfish, especially Atlantic croaker. A breakdown of mortality from inshore and offshore sources, by region, should be investigated.

5. Expand and improve yield-per-recruit analyses and determine the sensitivity of yield-per-recruit results to uncertainty in the estimation of natural mortality.

6. Explore integrative multivariate techniques for examining shrimp/groundfish interactions and habitat/groundfish relations.

V.3 Management

No management recommendations were made at this time.

SPOTTED SEATROUT AND RED DRUM

Spotted seatrout and red drum were not examined in detail at the Stock Assessment Workshop. Following is a summary of assessment results for several areas within the Gulf of Mexico and south Atlantic coast of the United States. The majority of the information presented was that from the Everglades National Park (ENP). Therefore, this summary focuses on those results.

I. DESCRIPTION OF THE FISHERY

Fishery data were only presented for the ENP at this workshop. Harvest (landed catch) and effort data have been collected continously since 1958 (Higman 1966, Davis 1980). Since 1973, the annual seatrout harvest has ranged from 114,000-240,000 fish (Figure GPC-9), representing 6-10% of the estimated total annaul fish harvest from ENP, and 15-38% of the total annual recreational harvest. Red drum harvest has ranged from 34,000 to 88,000 fish annually (Figure GCP-9), accounting for 1-6% and 7-18% of the total finfish and sport fish harvests, respectively. Harvests of both species are taken by four types of fisheries: recreational, guide, commercial hook and line, and gill net. Most seatrout were harvested by sport and commercial hook and line fishermen until 1980, when a bag limit of 10 fish per species (also applying to red drum) went into effect. Commercial hook-and-line harvest and effort dropped considerably after institution of the bag limit and presently the recreational fishery accounts for greater than 70% of the total annual estimated seatrout harvest. The harvest by guide boats is smaller, ranging from 4-38% of the total. The gillnet harvest occurs only as the bycatch of the mullet fishery, and the reported bycatch of spotted seatrout in the mullet fishery is negligible.

Estimated ENP effort on seatrout was variable from 1973 to 1983 (Figure GCP-10), but, has declined since 1980. Note that this effort is <u>successful</u> effort, measured in effort of those individuals who caught one or more seatrout.

Red drum ENP harvest and effort increased steadily after 1976 (Figures GCP-9 and GCP-10). Recreational and guide fishermen harvested the majority of the fish.

II. STOCK STRUCTURE

Spotted seatrout and red drum are harvested recreationally throughout the Southeast Region and Commercially wherever legal. Although both are estuarine-dependent species, spotted seatrout spawn in estuarine [20-35 ppt (Arnoldi, 1982)] waters, whereas red drum spawn in waters of higher salinity. Red drum life history is similar to that of other offshore-spawning estuarine dependent species. Iverson and Tabb (1962), Beaumariage (1969), and Weinstein and Yerger (1976) reported that there is little intermingling of spotted seatrout between estuaries in South Florida, and each estuary may have a separate spawning group.

Based on their research in Louisiana, Herke et al. (1984b) speculate that the nursery grounds of spotted seatrout in Louisiana west of the Mississippi River may lie outside the bay system in the nearshore Gulf of Mexico, where estuarine-like water conditions (e.g. low salinities, variable temperatures) prevail. If this is the case, there may not be distinct spawning groups of spotted seatrout within each bay system in Louisiana. Herke et al. (1984b) base their speculation on the extreme low numbers of early juvenile spotted seatrout in trawl and trap collections from a number of studies in Louisiana marsh waters.

Whether there are distinct spawning groups of red drum in the Southeast Region is unknown (Gulf of Mexico Fishery Management Council and Gulf States Marine Fishery Commission, 1984), but it is conceivable that eggs and larvae could be distributed over long distances by long-shore currents. At this point no conclusions were made on stock structure of these species.

III. STATUS OF STOCKS

III.1 Population Parameters

III.1.1 Mortality Rates

Mortality rates for spotted seatrout in the ENP were higher for males (Z = 1.72, F = 1.37) than females (Z = 1.39, F = 1.02) (Rutherford et al. 1982). Natural mortality calculated from von Bertalanffy parameters (Pauly 1980) were similar for both sexes (0.35, 0.36) (Rutherford et al. 1982). Another M value for Florida seatrout is M = 0.40 [calculated using Iversen and Moffett's (1962) data]. A comparision of ENP seatrout fisheries in 1959 (Stewart 1961) and 1979 (Rutherford et al. 1982), indicated no change in growth, a shift to proportionately more older fish (Figure GCP-11), and only a slight increase in mortality, despite a near two-fold increase in nominal fishing effort (Davis 1980, Rutherford et al. 1982).

Red drum total mortality rates in the ENP were estimated at Z = 1.05 (Figure GCP-11) for males and females. Natural mortality rates have not yet been calculated for ENP red drum but probably range from 0.15 to 0.60 (Gulf States Marine Fisheries Commission 1984). Given this range, fishing mortality rates (by subtraction) range from 0.45 to 0.9.

III.1.2 Growth Rates

Growth rates have been reported for seatrout throughout the Gulf of Mexico and for the ENP. In all studies, females grew faster than males. The ENP growth rate is intermediate between east central Florida's fast growing population (Tabb 1961) and Texas' slower growing population (Pearson 1928). Von Bertalanffy growth parameters for ENP male and female park seatrout were:

	K	L_{∞} (mm)	t_0
Males	.12	591	-2.95
Females	.13	654	-2.04

Calculated growth estimates for ENP red drum should be treated with caution since there are few older fish (age 3, 4) from which to back calculate growth, leaving only sizes at ages 1 and 2 valid. Therefore, von Bertalanffy parameters K, l and t_0 have not yet been calculated.

III.2 Catch Per Unit Effort Trends

A perceived decline by sport fishermen in spotted seatrout abundance in ENP in the middle 1970's was not reflected in catch rates. Both sport fishermen harvests and effort declined during this period, while successful fisherman catch rates remained constant. Catch rates and harvests by commercial hook-and-line fishermen peaked within this time. Catch rates by commercial hook-and-line fishermen may more accurately reflect relative abundance than recreational effort, because most if not all of this effort is directed at seatrout. Successful catch rates of red drum in the ENP were relatively constant 1973-83 (Figure GCP-12).

Seasonal harvests and catch rates were highest for spotted seatrout in the 2nd and 4th quarters of the calendar year when they formed spawning aggregations (2nd quarter) and when cool water temperatures drove them into channels and holes (4th quarter). Red drum harvest and catch rates were highest from September through January, when young of the year and one year old fish enter the fishery (Figure GCP-12).

Correlation between harvest and effort for both spotted seatrout and red drum was high (r = 0.93, 0.94). There was no significant correlation between successful sport fishermen harvest rate and total effort the previous year for spotted seatrout or red drum.

II.3 Stock Assessment Analyses
III.3.1 Yield Per Recruit

Yield-per-recruit analyses were performed for ENP spotted seatrout by sex, because growth differed by sex (Rutherford 1982). Yield-per-recruit for both males and females was near maximum given the level of F in 1979 (Figure GCP-13). Increasing F would not have significantly increased yield-per-recruit. Increasing age at recruitment from its current age (2 yrs) would have significantly increased yield-per-recruit (Figure GCP-13). At age 2, yield-per-recruit was far below maximum for both males and females.

No yield-per-recruit analysis has been done for ENP red drum, although it has been done for red drum off west Florida (Gulf States Marine Fisheries Commission 1984). Calculations for juveniles (0-4 yrs) and adults (4 yrs) were separate because the two age groups occupy different habitats and have different growth rates (Gulf States Marine Fisheries Commission 1984).

III.3.2 Other Indices

Herke et al (1984b) have recently compiled and summarized both published and unpublished data on spotted seatrout from a number of research projects conducted in the tidal marsh waters of Louisiana. The following information is extracted from their summarization.

Catches of young-of-the-year spotted seatrout in the marshes around Calcasieu Lake by Herke, et al. (1984a) progressively increased from 1980 through 1982. Catches in the littoral zone of Calcasieu Lake peaked in 1977 and 1982 (Arnoldi 1982). Observations in 1983 indicate an extremely poor year for inshore juvenile spotted seatrout (Herke et al. 1984b; David Arnoldi, Louisiana Department of Wildlife and Fisheries, Lake Charles, Louisiana). Ditty (1984) reported spawning occurred from April through September off Caminada Pass, Louisiana. Sabins (1973) collected larval seatrout (2-14 mm SL) from April through September in beam trawl samples in Caminada Pass, but Arnoldi (1982) did not find any indication of young-of-the-year in April or May in Calcasieu Lake from 1977 to 1980. Herke, et al. (1984a) took 56 spotted seatrout (20-35 mm SL) in the marshes and canals west of Calcasieu Lake from 9 April 1982 to 17 April 1984. These are the only records for this size seatrout inshore in April for the Calcasieu area. The major peak in juvenile abundance occurred from late July through early September (Herke et al. 1984a, Arnoldi 1982).

The National Park Service is presently conducting a study of the distribution and abundance of early life stages of spotted seatrout and red drum in the ENP. Park spotted seatrout spend their entire lives in or near park waters. Roessler (1967), Jannke (1970), Collins and Finucane (unpublished manuscript) and NPS (unpublished data) have collected seatrout larvae in park waters throughout the year. Peaks in catches occur from May through June and from August through September. Juvenile seatrout (10-100 mm TL) have been collected in shallow water seagrass beds shortly after peak larval catches from June through December. Adults in spawning condition have been collected in mid-high salinity waters of the park. Tagging studies (Beaumariage 1969) and gel electrophoretic studies (Weinstein and Yerger 1976) indicated little inter-bay movement between sub-populations of fish.

Adult red drum do not occur in the park, but apparently inhabit deeper offshore Gulf waters. Spawning occurs in the fall. Larvae are carried into the park in September-November and orient to shallow low-salinity habitat soon thereafter (National Park

Service unpublished data). After spending 2 to 3 years in the estuary, they disappear from the park catch. Tagging studies of juvenile red drum show little inter-bay movement.

IV. EFFECT OF CURRENT REGULATIONS

Current regulations were not evaluated.

V. RECOMMENDATIONS

V.1 Data and Research Needs

1. Data collection and research efforts need to address distribution, movement, and habitat requirements of pre-recruit spotted seatrout and red drum and to identify the parent stock of park red drum.

2. Catch-by-size data need to be organized for use in virtual population assessment.

3. Harvest rate estimates need to be adjusted for zero catches.

4. Age and growth estimates for spotted seatrout in the literature need to be validated. Growth rates may have been grossly underestimated in most studies.

V.2 Management

No management recommendations were made at this time.

Table GCP-1. Annual commercial landings (thousands of lbs) of king mackerel in Gulf of Mexico and South Atlantic coasts of the United States.

Year	Gulf of Mexico1/	South Atlantic Coast1/
1960	1785	1856
1961	1683	2120
1962	2021	2128
1963	2817	2230
1964	1314	2109
1965	1898	2688
1966	2633	1881
1967	3084	3012
1968	3604	2594
1969	3242	2961
1970	2372	4350
1971	2738	2922
1972	1378	3499
1973	2217	3749
1974	6133	4311
1975	2622	3805
1976	2801	4985
1977	5217	4167
1978	1617	3251
1979	1691	3808
1980	3002	4049
1981	3073	5739
1982	2197	6045
19832/	2742	4089

1/ Gulf of Mexico includes Texas, Louisiana, Mississippi, Alabama and the west coast of Florida; south Atlantic includes North Carolina, South Carolina, Georgia and the east coast of Florida.

2/ Preliminary.

Table GCP-2. Estimated effort trends in king mackerel fishery

	Total Effort 1/			Florida 2/
Year	Constant Recreational Catch	Constant Recreational Effort	Constant Ratio of Recreational and Commercial Effort	Commercial Effort
1969	--	--	--	108.2
1970	5.6	6.3	5.8	107.8
1971	6.3	6.3	5.6	125.7
1972	--	--	--	134.2
1973	8.1	6.8	7.6	183.1
1974	13.7	9.9	18.8	205.8
1975	6.1	6	.1	240.4
1976	10.3	8.0	11.7	284.7
1977	18.7	11.4	24.1	314.4
1978	6.7	8.5	13.5	--
1979	7.1	7.1	7.1	--
1980	6.2	6.2	6.2	341.4
1981	25.7	13.5	31.6	--
1982	31.0	14.6	35.7	--

1/ Effort in millions of standardized trolling hours for Atlantic & Gulf Migratory Group commbined (SAW/84/GCP/2) assuming 3 scenarios of recreational catch.

2/ Florida commercial effort in standard boats (SAW/84/GCP/12).

Table GCP-3. Survival rates of king mackerel obtained by Heincke method from (SAW/84/GCP/4).

Tagging Location	Tagging Period	Year Tagged	Unlagged Survival Estimate	Lagged Survival Estimate	Equivalent Unlagged Z Estimate
Southeast Florida	Dec-March	1975	0.381	0.389	
		1976	0.428	0.370	
		1977	0.491	0.447	
		1978	0.415	0.351	
		Overall	0.441	0.387	0.82
Key West/Naples	Jan-March	1976	0.134	0.143	2.01
		1977	0.161	0.293	
		1978	0.474	0.500	
		Overall	0.202	0.277	1.60
Southeast Florida	May-June	1975	0.639	0.618	
		1976	0.514	0.522	
		1977	0.522	0.484	
		1978	0.630	0.625	
		Overall	0.554	0.539	0.59
Southeast Florida	August	1975	0.750	0.750	
		1976	0.474	0.444	
		1977	0.888	0.778	
		Overall	0.650	0.615	0.43
Carolinas	Summer	1978	0.750	0.330*	0.29
		1979	0.690	0.480*	0.37

*Pattern of recaptures, apparently changed during course of experiment which affected lagged estimates (SAW/84/GCP/4).

Table GCP-4. Commercial landings (lbs) of King mackerel for Atlantic Migratory Group for 1977-78 through 1983-84 fishing years (July-June).

Total Fishing Season	North Carolina July-June	South Carolina July-June	Georgia July-June	East Coast Florida May-Oct	Total Atlantic Migratory Group 1/
1977-78	233,673	6,410	11,313	1,436,052	1,687,448
1978-79	214,130	22,235	31,808	1,279,738	1,547,911
1979-80	425,289	76,042	15,708 2/	1,275,036	1,792,075
1980-81	769,530	235,295	14,294	1,461,568	2,480,687
1981-82	872,398	155,591	8,695	1,773,254	2,809,938
1982-83	1,130,810	160,054	2,546	843,013	2,946,929
1983-84	Preliminary --	--	--	--	approximately 1.2 million

1/ Atlantic Migratory Group includes all North Carolina, South Carolina and Georgia landings, plus the Florida east coast landings from May through October.

2/ Division of Georgia landings estimated because monthly landings are confidential. Totals are correct.

Table GCP-5. Commercial landings for Gulf Migratory Group* for 1969-70 through 1982-83 fishing seasons.

Fishing Season	Commercial Landings in Pounds
1969-70	5,784,104
1970-71	4,436,844
1971-72	4,088,264
1972-73	4,512,914
1973-74	9,064,496
1974-75	4,888,621
1975-76	6,359,122
1976-77	8,332,366
1977-78	4,434,734
1978-79	3,669,092
1979-80	4,273,602
1980-81	5,892,590
1981-82	5,801,995
1982-83	4,606,654**
1983-84 (July-March 31)	Approximately 2.5 million

* Gulf Migratory Group landings are defined as all landings from Alabama, Mississippi, Louisiana, and Texas and the Florida west coast from July through June; also, Florida east coast landings from November through April.

** 3,336,303 pounds without Louisiana catch.

Table GCP-6. Species composition of catches by trolling between areas surveyed during 1982 and 1983 charterboat surveys off the southeastern Unites States (SAW/84/GCP/14).

Area	Top Ten 1982 Species	1982 CPH	Top Ten 1983 Species	1983 CPH
North Carolina	Dolphin	3.83	Dolphin	1.71
	Bluefish	1.69	Yellowfin tuna	0.91
	Yellowfin tuna	0.79	King mackerel	0.75
	King mackerel	0.35	Bluefish	0.66
	Little tunny	0.10	Little tunny	0.17
	White marlin	0.05	Spanish mackerel*	0.10
	Wahoo	0.04	Wahoo	0.06
	Blackfin tuna	0.03	Albacore	0.05
	Atlantic bonita*	0.02	White marlin	0.05
	Albacore	0.01	Blackfin tuna	0.04
Hours fished		1,368.0		4,498.5
South Florida	Dolphin	1.70	Dolphin	1.55
	Great barracuda	0.59	Great barracuda	0.28
	Yellowtail snapper	0.13	Blackfin tuna*	0.22
	Cero	0.11	Little tunny	0.13
	King mackerel	0.11	King mackerel	0.10
	Little tunny	0.10	Atlantic bonito	0.05
	Atlantic bonito	0.07	Yellowtail snapper	0.04
	Wahoo	0.03	Wahoo	0.04
	Black grouper*	0.03	Cero	0.04
	Sailfish*	0.03	Skipjack tuna*	0.04
Hours fished		1,370.0		5,938.5
Northwest Florida	Blue runner	1.81	Blue runner	2.00
	Spanish mackerel	1.68	King mackerel	1.37
	Little tunny	1.12	Atlantic bonito	0.80
	King mackerel	0.72	Little tunny	0.62
	Bluefish	0.55	Spanish mackerel	0.40
	Dolphin	0.36	Ladyfish	0.16
	Atlantic bonito	0.20	Dolphin	0.16
	Ladyfish	0.11	Bluefish	0.13
	Greater amberjack	0.09	Greater amberjack	0.07
	Red drum*	0.03	Gray triggerfish*	0.05
Hours fished		576.5		3,603.0

* Species change from 1982 to 1983.

Table GCP-6 (continued).

Area	Top Ten 1978 Species	1982 CPH	Top Ten 1983 Species	1983 CPH
Louisiana	Dolphin	9.19	Spanish mackerel	2.54
	Spanish mackerel	1.20	Dolphin	1.14
	Red drum	0.66	King mackerel	1.00
	Little tunny	0.65	Little tunny	0.37
	Blue runner	0.48	Blue runner	0.23
	Crevalle jack	0.25	Yellowfin tuna*	0.14
	Wahoo*	0.19	Red drum	0.14
	Bluefish	0.18	Bluefish	0.13
	King mackerel	0.11	Crevalle jack	0.07
	Cobia*	0.03	Blackfin tuna*	0.05
Hours fished	302.5		650.0	
South Texas	King mackerel	1.28	King mackerel	0.61
	Spanish mackerel	0.52	Little tunny	0.24
	Dolphin	0.14	Crevalle jack	0.20
	Crevalle jack	0.11	Dolphin	0.12
	Cobia	0.07	Blackfin tuna*	0.09
	Atlantic sharpnose shark*	0.06	Atlantic bonito*	0.09
	Red snapper*	0.04	Spanish mackerel	0.07
	Blacktip shark*	0.04	Yellowfin tuna*	0.05
	Little tunny	0.03	Wahoo*	0.03
	Unidentified shark*	0.01	Cobia	0.03
Hours fished	771.0		2,590.5	

* Species change from 1982 to 1983

Table GCP-7. Comparison of Ricker model yield-per-recruit estimates (weight/1000 weight units of recruits) calculated from growth parameters from several sources. Size at recruitment = 620 mm; M and F = 0.36. Mean Y/R was not weighted by sex. (SAW/84/GCP/4).

Tagging	combined	820.9	890.9	---
Beaumariage (1973)	M	743,0	829.4	+1.0%
	F	915.7		
Johnson et al. (1983)	F*	868.2	811.5	-1.1%
	M	754.8	849.7	+3.5%
	F**	944.6		
Nomura and Rodrigues (1967)	M	792.8	831.7	+1.3%
	F	870.6		
	combined	869.0		
Ximenes et al. (1978)	M	850.7	860.8	+4.9%
	F	870.8		
	combined	868.3		

* excluding Louisiana

** Louisiana only

Table GCP-8. Commercial landings of Spanish Mackerel for South Atlantic and Gulf of Mexico, 1950-1982 in thousands of lbs.

Year	South Atlantic	East Coast Florida	Gulf of Mexico	West Coast Florida	Total Landings
1950	3,725	3,577	2,593	2,313	6,318
1951	2,183	1,977	6,511	6,267	8,694
1952	3,609	3,435	4,517	4,361	8,126
1953	3,775	3,580	3,015	2,939	6,790
1954	2,431	2,101	2,887	2,848	5,318
1955	3,403	3,238	1,627	1,576	5,030
1956	4,925	4,578	2,919	2,887	7,844
1957	4,469	4,221	3,649	3,610	8,118
1958	7,524	7,308	3,870	3,830	11,394
1959	2,508	2,352	4,691	4,670	7,199
1960	2,406	2,282	5,468	5,435	7,874
1961	3,296	3,158	4,014	3,988	7,310
1962	2,674	2,578	6,912	6,869	9,586
1963	2,267	2,123	5,447	5,405	7,714
1964	2,083	2,002	3,957	3,880	6,040
1965	3,032	2,901	4,905	4,883	7,937
1966	2,261	2,181	7,066	7,004	9,327
1967	1,879	1,802	5,976	5,867	7,855
1968	4,484	4,406	7,232	7,066	11,716
1969	2,402	2,359	8,342	8,175	10,744
1970	3,639	3,574	8,298	8,100	11,937
1971	2,681	2,582	7,658	7,383	10,339
1972	3,475	3,369	7,222	6,532	10,697
1973	3,276	3,203	6,457	6,194	9,733
1974	2,422	2,346	8,554	8,267	10,976
1975	5,210	5,145	6,137	5,621	11,347
1976	9,627	9,589	8,342	7,783	17,969
1977	11,035	10,987	2,636	2,393	13,671
1978	3,465	3,424	1,583	1,478	5,048
1979	4,901	4,886	2,122	1,946	7,023
1980	9,893	9,811	1,952	1,770	11,845
1981	4,227	4,174	3,700	3,550	7,927
1982	3,949	3,759	3,443	3,287	7,392
1983	5,987	5,945	1,800	1,627	7,787

Table GCP-9. Mean annual landings of Spanish mackerel by state in the south Atlantic and Gulf of Mexico, 1977-1983 in thousands of pounds and percent of catch by state.

	NC	SC	GA	FL-East	FL-West	AL	MS	LA	TX
Annual Mean (thousands of lbs)	65	1	1	6,141	2,293	53	71	49	-
Percent Total	0.75	0.01	0.01	70.80	26.44	0.61	0.82	0.56	-

Table GCP-10. Spanish mackerel commercial landings on the east and east coasts of Florida by month of the fishing season. Landings are in thousands of lbs.

Season	NOV	DEC	JAN	FEB	MAR	APR	TOTAL
East Coast Florida							
1966-67	270	330	238	280	227	109	2,031
1967-68	442	180	785	1,121	300	362	3,496
1968-69	1,060	482	291	375	647	283	3,418
1969-70	281	321	443	70	400	183	1,898
1970-71	1,662	471	634	149	184	416	3,838
1971-72	596	275	126	46	475	263	2,191
1972-73	934	924	456	242	536	215	3,830
1973-74	601	759	481	251	644	213	3,322
1974-75	132	409	149	1,452	1,363	460	4,127
1975-76	309	1,189	2,960	2,946	1,444	111	9
-77	727	1,161	4,368	2,803	474	12	9,738
1977-78	710	2,355	2,502	520	173	28	6,549
1978-79	139	2,087	1,184	2,581	119	33	6,076
1979-80	88	697	4,132	1,049	47	19	6,136
1980-81	97	4,375	1,561	153	24	11	6,313
1981-82	162	2,073	229	166	2,171	73	5,078
1982-83	77	842	3,436	65	25	96	4,752
West Coast Florida							
1966-67	709	1,370	1,481	684	816	700	6,639
1967-68	839	378	1,172	717	607	1,128	6,027
1968-69	457	2,131	1,646	1,640	600	1,075	8,375
1969-70	793	1,498	1,705	851	752	1,053	7,373
1970-71	1,035	1,416	1,542	518	1,154	624	7,750
1971-72	627	1,322	1,094	289	1,426	603	6,839
1972-73	389	795	766	1,200	1,082	57	5,620
1973-74	828	1,209	2,753	1,101	2,132	195	9,240
1974-75	393	1,021	1,534	825	664	294	6,833
1975-76	442	1,160	2,576	2,138	1,051	305	8,369
1976-77	387	902	925	193	73	109	3,282
1977-78	225	508	411	408	75	106	1,984
1978-79	65	122	208	445	71	213	1,609
1979-80	24	635	573	363	38	220	2,179
1980 81	50	132	392	68	38	661	1,845
1981-82	555	1,266	818	87	414	312	3,997
1982-83	633	611	576	140	35	64	2,579

Table GCP-11. Number of Spanish mackerel and weight caught by recreational fishermen in 1979 and 1980 (National Marine Recreational Survey) compared to commercial landings.

	1979			1980		
	Recreational		Commercial	Recreational		Commercial
	(#'s x 10^3)	(lbs x 10^3)	(lbs x 10^3)	(#'s x 10^3)	(lbs x 10^3)	(lbs x 10^3)
South Atlantic	909	2,101	4,901	885	1,694	9,893
Gulf of Mexico	2,435	8,013	2,122	2,278	3,993	1,952
TOTAL	3,344	10,114	7,023	3,163	5,686	11,845

Table GCP-12. Total instantaneous mortality rates of Brazilian Mackerel in Trinidad in 1971-72 from samples from beach seines (a) and gill net (b). Taken from Sturm (1978).

	(a)		(b)	
Age Class	Number of Fish Sampled	Z	Number of Fish Sampled	Z
I	46	-	-	-
II	286	-	21	-
III	266	0.70	231	-
IV	181	.38	176	0.27
V	61	1.09	30	1.77
VI	31	0.68	11	1.00
VII	9	1.23	2	1.70
VIII	2	1.50	-	-
OVERALL	(II-VIII)	0.07	(III-VII)	0.99

Table GCP-13. Von Bertalanffy growth parameters for Spanish mackerel.

	Males		
Source	K	L_∞ (FL mm)	t_0 (years)
Fable et al. all areas combined	0.24	794	-0.94
Fable et al. Florida	0.27	776	-0.73
Powell (1975)	0.48	555	-1.12
Nomura (1967) using Klima's (1959) data	0.40	607	+0.15

	Males		
Source	K	L_∞ (FL mm)	t_0 (years)
Fable et al. all areas combined	0.33	739	-0.99
Fable et al. Florida	0.38	731	-0.73
Powell (1975)	0.45	694	-0.78
Nomura (1967) using Klima's (1959)	0.40	720	+0.28

Table GCP-14. Landings, value, and average price of Atlantic croaker[1] in Alabama, Mississippi, and Louisiana (combined) and in North Carolina.

Year	Alabama, Mississippi, Louisiana			North Carolina		
	Landings (mt)	Value ($1000)	Price ($/kg)[2]	Landings (mt)	Value ($1000)	Price ($/kg)
1968	1,400	334	.239	654	60	.092
1969	2,159	623	.289	621	62	.100
1970	2,899	851	.294	366	38	.104
1971	4,162	1,136	.273	430	54	.126
1972	4,484	1,288	.287	1,864	227	.122
1973	6,365	1,653	.260	1,961	372	.190
1974	5,665	1,579	.279	2,759	600	.217
1975	4,787	1,399	.292	4,650	904	.194
1976	3,213	979	.305	6,821	1,577	.231
1977	1,677	534	.318	8,616	2,076	.241
1978	1,339	512	.382	9,047	2,735	.302
1979	4,320	750	.174	9,325	4,345	.466
1980	5,226	1,050	.201	9,592	5,214	.544
1981	5,054	1,708	.338	5,083	3,945	.776
1982	1,034	889	.860	5,845	4,031	.690
1983	313	250	.799	3,291	2,841	.864

[1] Fresh food fish croaker, only (not petfood fishery landings).

[2] Convert to price per pound by muliplying by 0.4536

Table GCP-15. Data used in the regression of estimated groundfish and croaker number and weight per unit area in the nearshore area from Perduco Bay, Florida, to Pt. Au Fer, Louisiana,[1] and estimated shrimping effort[2].

	Croaker				Groundfish		Shrimp Effort[b]		
	No/Ha		Kg/Ha		Kg/Ha		No. of 24 hr Days		
YEAR	MEAN	C.I.	MEAN	C.I.	MEAN	C.I.	BROWN	WHITE	TOTAL
1972	176.80	74.10	21.75	8.96	74.67	16.96	54,510	53,559	108,728
1973	531.54	120.65	56.27	12.56	107.59	15.79	46,979	40,170	90,201
1974	444.96	90.87	43.06	7.46	75.77	12.35	44,204	45,957	92,531
1975	334.65	91.90	31.64	7.22	65.55	10.67	35,381	47,625	92,126
1976	233.08	53.22	21.99	4.05	64.88	15.28	47,374	37,167	87,630
1977	245.55	78.46	16.65	4.15	38.86	5.45	49,342	48,731	102,082
1978	280.35	63.33	19.51	4.15	43.89	5.51	44,831	54,331	106,384
1979	181.85	53.73	14.67	3.49	44.17	8.70	68,535	69,757	148,470
1980	252.39	53.71	20.42	4.10	53.68	6.43	44,243	63,065	103,122
1981	287.78	95.93	20.16	6.59	55.81	10.34	45,379	48,032	94,940
1982	232.65	81.87	19.72	6.17	47.96	9.31	53,554	42,373	93,389
1983	195.62	64.52	11.94	3.25	33.45	6.21	49,983	54,678	103,861

[1] from OREGON II fall resource survey cruises (data collected and compiled by the Mississippi Laboratories, National Marine Fisheries Service, Pascagoula, MS).

[2] calculated from shrimp landings and interview records by S. Nichols (National Marine Fisheries Service, Southeast Fisheries Center, Miami, Florida.)

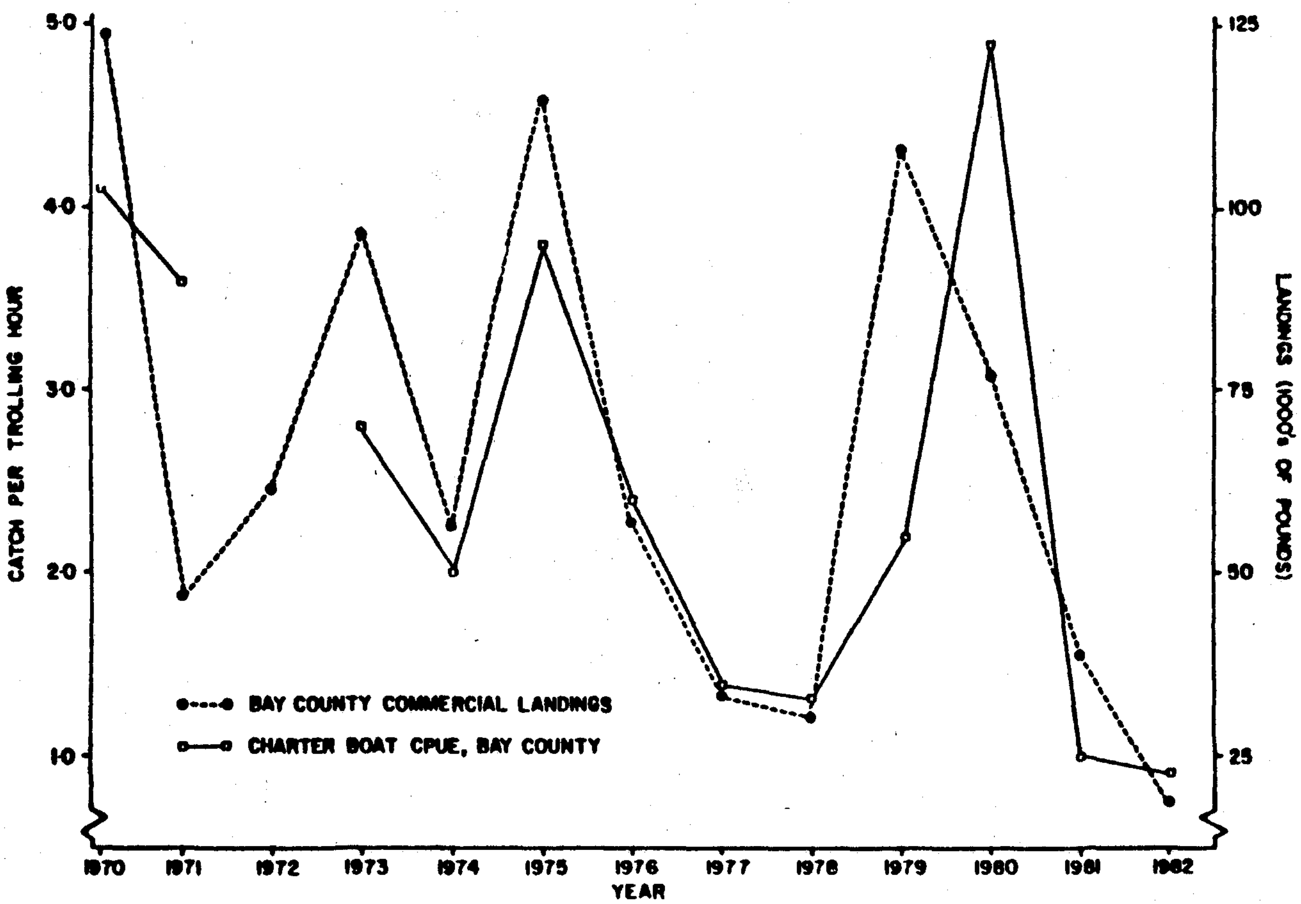


Figure GCP-1. Catch per unit effort (# per trolling hour) from a single northwest Florida charterboat, 1970-82. Also given is the commercial landings from the northwest Florida county of the charter operation (SAW/84/GCP/2).

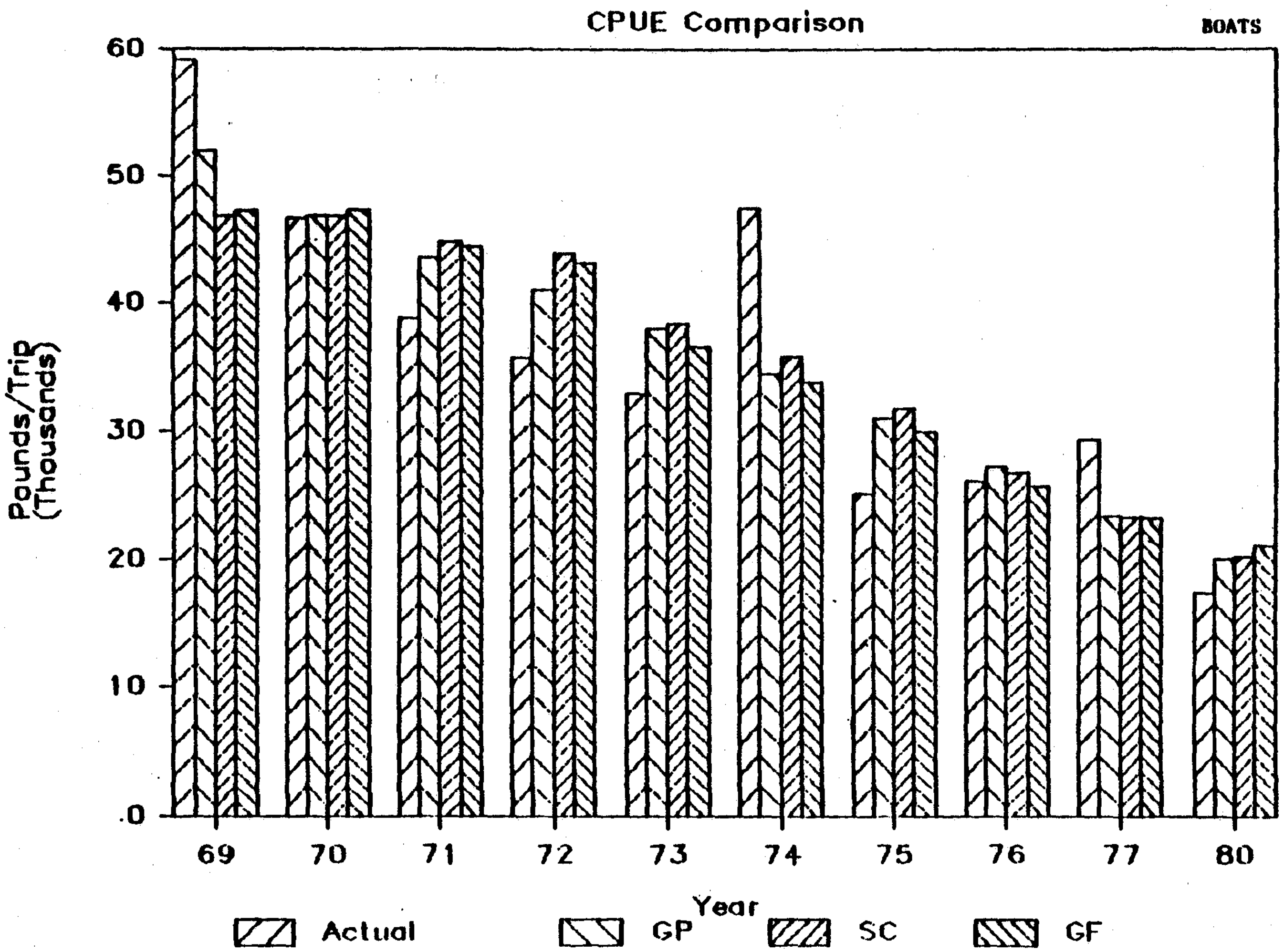


Figure GCP-2. Catch per unit effort (CPUE) in standard boats from Florida commercial fishery (SAW/84/GCP/12). Actual is the observed CPUE. Other values are the predicted CPUE's using the generalized production model (GP), the Schaefer model (SC) and the Gulland-Fox model (GF).

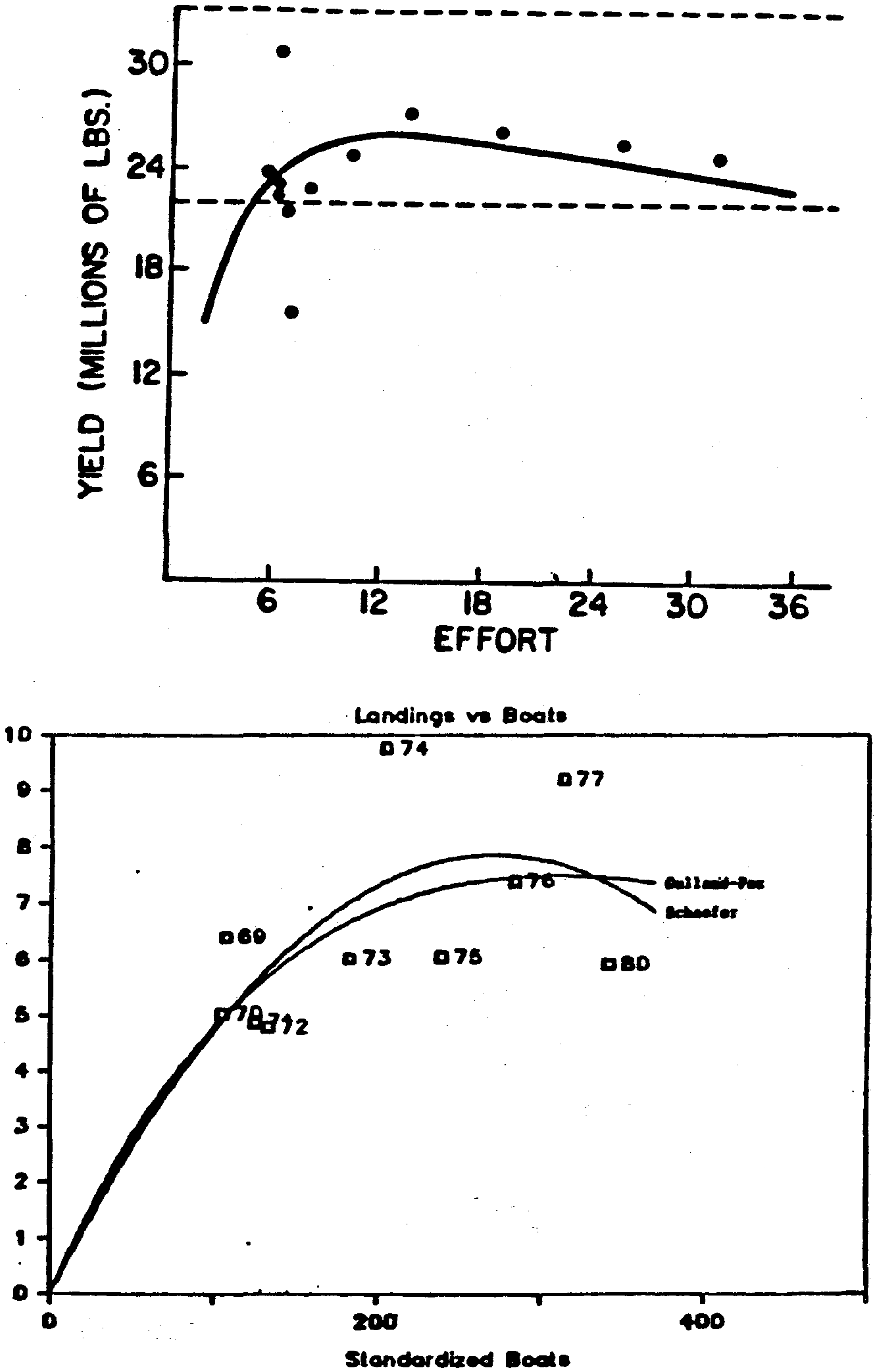


Figure GCP-3. Yield (millions of lbs) of king mackerel versus effort. Top graph gives total yield (Atlantic plus Gulf) versus total effort in standardized trolling hours (SAW/84/GCP/2). Data points are based on constant recreational catch scenario. Dashed lines define the range of uncertainty to the estimate of MSY.

The bottom graph gives Florida commercial yield versus Florida commercial effort in standard boats (SAW/84/GCP/12). Note that recreational catches are not included in this graph.

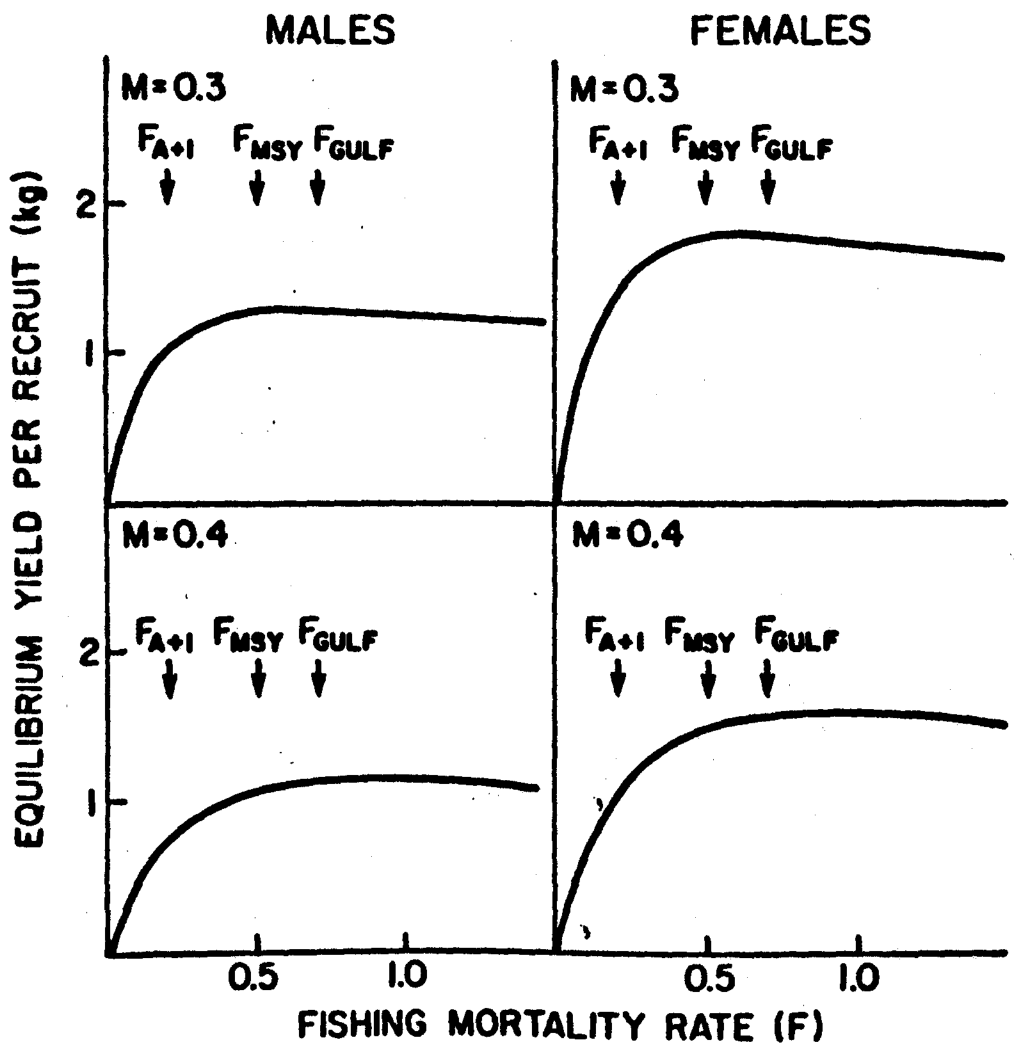


Figure GCP-4. Yield per recruit of king mackerel based upon growth parameters and natural mortality rates given in SAW/84/GCP/2. F_{A+1} is the estimated fishing mortality rate on the Atlantic Migratory Group in 1980. F_{GULF} is the estimated fishing mortality rate on the Gulf Migratory Group in 1980. F_{MSY} is the fishing mortality rate which will produce MSY.

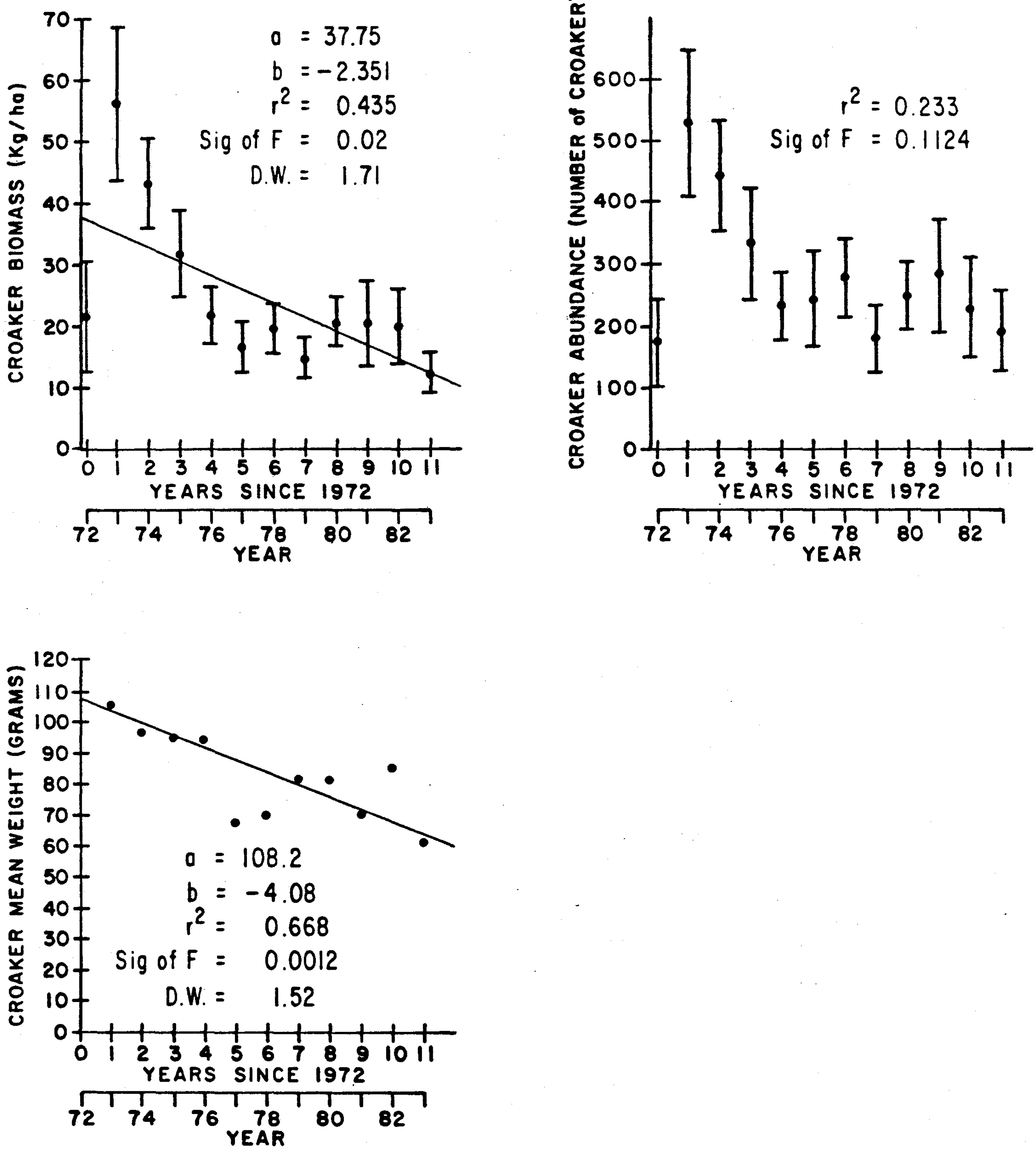


Figure GCP-5. Abundance indices of Atlantic croaker determined from fall research vessel surveys in the Gulf of Mexico, 1972-1983. Indices are in biomass (kg/ha), density (#/ha) and average size (g) from SAW/84/GCP/8. (Data collected and compiled by Mississippi Laboratories of the National Marine Fisheries Service, Pascagoula, Mississippi.

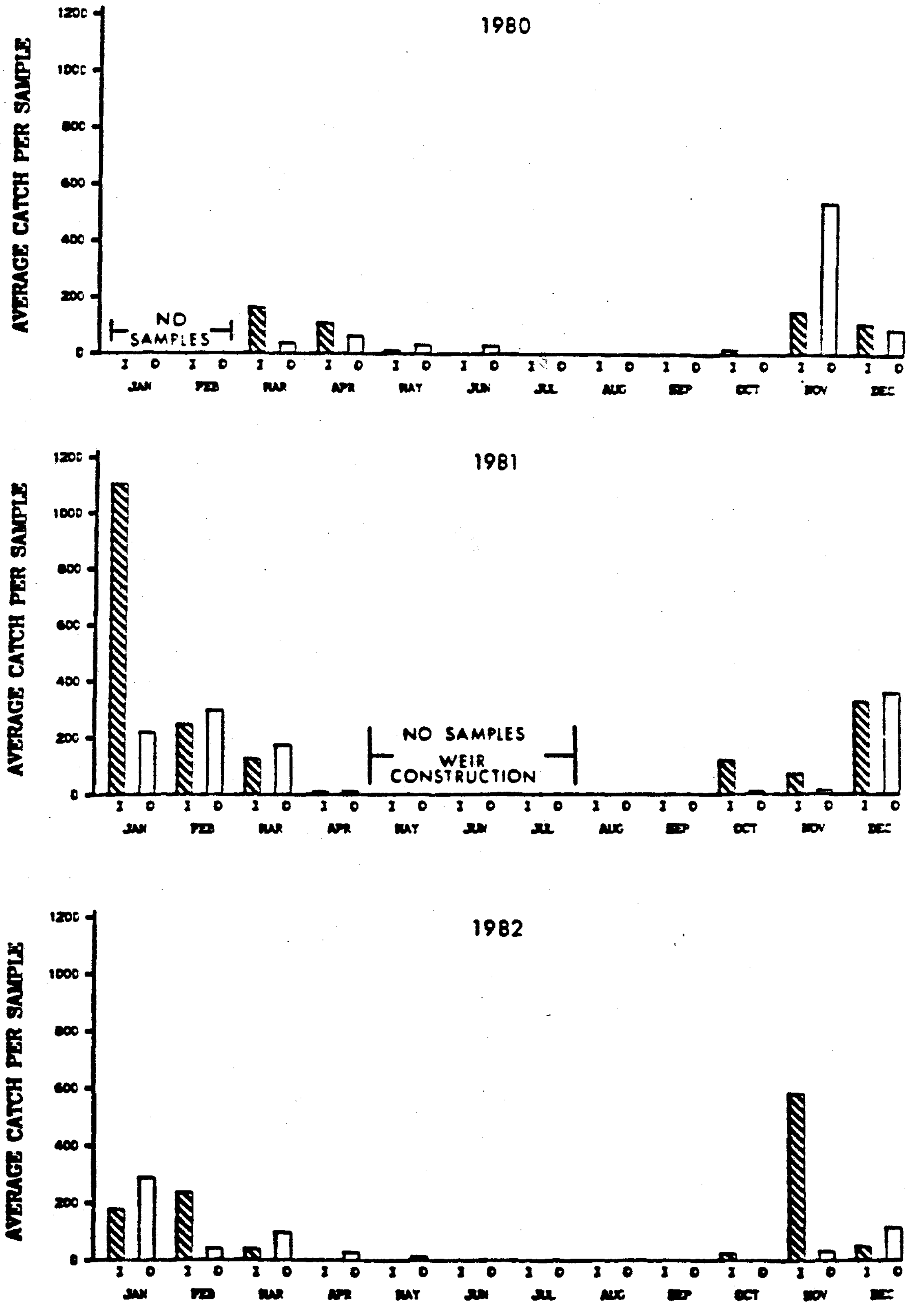


Figure GCP-6. Mean monthly catch of Atlantic croaker per sample (1980-82) in channel traps in Southwest Louisiana. Incoming fish (I) and outgoing fish (O) are denoted (from Herke et al. 1984).

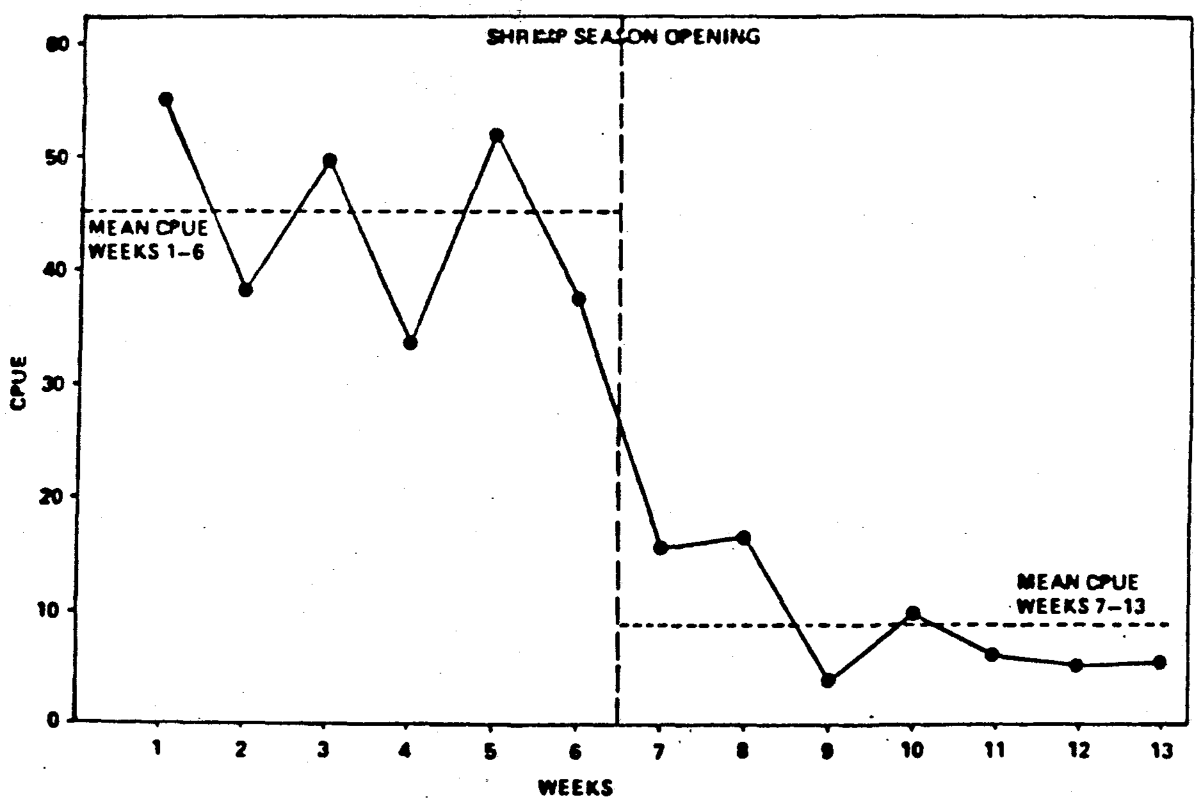


Figure GCP-7. Weekly catch-per-unit-effort of Atlantic creaker by Gulf Coast Research Laboratory surveys before and after opening of shrimp season in 1979 (from Warren 1981).

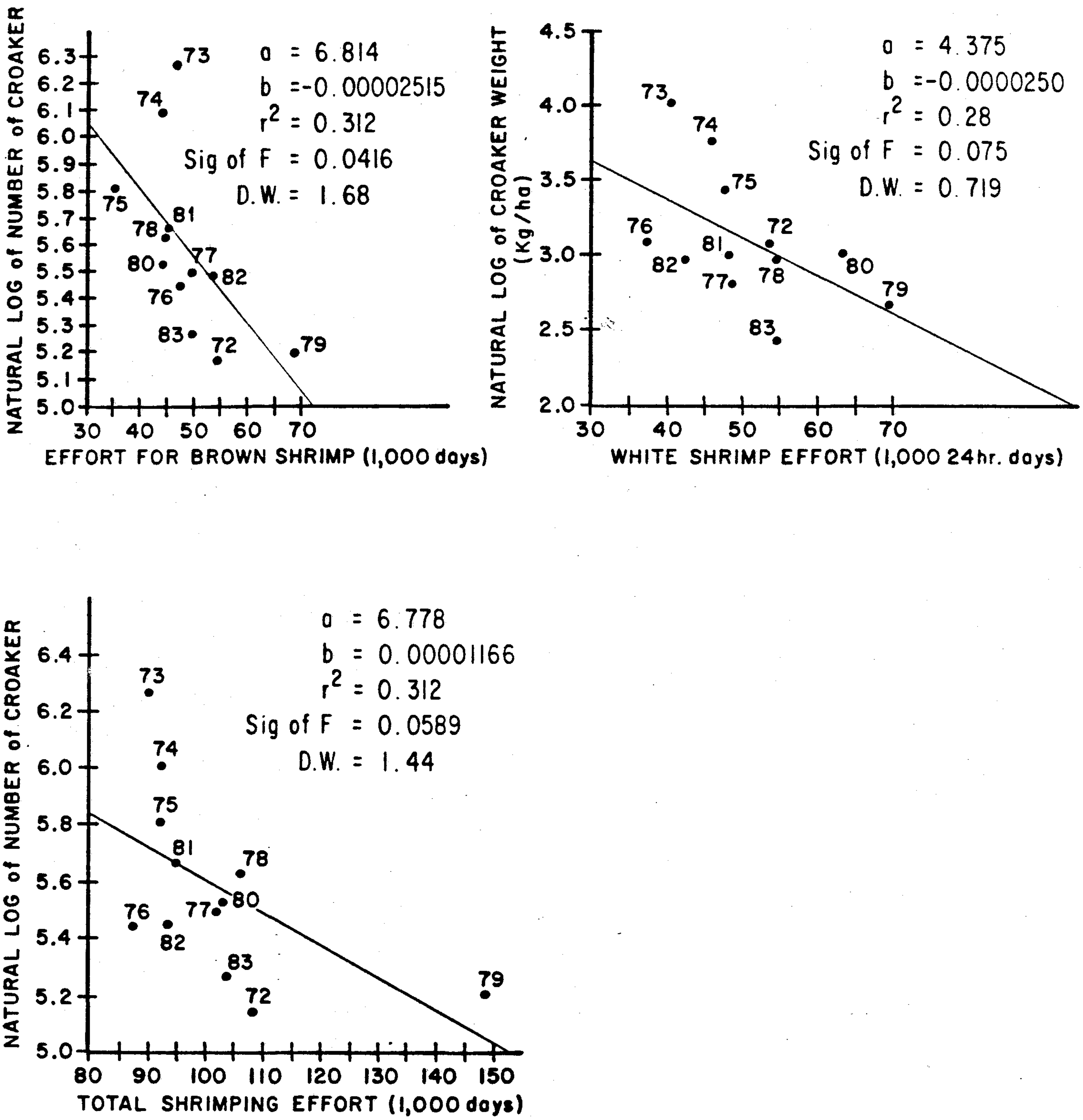


Figure GCP-8. Abundance indices of Atlantic croaker determined from fall resource surveys in relation to brown shrimp effort, white shrimp effort and total shrimping effort. Effort is in thousands of 24-hr fishing days. Abundance indices are in #/ha and kg/ha. (Data collected and compiled by the Mississippi Laboratories of the National Marine Fisheries Service, Pascagoula, Mississippi.)

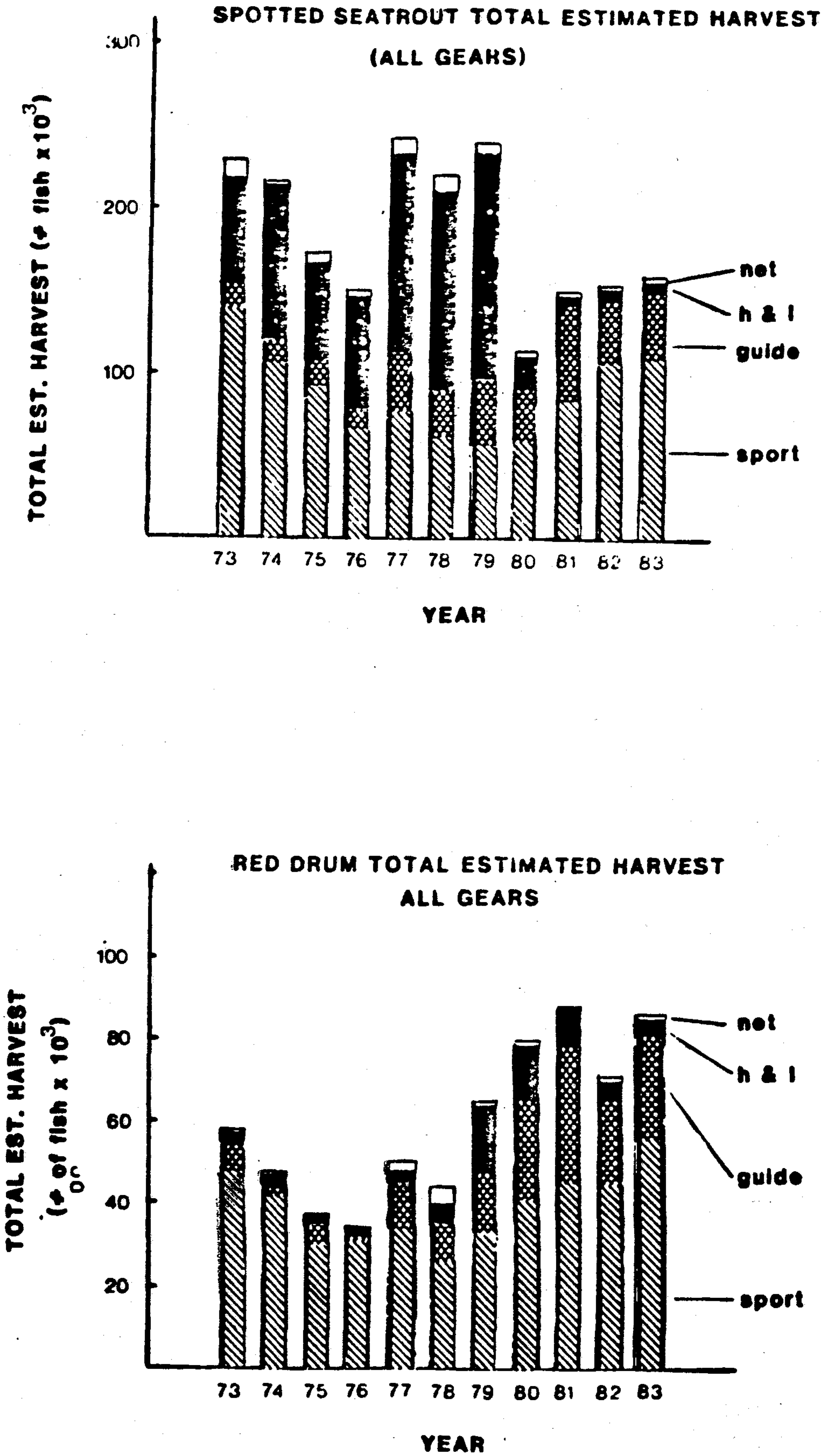
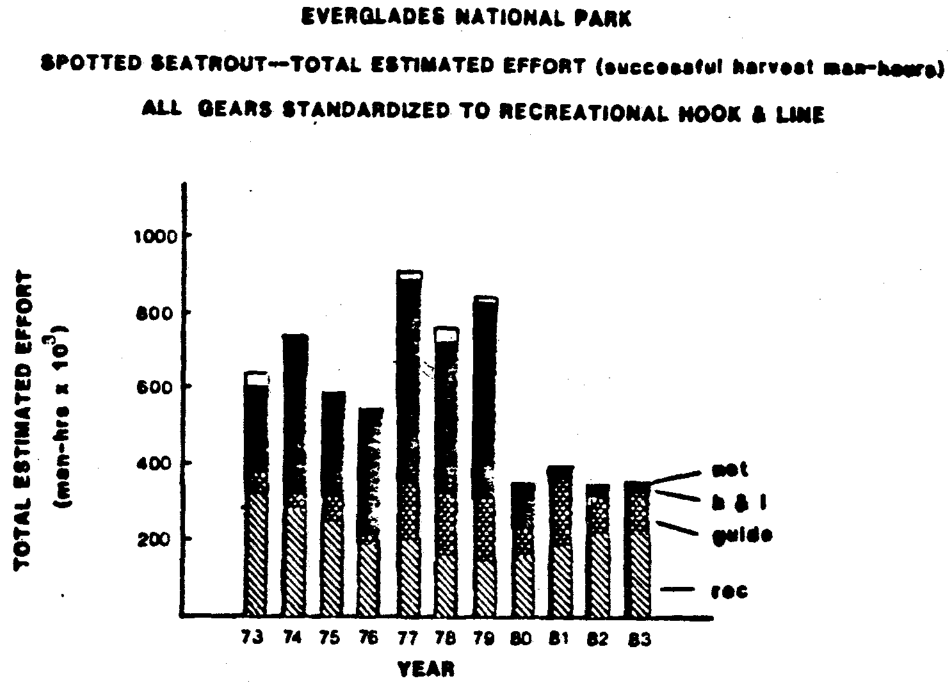


Figure GCP-9. Estimated harvest (landed catch) of spotted seatrout and red drum in Everglades National Park 1973-83 by gear (National Park Service unpublished data).



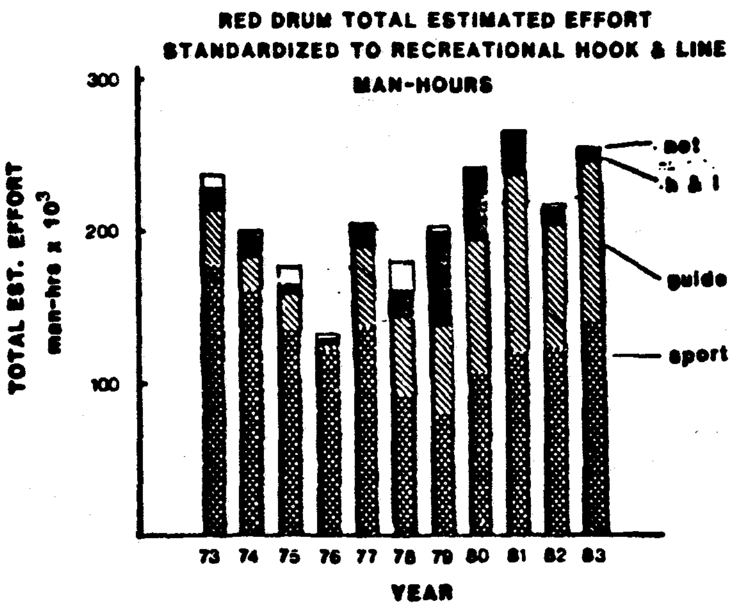


Figure GCP-10. Estimated successful effort on spotted seatrout and red drum in the Everglades National Park 1973-1983 by gear. Successful effort is defined as those trips in which one or more seatrout (red drum) were caught. All gears are standardized to recreational hook and line. (National Park Service unpublished data.)

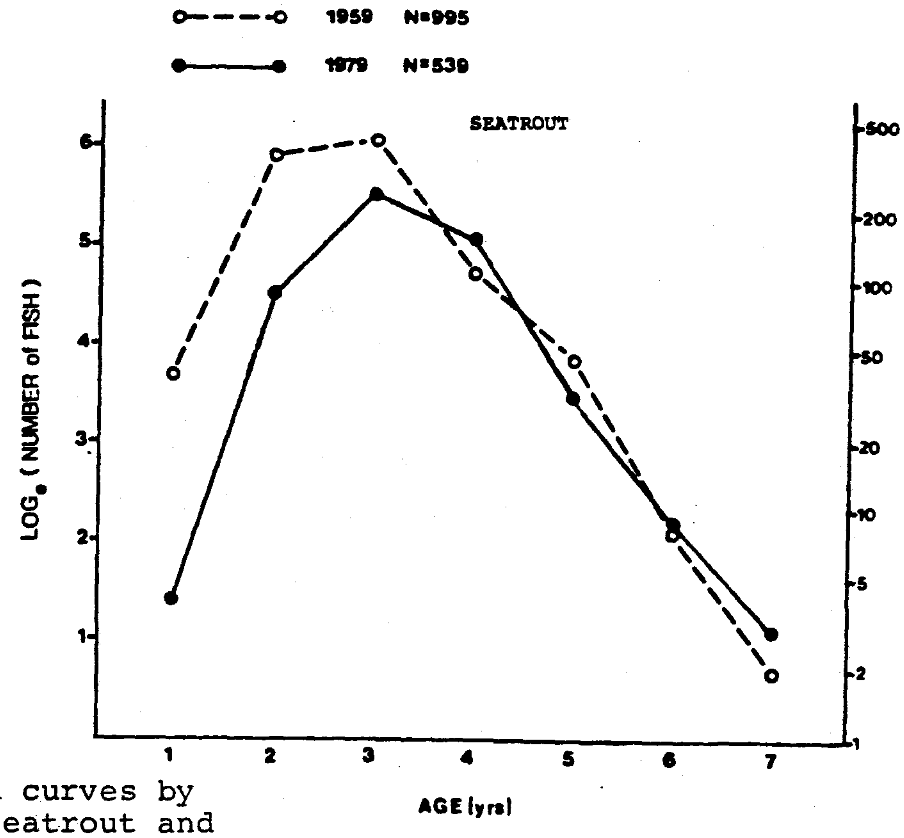
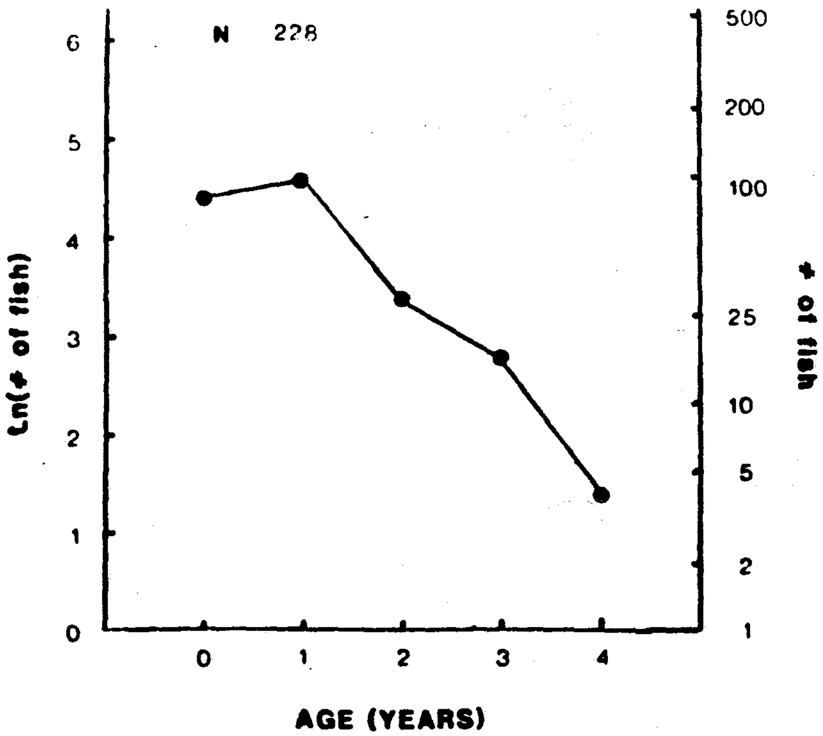
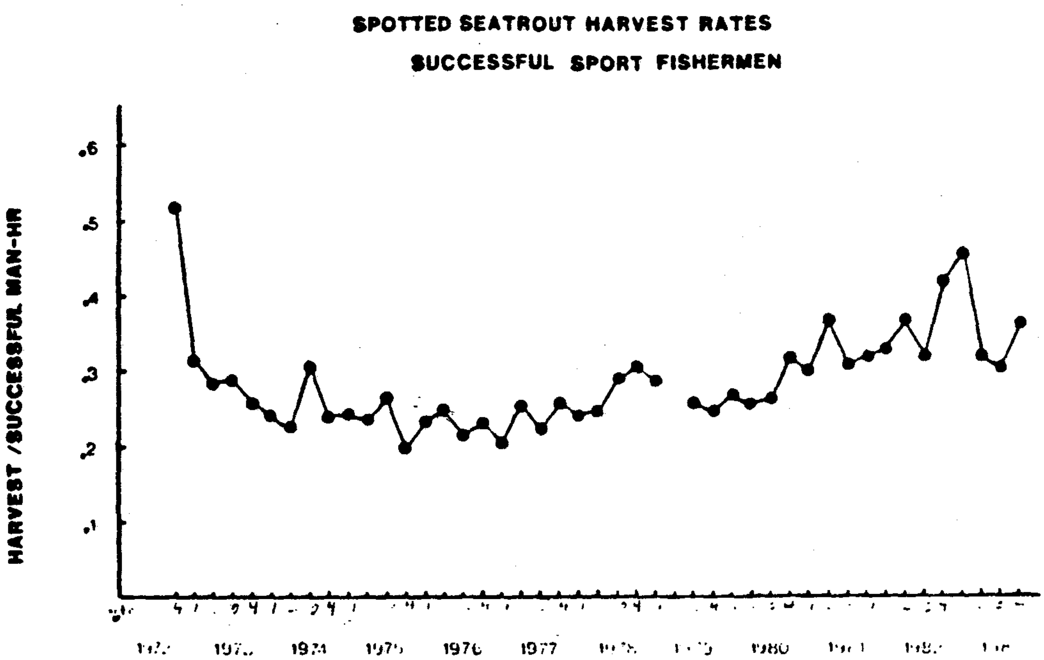


Figure GCP-11. Catch curves by age of spotted seatrout and red drum in the Everglades National Park. Seatrout curves are from sportfishermen catches in 1959 (Stewart 1961) and 1979 (Rutherford et al. 1982) and red drum are from sportfishermen catches in 1980.

RED DRUM CATCH CURVE





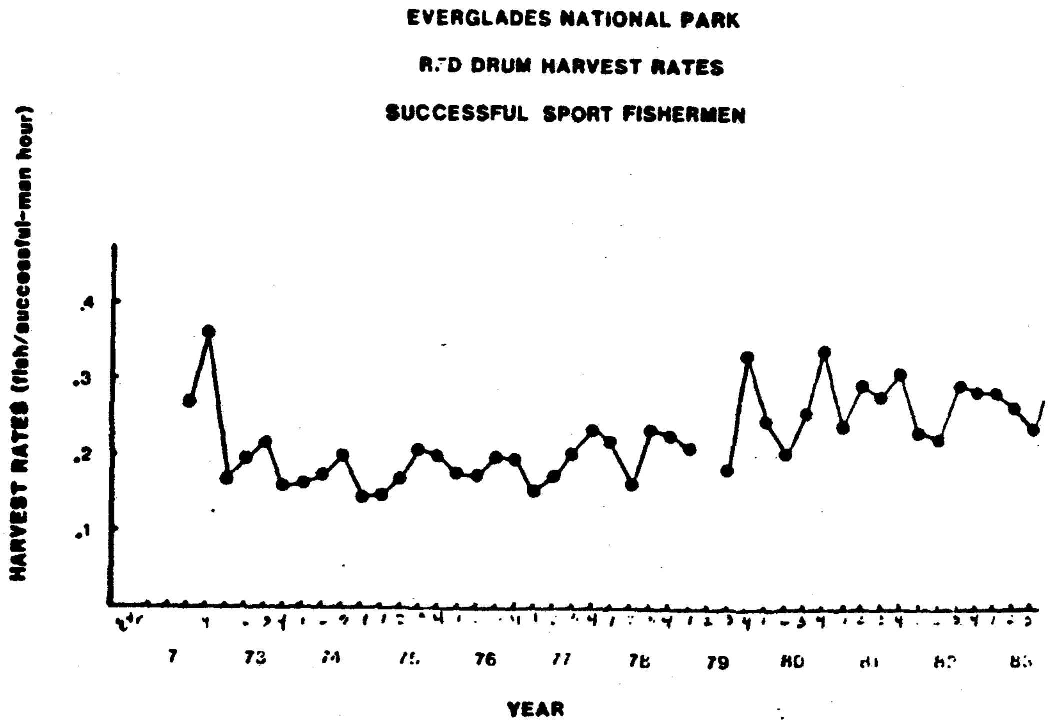
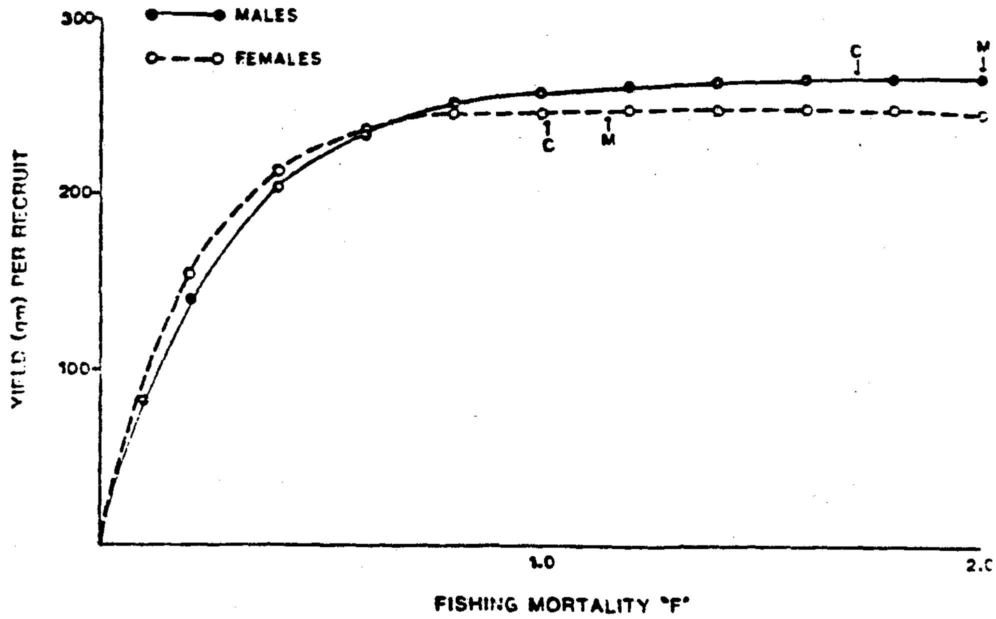


Figure GCP-12. Catch-per-unit-effort (CPUE) of spotted seatrout and red drum in the Everglades National Park by year and quarter 1972-1983. CPUE is in harvest (landed catch) per successful man-hour of sportfishing. Rates are log transformed mean values (National Park Service unpublished data).



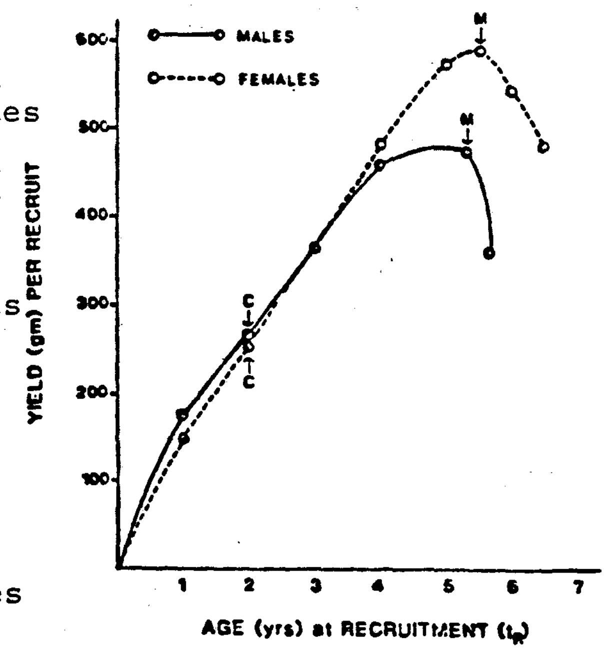


Figure GCP-13. Yield per recruit (Y/R) of spotted seatrout in the Everglades National Park. Top curve gives Y/R versus fishing mortality rate at age of recruitment of 2 years. The symbol C indicates the Y/R at current levels of fishing mortality, M is the maximum Y/R at the current age of recruitment. The bottom curve is the Y/R versus age of recruitment at current levels of F (F=1.37 for males; 1.02 for females). C indicates the Y/R at the current age of recruitment. M is the maximum Y/R at the current F.

Marine Mammals and Turtles (MMT)

SEA TURTLES

As stipulated in the Endangered Species Act (ESA), 1973, and Amendments of 1978 (P.L. 93-205 (87 Stat. 884)), the U.S. Fish and Wildlife Service (USFWS) of the Departemnt of the Interior has jurisdiction over endangered and threatened species in the U.S. In 1978, through a Memorandum of Understanding (MOU) the USFWS maintains responsibility over marine turtles on land and the National Marine Fisheries Service (NMFS) is given the responsibility of marine turtles in the water.

Under the ESA, 1973, the NMFS is charged with the purpose, relative to marine turtles in the water, of "conserving" endangered and threatened species (ESA, p. 2). The verb "to conserve" is defined (ESA p. 3) as using all methods of "scientific resource management" to bring any endangered or threatened species to the point where the measures in the ESA are no longer necessary. "Listing" of a species as endangered or threatened results when one the following criteria is met (ESA, p. 5):

"1) the present or threatened destruction, modification, or curtailment of its habitat or range;

2) over utilization for commercial, sporting, scientific or educational purposes;

3) disease or predation;

4) the inadequacy of existing regulatory mechanisms; or

5) other natural or man-made factor affecting its continued existence."

In the literal application of the ESA, the NMFS is responsible for recovery of marine turtles such that protective measures under the ESA no longer apply. Minimally, a review of the status of marine turtles is required by the ESA at least once every five years (ESA, p. 8). After the review, species are removed from the list, remain as either endangered or threatened or changed in status from threatened to endangered or vice versa in accordance with previously listed criteria. Thus, it is the explicit responsibility of the Departments of Commerce and Interior to remove species from the threatened and endangered species list, through "conservation" efforts. Included in the

ESA is the requirement to assess the status of stocks. An assessment is mandated under the ESA, 1973 and this report summarizes the progress made towards meeting this mandate since the first SEFC Stock Assessment Workshop in 1982 (SAW/82/MMT).

The leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempi*) and Florida green turtles (*Chelonia mydas*) are listed as endangered. The loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) are listed as threatened.

I. DESCRIPTION OF FISHERIES

In July, 1983, the Western Atlantic Turtle Symposium (WATS) convened in Costa Rica with the purpose of summarizing marine turtle data from the 35 participating Caribbean countries. Data for the extant fisheries for marine turtles are presented with summary catch statistics in the Proceedings of the Western Atlantic Turtle Symposium, Volume I (1984). In these Proceedings (p. 73), a summary of the number of Caribbean countries exploiting turtles and/or eggs by species are (from a total of 38 reporting countries):

Species	Number of Countries Reporting Exploitation
Caretta caretta	18
Chelonia mydas	31
Dermochelys coriacea	14
Eretmochelys imbricata	29
Lepiochelys kempi	0
Lepiodchelys olivacea	2
Unknown species	0

Hawksbill turtle (*E. imbricata*) is fished almost exclusively for its carapace which is used in producing tortoiseshell. All the other species and their eggs are exploited for food, leather or oil and levels of exploitation vary significantly between countries. For each species, the annual catch in weight for 1982 for the most significant fisheries are (Proceedings of the WATS):

Species	wt(kg)	Country
C. caretta	7,184	Bahamas
	4,111	Brazil
	3,170	Jamaica
C. mydas	63,660	Costa Rica
	12,346	Bahamas
D. coriacea	1,000	Grenada
	Other "major" fisheries listed but no figures available.	
E. imbricata	33,975 (shell)	Jamaica
	20,117 (shell)	Dominican Republic
L. olivacea	(No figures available)	
Unknown	51,712	Dominican Republic
	40,823	Jamaica

Historical catch levels for U.S. landings are discussed in SAW/82/MMT. Outside the U.S. there are historical catch data available but often these are confused as to species identification.

II. STOCK STRUCTURE

All six species of marine turtles are within the purview of the NMFS. The stock structure within each species is based on occurrence of nesting beaches and is defined in SAW/82/MMT. Stocks remain defined by occurrence of nesting beaches even though in the pelagic habitat the actual distributions of marine turtles, including sexually mature females, extends well beyond the limits of any given nesting beach during the nesting season (SAW/84/MMT/7).

Intensive mark-recapture studies on loggerhead turtles in selected areas of Georgia support the hypothesis that nesting aggregations represent isolated stocks based on nest site fidelity. Mark-recapture studies of loggerhead turtles in selected areas of Florida have demonstrated dispersal of post-nesting females to the Bahamas, Antilles and along Gulf of Mexico beaches.

The SAW/82/MMT outlines the recommended research for defining stocks of marine turtles. As a first priority, it was recommended that a biochemical genetics study be initiated to examine stock separation among female loggerhead turtles nesting along the southwest U.S. beaches. An ongoing contract (NMFS Contract No. NA83-GA-C-00036) is examining the potential for the use of electrophoresis to identify genetic markers in Caretta caretta. The purpose of the pilot study is to 1) identify the presence of genetic markers to evaluate variability between nesting aggregations and 2) begin to map collection sites genetically. Isoelectric focusing will be completed on blood proteins collected from nesting females and hatchlings if possible. Currently, samples will be derived only from turtles nesting on Florida beaches to evaluate the appropriateness of this technique.

In lieu of any results demonstrating the presence or absence of stock separation between nesting aggregations, the assumption is made that each nesting aggregation is a distinct stock. This conservative approach is consistent with that presented in the SAW/82/MMT. However, the mark-recapture studies provide a working hypothesis for continued biochemical studies designed to evaluate gene flow, inbreeding and reproductive isolation.

III. STATUS OF STOCKS
III.1 Population Parameters
III.1.1 Mortality Rates

Estimates of total mortality by life history stage are reviewed in the SAW/82/MMT. "Nest success" or hatching rates are derived from counts and are available where ground surveys are completed on nesting beaches. Estimates of mortality rates for loggerhead nesting females are provided in SAW/82/MMT/3. Total mortality rates can be estimated as in SAW/82/MMT/3.

A summary of incidental capture of turtles by species with mortality estimates, when available, for each fishery are presented in Table MMT-1. The three major fisheries which capture turtles for which we have data are directed at shrimp (trawls), tuna (long-lines) and sturgeon (gills). Under the ESA, the capture of any of the federally protected turtle species is prohibited. Thus, when fishermen capture turtles incidentally and then report this capture, they violate federal law and usually state law. Because foreign vessels fishing within the 200 mile Fishery Conservation Zone (FCZ) are required to report all captures, including non-directed species. Also, sometimes they carry official observers aboard. Therefore, the capture of turtles incidental to the Japanese long-line fishery is well documented. An estimated total number of leatherback and "non-leatherback" turtles was derived from the 1978-1979 long-line observer data (Table MMT-1). No data are available on the sizes of animals caught or killed.

Observer reported data of turtle capture and mortality were summarized for the South Carolina Atlantic sturgeon fishery (Table MMT-1). Data were summarized for 1978-1979. Catch per unit effort estimates are primarily for Caretta and effort is measured per 100 yards of gill net set. The majority of turtles are "sub-adult" in size as described in SAW/82/MMT.

For the shrimp fishery, turtle captures are standardized to a standard unit of effort for the commercial fishery (Table MMT-1). A standard unit is one fishing day which is defined as 24 hours of fishing effort (S. Nichols, personal communication). Additional sources of mortality for marine turtles captured incidentally may be from the roller-rig and calico scallop fisheries in the coastal area from Georgia and Florida, and the Virginia pound net fishery.

III.1.2 Growth Estimates

SAW/84/MMT/9 and SAW/84/MMT/2 examine growth rates using straight line carapace lengths for turtles in captivity and in the wild, respectively. Mark-recapture data from juvenile green (C. mydas) and loggerhead turtles (C. caretta) from the Misquito Lagoon in Florida were fit with both the logistic and Von Bertalanffy growth models (SAW/84/MMT/2). Because of small sizes samples and particularly the lack of data at the small sizes (i.e., <50 cm carapace length), results are considered preliminary and estimates of age at sexual maturity range from 12-30 years. However, the primary purpose of SAW/84/MMT/2 and SAW/84/MMT/9 is to present one methodology to estimate age of sexual maturity in lieu of any available technique to directly age turtles.

An alternate aging method may result from the examination of annuli in long bones.

III.2 Abundance Trends

III.2.1 Eggs and Hatchlings

A method to estimate age-specific fecundity for marine turtles is presented in SAW/84/MMT/1. Mark-recapture data for Caretta nesting on Little Cumberland Island, Georgia since 1964 are used to estimate average annual nesting intervals, intra-seasonal nesting frequency and the proportion of non-nesting females in a given year to compute the age specific mean reproductive output.

The same data were used to examine variability in clutch size and frequency within and among years (SAW/84/MMT3). Clutch size was positively correlated with curved carapace length, although clutch frequency was not. Mean clutch size did not vary significantly among years, but mean clutch frequency did.

As described in SAW/82/MMT, percent hatch is derived empirically using counts.

III.2.2 Nesting Females

The nesting seasons by species are somewhat temporally and spatially predictable on U.S. beaches. Loggerhead turtles nest from April to September, with a peak in June and July and nest primarily on southeast U.S. beaches. Green turtles nest from June to August in the U.S. with a peak in July which coincides with loggerheads. Green turtles nest primarily outside the continental U.S. in the Caribbean. The peak nesting occurs in October. Leatherback turtles nest from April to July in the southeast U.S., but are much rarer in the southeast US than in the U.S. Virgin Islands or Puerto Rico. The U.S. Virgin Islands and Puerto Rico are the most important leatherback nesting areas under U.S. jurisdiction. Hawksbill and ridley turtles rarely nest on continental U.S. beaches. However, hawksbills do nest on beaches in the Virgin Islands from May through December with a peak in October.

Because of this seasonality in nesting and because tracks made on beaches by nesting females are identifiable to species level, track counts are used to estimate the number of nests in a given year which is used to estimate the number of females nesting in a given year. SAW/84/MMT/5, SAW/MMT/84/6 and SAW/MMT/4 describe nesting survey techniques and estimation methods for 1982 (SAW/84/MMT/5, SAW/84/MMT/6) and 1983 (SAW/84/MMT/4), respectively. The estimated number of Caretta nests in 1982 from North Carolina to Key Biscayne was 57, 767.

If there were 2 nests per females, the resulting estimate of females was 28,884 ± 13,144 SAW/84/MMT/4). In 1983, the estimate for nests was 58,016 and using 4 nests per female gave an estimate of 14,150 female Caretta nesting in 1983 (SAW/84/MMT/4). No variance estimate is presented for 1983. While the numbers of nests appear stable for 1982 and 1983, the estimate for females depends upon the number of nests per female; the value ranging between 2 and 4.7. The value of 2 nests per female was from the Draft, Recovery Plan for Marine Turtles (S.R. Hopkins and J.E. Richardom, editors). The value of 4.1 was derived using data collected from Little Cumberland Island, Georgia from 1966 to 1982. Using the Georgia data base it was shown that clutch frequency per female did not differ significantly between years (SAW/84/MMT/3). However, this value may differ between nesting aggregations and this requires investigation before a single value of nests per female is used in all estimates of female abundance resulting from track counts. Causes of bias in nesting beach surveys include 1) the misidentification of "false" crawls (or crawls that do not terminate in a nest) as nesting crawls 2) misidentification of old crawls (i.e. older than 24 hours) crawls as fresh crawls (less than 24 hours old) 3) properly defining the season temporally and 4) deriving a frequency distribution of nests per day throughout the season. To improve the accuracy of these counts, ground surveys were completed to attempt to reduce the above biases. However, because turtles are not counted, these surveys will probably be positively biased. Thus far, the greatest precision (coefficient of variation) reported for the numbers of females nesting in a season is about 23% (SAW/84/MMT/6).

A review of the status of the Kemp's ridley turtle (Lepidochelys kempi) is presented in the Proceedings of the WATS (1984) and is briefly summarized. The major nesting beach is located on Rancho Nuevo, Mexico and the season extends from April to August. In 1947, 40,000 turtles were observed nesting "en masse" (i.e., arribada). Exploitation of females and eggs continued through 1966 when 2,000 turtles nested. In 1972, following five years of protection it is estimated that 250 females nested. It is currently estimated that about 800 females nest per season, which has been stable since the mid 1970's.

Approximately fourteen known nesting localities of the leatherback turtle (Dermochelys coriacea) are found in the Caribbean basin. Of these, Costa Rica, French Guiana, Panama and Suriname are the major rookeries. Although the remaining countries support low to moderate numbers of nesting females, collectively the Caribbean basin is considered an important area for nesting (SAW/84/MMT/19). In light of results from recent beach aerial surveys conducted for the Western Atlantic Turtle Symposium, further studies in Honduras, Panama and Costa Rica are necessary to better measure the sizes the these rookeries. Efforts should be made to quantify nesting in the Caribbean where only relative abundance (i.e., low, moderate, high) is reported. Further research on within season nesting frequency, remigrant intervals and nest site fidelity is necessary before preliminary assessment using nest counts can be made.

Two large scale pelagic aerial surveys have provided data on seasonal distribution of the leatherback turtle in western Atlantic waters from the Florida Keys to Nova Scotia. Sightings of leatherbacks are recorded throughout the year with seasonal peaks occurring during the summer months. Leatherback sightings are also reported from aerial surveys and incidental catch data in the Gulf of Mexico (SAW/84/MMT/6). Results of aerial surveys indicate that the near shore shallower continental shelf waters are important areas of utilization by leatherbacks (SAW/84/MMT/19).

Because of its coloration, the habitats in which it is observed and the small size of most individuals in U.S. waters (i.e., "juvenile" as defined in SAW/82/MMT), populations of the green turtle, Chelonia mydas, are more difficult to enumerate from both nesting and pelagic aerial surveys.

A population of green turtles that probably numbered many thousands thrived in the Indian River Lagoon System, on Florida's east coast prior to 1900. Green turtles are still observed in the Indian River system but it is impossible to compare this with historical levels. No information is available to determine if this "stock" is increasing, decreasing or stable.

Mendonca and Ehrhart (1982) estimate 135 green turtles in a 60 km^2 area (2.25/km) of Mosquito Lagoon, the extreme northern reach of the Indian River system. That estimate was based primarily on numbers of animals handled and tagged during a cold-stunning espisode in 1977 (Ehrhart, 1983). Ehrhart and co-workers have recently begun to assess the status of the green turtle (and loggerhead) populations in the region of the Indian River from Melbourne to Sebastian, which historically presented the focal area for the past fishery. Results are preliminary and inferences about population density from catch per unit of effort (CPUE) have been completed. Green turtle density is estimated as 2.25/km^2 over a 60 km^2 of Mosquito Lagoon with a C.P.U.E. of .17 turtles/km-hr of netting. In the central region as a whole, C.P.U.E. has been estimated as 1.2 turtles/km-hr, but in the larger area near Sebastian, C.P.U.E. is estimated as 1.7 turtles/km-hr which is 10x the value for Mosquito Lagoon. This suggests that green turtle density is about 20 turtles/km^2 in the central region. This figure is presented as a baseline value and will be revised as opportunities for further work are presented.

Lepidochelys olivacea in the 1950s numbered in the "tens of millions of nesting females" concentrated mainly in 16 nesting locations in the Atlantic, Pacific, and Indian Oceans. In the Indian Ocean significant nesting now occurs only along the east coast of India (300,000 females/year) and Sri Lanka (several thousand females/year). In the Pacific Ocean, large numbers of L. olivacea still occur only in Mexico (79,900 adults) and in Costa Rica (481,000 to 656,000 females). Nesting of any consequence in the Atlantic Ocean occurs only in Suriname (400 nesting females estimated for 1982).

The hawksbill turtle (Eretmochelys imbricata) forages and nests in all the western Atlantic countries. However, there is only rare nesting on the continental United States and moderate nesting in Puerto Rico and the U.S. Virgin Islands. The species is exploited in all areas of occurence because of its valuable carapace and it is believed that most nesting populations are declining. However, the status of stocks are unknown because of its diffused nesting on small, scattered, inaccesible beaches and its rapid nesting behavior. However, because of the continued harvesting of the species any assessment must utilize current and historical catch data as available.

III.2.3 Juveniles and Adults - Pelagic Habitat

Loggerhead and leatherback turtles in the Atlantic are the primary target species for NMFS sponsored aerial pelagic surveys and are the most abundant and conspicuous species within our study area. Data from the first year of surveys completed from April 1982-March 1983 are used to estimate density of Caretta and define distributions for both Caretta and Dermochelys from Cape Hatteras, N.C. to Key West, Florida (SAW/84/MMT/7). For Caretta, the most precise estimates of abundance have resulted from aerial surveys and to date no other survey method available provides indices of abundance with higher precision (coefficient of variation $<10\%$). In addition, those factors which contribute to variability including Beaufort sea state, glare, "time of day" and observer differences are measured and correction factors are being derived from an experimental survey completed in July 1983. Seasonal estimates are provided in Table MMT-2. These estimates are minimal in the absence of a correction for surface vs. subsurface time.

An experiment to determine the minimum size animal observable from the air at 500 feet will be completed during the July/August (summer) 1984 survey. The total observed population can be apportioned by size.

Information on juvenile or developmental locations for green and Kemp's ridley turtles is lacking. The NMFS/SEFC is conducting a vessel survey in the Gulf of Mexico to identify juvenile habitats. It is anticipated that in estuaries and embayments both Kemp's ridley and green turtles will be tagged and released and developmental habitat will be identified (L. Ogren, personal communication).

III.3 Stock Assessment Analyses

III.3.1 Recruitment Indices

Age of sexual maturity may be estimated from animals in the wild as in SAW/84/MMT/12. To improve the precision of these estimates, sample sizes need to be increased. Recruitment for marine turtles usually only refers to females attaining sexual maturity and this is derived from mark recapture studies such as in SAW/84/MMT/2.

III.3.2. Density-Dependence

No information is available on the potential affects of reducing or altering nesting and foraging area on mortality, or reproductive output.

III.4 Current Status

Current population estimates have been presented; however, there are no valid historical estimates with which to compare current levels. In addition, recent discoveries of concentrated areas of leatherback nesting activity have revised estimates for nesting females upward from "tens of thousands" to "hundreds of thousands". It is assumed that for loggerhead turtles, the most precise indices of abundance available be used as a baseline to project levels backward in time. To date, best available estimates for loggerhead turtles are from pelagic surveys (SAW/84/MMT/7). These surveys have provided synoptic information on a portion of the population and provide supportive data for loggerhead abundance estimates (SAW/84/MMT/4, SAW/84/MMT/5, SAW/84/MMT/6).

The available historical and recent catch data for the hawksbill will be used to evaluate the status of E. imbricata. Rene Marquez of the Instituto de Pesca, Mexico is continuing with stock assessments for L. kempi and L. olivacea.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

Current management procedures follow total protection in U.S. and jurisdictional waters or the six species, all of which are listed as either threatened or endangered. Headstarting (the release of captive reared turtles) continues by the NMFS/SEFC for L. kempi based on the hypotheses that a) female turtles will imprint to the beach released on and b) growth to the release size reduces mortality. However, because of the protracted time to sexual maturity (maybe at leat 6 years in L. kempi) the results are not immediately observable. Thus far, no female headstarted turtle of any species has ever been reported nesting anywhere. The NMFS/SEFC program released L. kempi beginning in 1978. About 1500 turtles are released per year (i.e., in a cohort). If 10% survive to sexual maturity then about 150 from the first cohort would be expected to nest on Padre Island beginning in 1984, if imprinting occurs. Only a portion of the 150 survivors is anticipated because the estimated age of sexual maturity may be 6 years at the earliest. However, current reporting of tag returns for headstarted turtles suggest that turtles can survive. However, to evaluate headstarting properly, a period of waiting without the continued release is required, and should be based on expected returns.

The Turtle Excluder Device (TED) developed by the NMFS/SEFC has met its management objective of reducing turtle capture and mortality without adversely affecting shrimp catch. Estimates for turtle mortality may be obtained by the placement of observers on shrimp boats or through the use of permits allowing fishermen to report the incidental capture of turtles.

V. RECOMMENDATIONS
V.1 Data Needs
V.1.1 Stock Definition

1) Genetic evidence to support reproductive isolation of nesting aggregations.

2) Data on dispersal patterns.

3) Morphometric data base.

V.1.2 Catch Statistics - Fishing Mortality

1) Time series of incidental capture and mortality by species and fishery.

2) Historical and recent catch data from directed fisheries particularly for hawksbill.

V.1.3 Natural Mortality

1) Need age/stage specific estimates particularly for early life history stages.

V.1.4 Recruitment

1) Estimates for age of sexual maturity for all species.

2) Evaluation of recruitment as measured from mark-recapture studies.

V.1.5 Population Sizes

1) Site specific information particularly for green (C. mydas) and Kemp's ridley (L. kempi).

2) Evaluate juvenile to adult ratios such as 9:1 and examine for bias.

3) Improve survey techniques for nesting surveys to improve precision of estimates.

4) Sex ratios by stage/age class.

V.1.6 Density Dependence

1) Nesting beach availability and utilization by species for southeast U.S beaches.

2) Information on dispersal patterns of nesting females.

3) Energy budgets by species.

V.2 Research

The recommended research approach is as follows and in general data need to be collected within and between years or within and between beaches or by stage/age class to evaluate variability.

V.2.1 Stock Definition

1) Continue biochemical genetic work to develop techniques for stock identification.

2) Examine and compare remote sensing data.

3) Collect and analyze morphometric data.

V.2.2 Catch Statistics

1) Encourage use of observer programs on fishing vessels.

2) Use permit process to obtain data from shrimp fishermen as is being done in Georgia.

3) Collate, review and analyze existing catch data available from all potential sources. If one source can be identified, it is probably most cost/effective to obtain data from this one source.

V.2.3 Natural Mortality

1) Collect and analyze data on natural mortality of eggs and hatchlings. These efforts should be stratified such that the effort is proportional to nesting frequency or density.

V.2.4 Recruitment

1) Continue and encourage comparative growth studies on wild populations.

2) Continue research and development for alternative aging techniques.

3) Develop and use permanent tag such as tetracycline.

4) Compare and analyze existing mark-recapture data bases to quantify recruitment on beaches.

V.2.5 Population Sizes

1) Develop juvenile to adult ratio (e.g., 9:1) from available mark-recapture data, site specific survey data (e.g., NMFS/SEFC Cape Canaveral data), pelagic aerial surveys.

2) Improvement and evaluation of the cost effectiveness of aerial and nesting surveys to determine the investment into future efforts.

3) Improve estimates for surface vs. sub-surface time using state of the art radio tagging techniques or time-depth recorders.

4) Replication of pelagic aerial surveys in localized areas of high density within present NMFS/SEFC study area. It is expected that such surveys will be used to monitor the southeast U.S. population of loggerhead and leatherback turtles.

5) Continue refining aerial beach survey techniques and use to monitor nesting populations of loggerhead turtles in southeast U.S.

V.3 Management

Marine turtles are the shared responsibility of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service within U.S. and jurisdictional waters. As highly migratory species they require international cooperative to protect species so they are no longer threatened or endangered. Presently, without definitive stock assessment results, no further recommendations are offered to achieve these management goals.

MARINE MAMMALS

The conservation and management of cetaceans and pinnipeds other than walrus is the responsibility of the National Marine Fisheries Service (NMFS) as described in the Marine Mammal Protection Act (MMPA) of 1972. A listing of the cetaceans and pinnipeds known or thought to occur in southeastern US jurisdictional waters appears in Table MMT-3. Research on marine mammals at the Southeast Fisheries Center (SEFC) was initiated in FY79 and has been oriented to provide advice for management of the live capture fishery for the bottlenose dolphin, Tursiops truncatus, in the Southeast.

I. DESCRIPTION OF THE FISHERIES

As per SAW/82/MMT the stock(s) of Tursiops truncatus in southeastern US jurisdictional waters have supported several fisheries since at least the 1700's. Among these are the now defunct seine-net fisheries at Cape Hatteras and Cape Lookout and a small harpoon fishery in Tampa Bay. The estimated catch from Cape Hatteras and Cape Lookout between 1883 and 1914 was 20,892 Tursiops (SAW/82/MMT). The fishery remained active until 1929.

The present take of Tursiops in US waters comes from the live-capture fishery for public display and scientific research, incidental catch in other fisheries, and by the shooting of "nuisance" porpoise. The reported removals from the population of Tursiops in the southeast since inception of the MMPA are presented in Table MMT-4. As in SAW/82/MMT the magnitude of annual removals due to incidental catch and nuisance shooting is not documented.

Leatherwood and Reeves (1983) summarized the history of the live-capture fishery, dating as far back as 1914 and report this to be the longest sustained fishery of its type in the world. They have estimated that at least 1,500 animals have been removed from the waters of the US, Mexico and the Bahamas for the purposes of public display and scientific research. In the Southeast alone, they estimated at least 1,170 individuals have been removed by this fishery. In the US, bottlenose dolphins are also occasionally taken from waters near California and Hawaii under permit for research and/or display.

II. STOCK STRUCTURE

SEFC-sponsored mark and resighting studies conducted in the Indian River, FL demonstrated that individual dolphins either reside in or return to the river over a period of at least three years (SAW/84/MMT/10). Similar studies along the FL west coast suggest "residency"[1] of at least ten years by an individual dolphin in Sarasota Bay (Wells et al. 1981). These observations, along with those from the Texas coast (SAW/82/MMT) support the hypothesis of the existence of resident dolphin populations in certain estuarine embayments in the southeast region.

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1 "Resident" animals are defined to have significantly restricted gene flow from those animals which seasonally migrate into and out of geographically localized estuarine waters of the southeast. Likewise, resident stocks are defined to share a common gene pool that is distinct from those of transient, migratory stocks as well as from other that of resident stocks.

Density distribution patterns along the northeastern U.S. Atlantic coast support the hypothesis of separate inshore and offshore stocks in this region (SAW/82/MMT). This hypothesis is also suspected to be true for the southeast region.

Biochemical genetics studies of dolphins marked in the Indian River, FL found a high degree of genetic similarity among the dolphins sampled within the system (SAW/84/MMT/11). Distinct differences were found between three individuals sampled from outside the system (two from the Cape Canaveral Atlantic coastline and one from Key West) and those within the system (SAW/82/MMT, Rodriquez et al. 1984). These observations support the hypothesis that the dolphins sampled in the Indian River are from the same stock, but distinct from animals outside the system.

In Mississippi Sound SAW/84/MMT/13 found a higher degree of variability in the isozyme systems studied than in the Indian/Banana River. This result indicates a possible genetic dissimilarity between the Indian/Banana River animals and those sampled from the Mississippi Sound. The differences may however be attributed to methodological differences in the two studies. Differences in survivorship of dolphins captured from different geographical locations have also been observed (SAW/84/MMT/17). Other indices of potential stock-specific characteristics such as pesticide and heavy metal concentrations were also discussed in SAW/84/MMT/17, but sufficient base-line data are missing to allow comparisons. Some differences in microbiological profiles from animals in the Mississippi Sound (SAW/84/MMT/14) and Indian River animals (SAW/84/MMT/10) were also found. These other indices, however, do not necessarily imply restricted gene flow between the groups.

The working hypothesis for stock structuring of this species is that the population of bottlenose dolphins in the southeast is organized such that there are local, resident stocks of dolphins in certain embayments and that trasient stocks migrate into and out of these embayments on a seasonal basis (SAW/84/MMT/16).

Data reported in SAW/84/MMT/16 were analyzed for evidence of seasonality in localized dolphin abundance to further test the hypothesis of the existence of resident stocks and transient, migratory stocks of this species within the Southeast. In all the areas compared, dolphins were present year-round. Some evidence of seasonal influx of dolphins into certain of the embayments was also found.

III. STATUS OF THE STOCKS

At present there is no comprehensive estimate of the size of the stock(s) of Tursiops in southeastern US jurisdictional waters. The abundance of bottlenose dolphins in certain "priority" regions in the southeast has been estimated (SAW/MMT/84/16, SAW/MMT/84/17). An updated summary of these estimates is presented in Table MMT-5. Based on these estimates, those from CETAP (1983), and Fritts, et al. (1983), the number of bottlenose dolphins in the eastern US regional waters may range to at least 23,000 individuals (Table MMT-6). This estimate, however, assumes that the stocks have been stable over a period of 10 years and that no net migration between the sampling areas occurred during the respective sampling periods.

SAW/84/MMT/10 found that onset of sexual maturity in male dolphins ranges from ages 8-10 years based on testosterone levels in the blood from Indian River dolphins. In females from the Indian Banana River, serum estrogen and progestrogen levels showed no correlation with age. In the Mississippi Sound, males aged 5 to 9 years showed pre-puberal levels of testosterone (SAW/84/MMT/15). The onset of maturity in females from the Mississippi Sound was found to range from 5 to 6 years (SAW/84/MMT/15). Although sexually mature at these ages, entry into the reproductive population may occur somewhat later. The ages of onset of maturity reported by these two studies are within the ranges reported earlier (SAW/82/MMT).

As in SAW/82/MMT, age-specific vital rates are generally not available for this species. SAW/84/MMT/20 estimated an annual mortality rate of 6.9% for animals in Indian/Banana River based on stranding data. This estimate may be biased upward if the abundance estimate upon which the rate was based was too low. On the other hand, if not all stranded animals were found, the estimate may be low. SAW/84/MMT/20 cautioned the use of stranding data for estimating mortality rates unless there is sufficiently high effort in recording strandings and independent estimates of population size are available. Both SAW/84/MMT/10 and SAW/84/MMT/15 present age and growth and other morphometric data. These remain to be comparatively analyzed.

In the Indian/Banana River, the available data suggest that the average annual mortality is on the order of 7% and the annual gross reproductive rate at 8% (SAW/82/MMT). Annual removal of 2% results in a estimated net loss to the stock of 1%. Given accurate rate estimates, this may indicate that the maximum net production for this stock is about 1% or that the stock is near carrying capacity.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

As outlined in SAW/84/MMT/16, the Secretary of Commerce, pursuant to Section 101 (a) (1) of the MMPA, after review by the Marine Mammal Commission (MMC) and its Committe of Scientific Advisors on Marine Mammals, is empowered to grant permits for the taking and importation of marine mammals for the purposes of scientific research and public display. Under the MMPA the management objective is to maintain marine mammal stocks within the range of optimum sustainable population which is defined as the range of population levels from carrying capacity to that level which results in maximum net productivity.

Implementation of the MMPA restricted take of Tursiops (and other marine mammal species) for research and public display and in 1977 a quota system was developed for bottlenose dolphins in the Southeast.

The geographically-based management scheme provided for 7 Management Areas, defined by historical regions of capture. The primary management regions for this fishery include: 1) Florida East Coast (Indian/Banana Rivers), 2) Florida Keys, 3) Florida West Coast: Charlotte Harbor to Crystal River, 4) Florida Panhandle: Crystal River to Mobile Bay, 5) Mississippi Sound Region[2]: Mississippi, Chandeleur, and Breton Sounds plus a portion of the Gulf of Mexico, 6) Texas Coast: north of Corpus Christi Bay to Matagorda Bay, and 7) other areas (see Figure MMT-1).

The management scheme that was first recommended by the Marine Mammal Commission and adopted by the Secretary was based on a quota system which limits annual removal from the wild dolphin populations to not more than 2% of the minimum estimated number of Tursiops in any management area. The basic assumptions upon which this management recommendation was developed included firstly that estimates of maximum annual net recruitment for cetacean stocks ranged from 2 to 6%. The 2% figure was used as a conservative guideline for establishing quotas in the absence of an accepted estimate of maximum net productivity for a particular stock. Secondly it was assumed that each management area or

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2 The Mississippi Sound Region is defined to include the Mississippi Schaudeleur, and Breton Sounds plus a portion of the Gulf of Mexico as depicted in Figure MMT-1. The Mississippi Sound proper is a subarea of the Mississippi Sound Region as depicted in Figure MMT-1 and geographically defined in Table MMT-7.

subarea represented a unit stock of dolphins. Given a lack of hard data available to test these assumptions, it was viewed that this conservative management scheme was the best option (SAW/84/MMT/16).

The quota system in place has evolved from analysis of the best available scientific information. Initially, quotas were established for 7 animals from the Florida East Coast, 0 from the Florida Keys, 6 from the Florida West Coast, 10 from the Florida Panhandle, 35 from the Mississippi Sound Region, and 17 from the Texas Coast mangement region (see SAW/82/MMT). The initial quotas were based on estimates of the abundance of Tursiops in each of the regions. In 1979 the aerial sampling surveys of "priority" inshore locations for which improved management advice was required were started under contract to the SEFC. In June of 1982, the quota scheme was modified based on recommendations from the SEFC as a result of analyses of the available aerial survey data collected under contract. These changes were detailed in SAW/82/MMT.

Subsequent to revisions made in 1982, the management scheme was further reviewed by the MMC in February 1983. The MMC recommended that available data be analyzed for evidence of seasonal trends in abundance of dolphins in the areas surveyed to test the hypothesis of resident stocks Tursiops within the southeast. As detailed in SAW/84/MMT/16, the available data tend to support the hypothesis of resident stocks in certain embayments, and based on this, recommendations for changes to the current management scheme were made to reduce the risk of overexploitation of the possible resident stocks in the Southeast (see Table MMT-7).

The effect of the current management recommendations is expected to substantially reduce the risk to the stocks of dolphins under the present quota system in place. The degree of risk, however, remain unquantified. In addition, the present quotas on a southeast region-wide basis allow for substantially more animals to be taken than the average annual demand for this species based on average annual take (see Table MMT-3). The recommended quotas may, however, require some redirection of fishing effort from some traditionally favorite areas.

The validity of the defined stock boundaries in the region is questionable, especially in areas where geographical "barriers" are not apparent such as between the Mississippi Sound, Chandeleur Sound, Breton Sound, and the Gulf of Mexico. It is recognized however, that geographical "barriers" need not exist for gene flow to be limited between geographically localized groups of animals. Preliminary information presented to the working group was insufficient to further evaluate the Mississippi Region multiple stock question.

V. RECOMMENDATIONS

V.1. Data Needs

As stated in SAW/82/MMT, the data requirements for assessment of the stock(s) of Tursiops truncatus and other cetacean species in the southeast remain unchanged. Assessment of the risk to the stocks of past and future exploitation requires knowledge of the population life- and death-rate processes as well as the abundance of the stocks involved. An appropriate technique for assessing these risks, given sufficient age- or life stage-structured data is the Leslie Matrix approach (see SAW/84/MMT/16). In lieu of sufficient age- or life stage-structure data, trend analysis, requiring a time series index of abundance is required. Given the degree of precision attainable with most marine mammals abundance estimation procedures and the relatively low recruitment rates exhibited by marine mammal species in general, monitoring abundance with assessments at intervals of 5 or more years is appropriate.

Data are still lacking on most other marine mammal species in the region. However, sighting data are being collected by current sampling surveys.

V.2. Research

In response to recommendations for research made in SAW/82/MMT, the SEFC has initiated several research projects to address the stated data needs and programmatic goals (SAW/84/MMT/16). Research on Tursiops truncatus, the primary species of focus, has three main themes including abundance estimation, stock differentiation, and life stage modeling (SAW/84/MMT/16).

Research to address stock structuring of Tursiops includes developing biochemical genetics baseline data (SAW/84/MMT/11, SAW/84/MMT/13) from animals captured during tagging studies (SAW/84/MMT/10, SAW/84/MMT/12) and a comparative evaluation of genetic variability within and between animals captured or captured and held in captivity from several distinct, geographically localized areas in the southeast (SAW/84/MMT/16). This research is expected to be completed by late 1984.

As per SAW/82/MMT, photogrammetric sampling was started in September 1983 to provide data allowing for a comparative study of the size-frequency distributions of along-shore and inshore-offshore groups of dolphins as well as providing a large length structured data base for population projection models. Samples were obtained during a survey off Cape Hatteras and are being obtained during regional aerial sampling surveys in the Gulf of Mexico. Results from the Cape Hatteras samples are expected in late 1984.

SAW/84/MMT/15 reported on the hormone analysis of samples obtained from animals in the Mississippi Sound Region and SAW/84/MMT/10 reported on research from the Indian River animals. Morphological comparisons are presently being made using data from the Indian River and Mississippi Sound tagging studies. Results of this analysis are expected by late 1984.

In response to recommendations by SAW/82/MMT for research on the status of stock(s) of bottlenose dolphins and other cetaceans in the southeast, regional aerial sampling surveys for estimating the abundance of Tursiops and other cetaceans were initiated in September 1983. Sampling is planned and/or underway throughout the southeastern US jurisdictional waters from the coast line to waters depths of 100 fathoms. Because of the large expanse (3.63×10^5 km^2) of this area and the associated expense of taking seasonally spaced samples of the entire Gulf of Mexico, four fiscal years are required to complete the sampling plan (SAW/84/MMT/16). Sampling in the Gulf of Mexico is expected to be complete in 1986. In addition to the Gulf of Mexico, data sufficient for abundance estimation of Tursiops and other cetacens in the South Atlantic region (SAW/84/MMT/16) have been collected during turtle pelagic aerial surveys (see SAW/84/MMT/7) and are planned for analysis in 1985.

The ongoing research at the SEFC is addressing the specified data requirements and research needs identified in SAW/82/MMT. Given that adequate guidelines are available for management recommendations and since ongoing research is directed at evaluating these guidelines, the highest priorities should be placed on abundance estimation in regions where estimates are lacking, developing methods for monitoring incidental removals due to fishery interactions or other activities (such as habitat alteration, shooting, trophic interactions, etc.), and intercalibration and standardization of research methods.

Other recommendations, although with lower priority in the context of stock assessment were also made and are listed below:

1. Examine the available tagging/resighting data bases for the purposes of estimation using mark and recapture techniques, estimating stock vital rates, and comparing size frequencies and growth rates between the Indian/Banana River and the Mississippi Sound Proper.

2. Focus genetic research on the Mississippi Sound Region to examine the question of resident stock boundaries for this region. Establish a cooperative research program with MMC paralleling present isoelectric focusing studies and future mt-DNA studies.

3. Expansion of effort in the Mississippi Sound resighting surveys outside of present boundaries to examine the question of transmigration between the Mississippi Sound Proper and nearby waters.

4. Standardize stranding network reporting effort and maximize return from stranded animals.

V.3. Management

The management recommendations outlined in this document have been based upon the best available scientific information. For this reason, implementation of this quota scheme is recommended. In the context of the MMPA, it is futher recommended that all take, including removals due to incidental catch and shooting, be considered part of the annual allowable quotas for each management area.

The working group also recommended a management action requiring that tissue samples (including blood, blubber, liver and teeth) and morphometric data be made available to the research community from all live-capture animals obtained under permit. This action would increase the available data base for stock assessment.

Table MMT.1. Fishing mortality rates of sea turtles.[1]

Fishery	% Dead	CPUE
Sturgeon Gill-Net		Turtles/100 yds net set
S. Carolina		
1978	46%	0.3
1979	49%	0.5
Japanese Tuna Longline Fleet[2]		Turtles/10,000 hooks
1978-1981		
Gulf	6.7%	0.18
Atlantic	29.6%	0.07
U.S. Shrimp Fleet[2]		Turtles/fishing day
1979-1981		
Gulf	40%	.07
Atlantic	22.5%	2.06

[1]Data are preliminary

[2]Total estimated by-catch estimated from observer data (Pascagoula Lab).

Table MMT-2. Survey results by block for each survey season, and pooled over blocks for each season (AN Blocks). The values for each block are in order: sample size (n); density in numbers per square nautical miles; var (D); N; and the standard error of (N) computed as var (N).

	BLOCK												
SURVEY	1	2	3	4	5	6	7	8	9	10	11	12	All Blocks
Spring	70	18	116	15	36	29	83	413	80	49			909
	0.480	0.132	0.727	0.103	0.203	0.180	0.671	2.700	0.678	0.337			0.619
	0.00004	0.00003	0.0009	0.00002	0.00007	0.00005	0.0007	0.0118	0.008	0.0002			0.0006
	1517	404	2141	314	589	586	2221	7846	2076	1020			18996
	42	128	122	132	119	128	131	117	128	127			1187
Summer	22	7	6	15	15	32	42	470	284	26	2	45	919
	0.130	0.470	0.042	0.078	0.085	0.182	0.226	2.700	1.800	0.159	0.023	0.405	0.487
	0.00004	0.0012	0.00005	0.000016	0.000019	0.00009	0.00013	0.0192	0.0085	0.00007	0.000001	0.0004	0.0006
	411	1438	124	238	247	593	748	7846	5512	481			14932
	154	226	157	175	48	54	167	149	157	159			477
Fall	69	34	19	21	2	8	13	20	23	18			227
	0.625	0.321	0.512	0.165	0.022	0.073	0.120	0.175	0.202	0.143			0.201
	0.0070	0.0012	0.0003	0.0003	0.000005	0.00006	0.0002	0.0004	0.0005	0.0002			0.0005
	198	982	448	502	64	238	397	509	619	433			6164
	264	330	336	320	295	350	390	332	335	299			671
Winter	NE	NE	14	27	22	30	43	5	6	2			149
			0.134	0.246	0.181	0.315	0.335	0.056	0.054	0.020			0.159
			0.0002	0.0008	0.0004	0.0013	0.0014	0.0004	0.00004	0.000005			0.0003
			394	749	525	1026	1109	163	165	605			4877
			334	352	325	349	324	116	388	338			3268
Spring thru Winter	161	59	15	78	75	99	181	908	393	95			2204
	0.360	0.143	0.195	0.124	0.123	0.168	0.303	1.194	0.707	0.161			0.376
	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0004	0.0015	0.0009	0.0002			0.0005
	1138	438	574	378	357	547	1103	3470	2165	487			11533
	176	303	214	347	334	274	219	94	128	266			564

Table [a]MMT-3. A list of cetaceans and pinnipeds other than walrus shown or thought to be found in southeastern U.S. jurisdictional waters.

Species	[b]Endangered Status
o. Cetacea	
f. Balaenidae	
Balaena glacialis, right whale	Y
f. Balaenopteridae	
Balaenoptera musculus, blue whale	Y
Balaenoptera physalus, fin whale	Y
Balaenoptera borealis, sei whale	Y
Balaenoptera edeni, Bryde's whale	N
Balaenoptera acutorostrata, minke whale	N
Megaptera novaeangliae, humpback whale	Y
f. Physeteridae	
Physeter catodon, sperm whale	Y
Kogia breviceps, pygmy sperm whale	N
Kogia simus, dwarf sperm whale	N
f. Ziphiidae	
Ziphius cavirostris, goosebeaked whale	N
Mesoplodon mirus, True's beaked whale	N
Mesoplodon europaeus, Antillian beaked whale	N
Mesoplodon densirostris, dense-beaked whale	N
f. Delphinidae	
Delphinus delphis, common dolphin	N
Feresa attenuata, pygmy killer whale	N
Globicephala macrorhynchus, short-finned pilot whale	N
Globicephala melaena, long-finned pilot whale	N
Grampus griseus, Risso's dolphin	N
Lagenodelphis hoseii, Frazer's dolphin	N
Orcinus orca, killer whale	N
Peponocephala electra, melon-headed whale	N
Phocoena phocoena, harbor porpoise	N
Pseudorca crassidens, false killer whale	N
Stenella clymene, short-snouted spinner dolphin	N
Stenella coeruleoalba, striped dolphin	N
Stenella frontalis, bridled dolphin	N
Stenella longirostri, long-snouted spinner dolphin	N
Stenella plagiodon, spotted dolphin	N
Steno bredanensis, rough-toothed porpoise	N
Tursiops truncatus, Atlantic bottlenosed dolphin	N
o. Pinnipedia	
f. Otariidae	
Zalophus californianus, California sea lion	N
f. Phocidae	
Phoca vitulina, harbor seal	N
Cystophora cristata, hooded seal	N
Monachus tropicalis, Caribbean monk seal	E

[a] Sources include Schmidley 1981, Winn *et al.*, 1979, and Leatherwood *et al*, 1976.
[b] Endangered species status abbreviations: Y, yes; N, no; E, considered extinct.

Table MMT-4

Summary of Permanent Removal from the Wild [1, 2]

Tursiops truncatus
(1973-1983)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	Total
Florida Indian-Banana River Complex	-	-	10	6	15	5	7	9	7	3	2	64
Florida Keys	15	-	-	-	-	-	-	-	-	-	-	15
Florida West Coast: Charlotte Harbor to Crystal River	-	-	16	5	16	5	-	8	5	7	11	73
(Tampa Bay)			(-)	(1)	(2)	(-)		(-)	(-)	(-)	(-)	(3)
(Charlotte Harbor)			(8)	(-)	(5)	(-)		(3)	(4)	(5)	(4)	(29)
(North of Charlotte Harbor to Crystal River, not including Tampa Bay)			(8)	(4)	(5)	(5)		(5)	(1)	(2)	(2)	(32)
Florida Panhandle: Crystal River to Mobile Bay Alabama	-	5	-	7	3	4	-	4	2	-	-	25
(Apalachicola-St. Joseph Bay)		(5)		(7)	(-)	(-)		(2)	(-)	(-)	(-)	(14)
(Destin-Fort Walton Beach)		(-)		(-)	(-)	(2)		(1)	(1)	(-)	(-)	(4)
Mississippi Sound	-	15	7	2	8	24	14	11	-	9	12	102
Texas Coast: North of Corpus Christi Bay up to and including Compano Bay Matagorda	6	-	5	-	2	15	13	12	8	8	-	69

Table MMT-4 (con't)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	Total
(Aransas-Corpona-San Bay Complex)	(5)	(-)	(5)	(-)	(-)	(2)	(6)	(-)	(2)	(-)	(-)	(20)
(Matogroda Bay)	(1)	(-)	(-)	(-)	(-)	(-)	(1)	(6)	(4)	(8)	(-)	(20)
Texas, Corpus Christi	-	-	-	-	-	2	-	-	-	-	-	2
TOTAL	21	20	38	20	44	55	34	44	22	27	25	350

1 Includes only removals under permit for research and public display for 1971 to present. Also includes animals accidentlly killed during research, which did not authorize permanent removal. Numbers in parentheses represent take from subareas within the defined management areas and sum to the total shown for each management area.

2 Information provided by NMFS, Protected Species Division, Washington D.C.

Table MMT-5
Nature and Results of Local Surveys for *Tursiops truncatus*

Area Surveyed	Data	Density (dolphins/km^2)	Abundance (95% CI)	References (citations presented in SAW/84/MMT/16)
1. Florida East Coast Indian/Banana River	NOV '79	0.274	222 (± 34)	Leatherwood and Show 1980; Leatherwood 1982
	JAN '80	0.264	214 (± 42)	
	MAY '80	0.255	206 (± 170)	Thompson 1981a, b
	AUGUST '80	0.539	435 (± 172)	
	NOV '80	0.251	202 (± 106)	
2. Florida Keys		NOT YET AVAILABLE		
3. Florida West Coast: Charlotte Harbor to Crystal River				
Tampa Area	SEP '79	0.120	364 (± 326)	Leatherwood and Show 1980
	NOV '79	0.210	634 (± 180)	Thompson 1981c
Port Charlotte Harbor	JUL '80	0.204	189 (± 186)	Thompson 1981d
	OCT '80	0.170	157 (± 454)	
	JAN '81	0.469	434 (± 275)	
	APR '81	0.206	191 (± 140)	
Charlotte Harbor to Crystal River	JUL '75 - JUN '76	0.070	569 (-)	Odell and Reynolds 1980

Table MMT-5 (con't)

4. Florida Panhandle Crystal River to Mobile Bay				
Apalachicola Bay/St. Joseph Sound	JUN '80	0.093	58 (± 242)	Thompson 1982a
	SEP '80	0.056	35 (± 120)	
	DEC '80	0.091	57 (± 34)	
	MAR '81	0.067	42 (± 96)	
Crystal River to Pensacola	JUL '75 - JUN '76	0.085	936 (-)	Odell and Reynolds 1980
5. Mississippi Sound				
Mississippi Sound	JUN '80	0.103	111 (± 104)	Thompson 1982a
	SEP '80	0.130	140 (± 172)	
	DEC '80	0.087	93 (± 44)	
	MAR '81	0.105	113 (± 72)	
Mississippi, Chandeleur, Breton Sounds plus portion of the Gulf.	JUL '74	0.148(sounds) 0.127(marsh)	1,342 (847,SD)[1] 438 (294,SD)	Leatherwood and Platter 1975
	JUL '75	0.097(sounds)	879 (368,SD)	Leatherwood et al. 1978

Table MMT-5 (con't)

6. Texas Coast:				
North of Corpus Christi Bay including Matagorda Bay				
Aransas/Copano/San Antonio	MAY '80	0.134	131 (± 32)	Thompson 1982a
	AUG '80	0.303	296 (± 58)	
	NOV '80	0.274	268 (± 56)	
	JAN '81	0.364	356 (± 154)	
Matagorda/Aransas/Copano/ San Antonio	APR '78	0.752	1319 (± 260)	Barham et al. 1979
Corpus Christi	SEP '79	1.134	115 ($81 < u < 421$)	Thompson 1982b
		1.016	103 (± 36)	Leatherwood and Show 1980 Leatherwood and Reeve 1983
Coastal Southern Texas	SEP '79	0.314	300 (± 74)	Leatherwood and Reeve 1983
Laguna Madre and portion of Gulf of Mexico	SEP '79	0.421	100 (± 11)	Leatherwood and Show 1980.
7. Other Areas				
Atchafalaya Bay, LA	JUL '75	0.099	897 (461,SD)	Leatherwood et al. 1978
Virgin Islands	AUG '81	0.45 (St. Croix) 0.05 (St. Thomas)	49 (± 88)	Scott 1982

[1] SD = Standard Deviation

Table MMT-6. Estimated abundance of <u>T. Tursiops</u> in certain "priority" areas of US jurisdictional waters.

Area	Estimated Abundance	Source (other than reported in SAW/84/MMT/16)
<u>U.S. Atlantic</u>		
1. Continental Shelf N of Cape Hatteras	8,603 (± 4307, 95% CI)	CETAP 1983
2. Indian/Banana Rivers, FL	[a] 211	
3. Merrit Island, FL, offshore to 100 m	665	Fritts et al., 1983
<u>U.S. Gulf of Mexico</u>		
1. Charlotte Harbor, FL	[a] 179	
2. Charlotte Harbor to Crystal River, FL	505	
3. Naples, FL, Offshore to 200 m	2,021	Fritts et al., 1983
4. Sarasota Bay, FL	105	
5. Appalachicola/St. Joseph Bays, FL	[a] 48	
6. Mississippi, Chandeleur, Breton	1,342	
6a. Mississippi Sound	[a] 114	
7. Marsh Island, LA, Offshore to 1000 m	2,292	

Table MMT-6. (con't)

Area	Estimated Abundance	Source (other than reported in SAW/84/MMT/16)
7a. Atchafalaya Bay, LA	897	
8. Aransas/Copano/San Antonio	[a] 131	
9. Matagorda Bay, TX	318	
10. Corpus Christi Bay, TX	109	
11. Lagaun Madre, TX	[a] 100	
12. Brownsville, TX, Offshore to 1000 m	2,292	Fritts et al., 1983

[a] Independent estimate of abundance in the subarea within the larger area.

Table MMT-7. Recommended changes to the current management scheme for the live-capture fishing for *Tursiops truncatus* in the Southeast based upon available data.[1]

MANAGEMENT AREA	PREVIOUS ANNUAL ALLOWABLE TAKE[2]	RECOMMENDED CHANGE
0. All Areas		Limit catch of females to not more than 50% of the annual total allowable catch within any management area or subarea.
1. Florida East Coast	6	Reduce allowable annual take to four animals in the Indian/Banana River.
2. Florida Keys	0	No change recommended.
3. Florida West Coast	23	(a) Define Florida west coast to include the waters between the southern end of Pine Island Sound (26°27'N latitude) and Crystal River, Florida.
Subareas		
i) Tampa Bay	(10)	
ii) Charlotte Harbor	(5)	
iii) North of Charlotte Harbor exclusive of Tampa Bay	(8)	(b) Establish an allowable annual quota of ten animals from Pine Island Sound to Crystal River, exclusive of Charlotte Harbor, Tampa Bay and Sarasota Bay.
		(c) Establish an allowable annual quota of two animals in the Sarasota Bay sub-area and lower the allowable quota in the Charlotte Harbor sub-area to three animals.
		(d) Remove Tampa Bay as an allowable sub-area for capture.
4. Florida Panhandle	10	(a) Increase the annual allowable catch from ten to eighteen animals.
Subareas		
i) Apalachicola/ St. Joseph's Bay	(1)	
ii) Destin/Ft. Walton Beach	(2)	(b) Retain the current limitations of two animals from the Destin/Ft. Walton Beach sub-area and one animal from the Apalachicola/St. Joseph Bays sub-area.
5. Mississippi Sound	35	(a) Define the Mississippi Sound Management Area to include the waters of Mississippi, Chandeleur, and Breton Sounds and that portion of the Gulf of Mexico

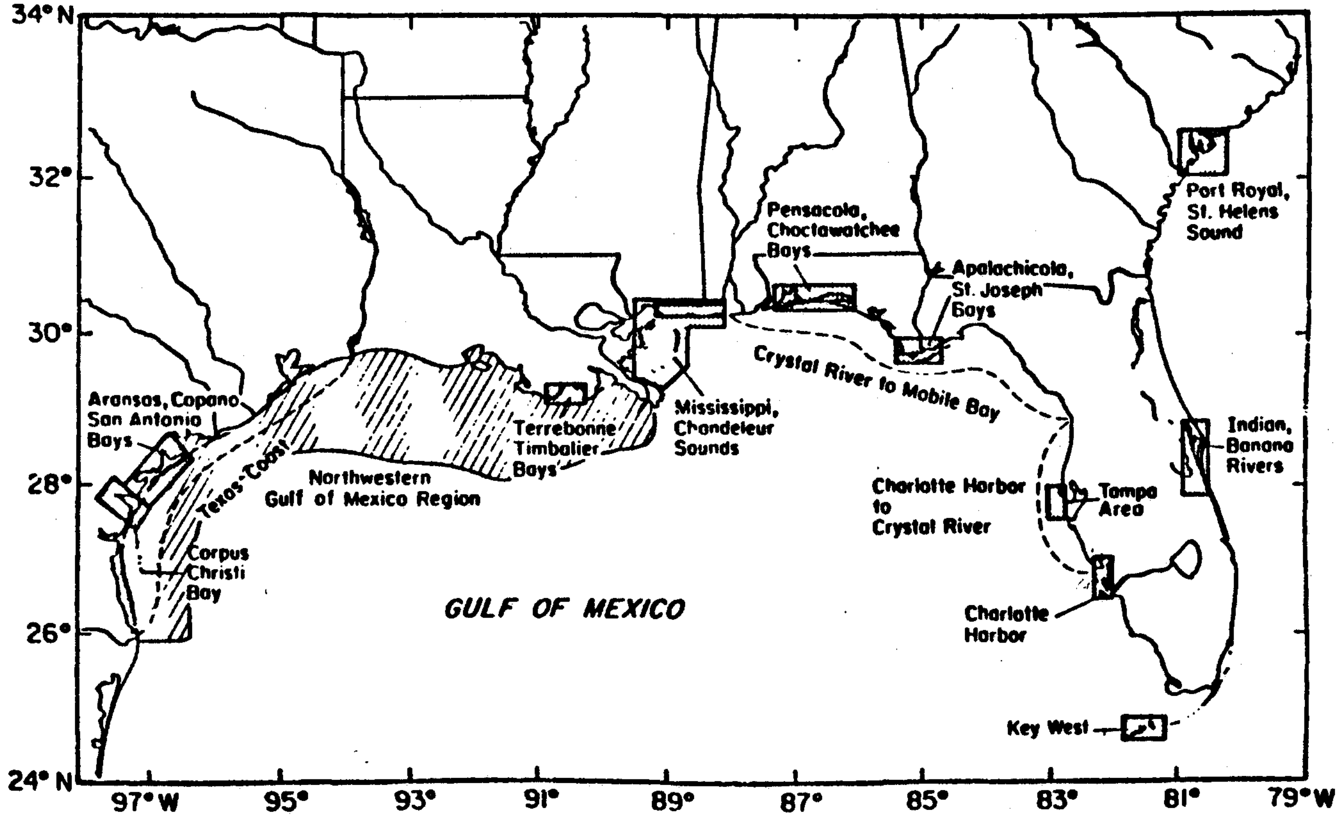
Table MMT-7. (con't)

		lying between the coast and 88°W longitude and 29°07'N latitude and maintain the current capture quota of 35 for the Management Area.
		(b) Define the Mississippi Sound sub-area as the waters lying between the coast and the island chain ranging from Cat Island to Petit Bois Island and between 88°30'W longitude and 89°10'W longitude.
		(c) Establish an annual allowable quota of two animals from the Mississippi Sound sub-area.
6. Texas Coast	17	(a) Reduce the allowable take in the Aransas/Copano/San Antonio Bays sub-area to two animals.
Subareas		
i) Aransas/Copano/ San Antonio Bays	(5)	
ii) Matagorda Bay	(12)	(b) Establish an allowable annual take of two animals in the Corpus Christi Bay sub-area.
		(c) Reduce the annual allowable catch in the Matagorda Bay sub-area to six animals.
		(d) Establish an allowable annual catch of two animals in the Laguna Madre and nearshore Gulf of Mexico waters from Laguna
7. Other Areas	0	Establish an annual allowable catch of 17 animals in the area off the mouth of the Atchafalaya Bay, Louisiana. Define the management area as the water lying between Marsh Island and Pt. Au Fer Island to 10 n.mi. offshore.

1 The recommendations submitted to the NMFS Protected Species Branch by the SEFC, as outlined above, have been reviewed by the Marine Mammal Commission and are being considered for incorporation.

2 Numbers in parenthesis represent quota limits established for Management Area subareas and sum to the total quota for any Management Area.

Figure MMT-1. Southeast regional waters where research on Tursiops stocks has taken place. Dark strippling represents localized survey efforts. Light shading indicates regional sampling study area. Management regions are indicated.



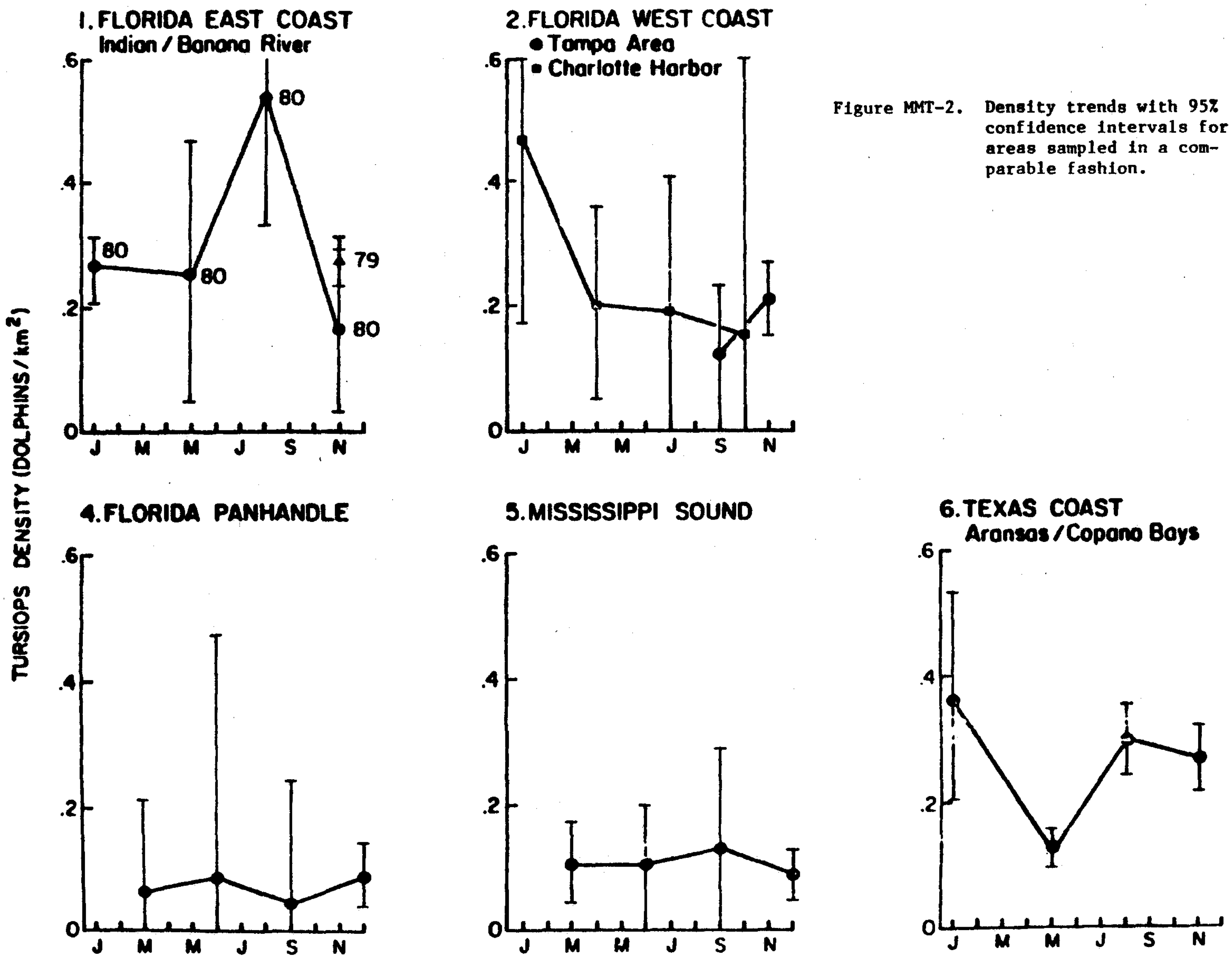


Figure MMT-2. Density trends with 95% confidence intervals for areas sampled in a comparable fashion.

MENHADEN AND COASTAL HERRINGS

ATLANTIC MENHADEN

I. DESCRIPTION OF FISHERIES

I.1. Catch Trends

Landings of Atlantic menhaden caught by purse seine between 1940-1983 range from 161 to 712 KMT. Over the last decade landings were between 250-419 KMT (Table MCH-1). Over 90% of the landings in 1979-83 occurred in New Jersey, Virginia, and North Carolina ($\bar{X}$ = 350 KMT). Distinct seasonality trends are evident in the landings, with peak activity in July-August (Fig. MCH-1). Details of the historic landings and distribution of fleet activity are provided in the Atlantic menhaden management plan (SAW/82/MCH/6). The Chesapeake Bay fishery dominates the industry today (Table MCH-2).

Landings by other gear principally enter the market as crab or lobster bait and pet food. They are minor in comparison with the purse-seine landings (about 5% of total).

I.2. Effort Trends

Number, type, location and intensity of vessel effort in the 1955-83 period have varied considerably (Table MCH-1 and SAW/82/MCH/6). Distinct changes have occurred in various geographic reporting areas: The North Atlantic area has varied from 40 vessels in 1956 to zero in 1967 and stood at 5 in 1980-81; the Middle Atlantic area declined from 48 in 1955 to 1 vessel in 1970, 4-6 vessels for 1976-1981, and zero vessels since 1982; vessel number in Chesapeake Bay area has been more stable (18 or more each year) and included between 21-24 vessels since 1976; the South Atlantic area has decreased from 34 vessels in 1955 to between 10 and 12 active vessels since 1970; the North Carolina fall fishery declined from 64 vessels in 1957 to 4 in 1973 and in the last four seasons has averaged about 18 vessels.

Present day vessels differ significantly from those of the 1950's. The modernized vessel is steel hulled with refrigerated holds; additional improvements include use of spotter planes, power blocks and synthetic webbing. The modern vessel typically carries a crew of sixteen. Changes in the vessel characteristics and fishing technique, particularly the use of spotter planes, have made it difficult to develop and estimate an effective unit of fishing effort for application throughout the fishery. Nominal effort (Table MCH-1) is the apparent or deployed amount of effort, herein defined as a vessel-week of activity. Over the last nine years effort has averaged about 1140 vessel-weeks per season. Chesapeake Bay area has contributed between 552-667 vessel-weeks of effort since 1972.

II. STOCK STRUCTURE

Based upon tagging and age composition data from commercial landings, the population of Atlantic menhaden from Florida to Nova Scotia is considered as a unit stock (Nicholson 1972, 1978a; and Dryfoos et al. 1973). There is some evidence for alternate hypotheses of stock structure from meristics and electrophoretic studies (SAW/84/MCH/1). The population exhibits a complex migratory pattern by size and age with larger and older individuals occurring in northern waters. A north-south migration by all age groups takes place in spring and fall. The working group accepts the hypothesis of a unit stock for Atlantic menhaden.

III. STATUS OF STOCKS
III.1. Population Parameters
III.1.1. Natural Mortality Rates

Estimated value of M from an iterated least squares regression of Z on effective effort was 0.37 (Schaaf and Huntsman 1972). Dryfoos, et al. (1973) obtained an estimate of 0.52 from analysis of tagging data. Deriso et al. (1980), with cohort analysis and weighted least squares nonlinear regression analyses of mark-recovery data, estimated a range for age specific M's from .15 to .54 and later adopted .5 $\pm$ .09 (1 standard deviation) (Ruppert et al. 1981). Present analyses by National Marine Fisheries Service employ .45 for age one and older fish (SAW/84/MCH/1). Preliminary sensitivity assessments by Ruppert et al. (1981) suggested that natural mortality rate was not critical to performance of their simulation model (MENSIM) relative to decision making for management policy. It is, however, a sensitive parameter when estimating catch.

III.1.2. Growth Estimates

Data on growth rates were presented in SAW/82/MCH/6 and SAW/84/MCH/5. Season and density-dependent effects on growth in the first year of life have led to development and use of area specific length-weight relationships and von Bertalanffy growth curves (see SAW/84/MCH/5). Their analyses suggest a strong density-dependent growth relationship in recent years, but this is not nearly so evident for previous years when the population was declining. More recent analyses suggest that mean weight at age, since at least 1973, is lower than would be expected by density-dependent factors alone. Possible causes of this observation are discussed in SAW/84/MCH/1.

III.2. Catch Per Unit Effort Trends (CPUE)

Landings per vessel-week (Table MCH-1) ranged from 147 MT in 1967 to 421 MT in 1983. CPUE has exceeded 310 MT/vessel-week since 1979 and has generally been increasing since the mid-1970's. Due to the changes in vessel characteristics and fishing technique, CPUE data are not considered representative of trends in abundance for the time series as a whole.

III.3. Stock Assessment Analyses

III.3.1. Production Model Analyses

Estimates of MSY in SAW/82/MCH/6, Schaaf (1975), Schaaf and Huntsman (1972) and SAW/82/MCH/1 range from 370 to 560 KMT (the lower figure is based upon recent values for age at entry and effort). The most recent estimates of MSY from SAW/84/MCH/1 are 414 and 557 KMT.

Factors such as variable growth rate and recruitment level, change in age structure, and change in vessel efficiency affect the estimates; thus estimates of MSY are considered of limited value for fishery management and should be integrated into plans with caution (SAW/82/MCH/6). Based upon MENSIM, a population simulation model (Ruppert et al. 1981 and SAW/82/MCH/8) sustainable yields of 475-525 KMT are considered possible; but higher values could only be sustainable if the age structure could be modified, i.e., through an increase in the average age at capture.

III.3.2. Yield Per Recruit (Y/R)

Overall Y/R under current conditions (1976-78 seasons) was 55 grams (SAW/84/MCH/1). Y/R has been decreasing since 1971; the proportional contribution of younger age groups to the landings has been increasing and the average size at age is decreasing. Both reduced growth and redirection of effort towards younger fish are contributing to the reduced levels in yield per recruit.

Given the hypothetical case of no fishing, maximum biomass would occur at approximately age 3.25 (Fig. MCH-3). Increases in Y/R from present levels are expected with reduced fishing mortality and/or increased age at entry (Table MCH-3). Changes in the age at entry would change the current allocation of Y/R as well as the catch in the five fishing areas as would reduced effective effort (Table MCH-4). Losses in landings would occur in the North Carolina Fall fishery.

III.3.3. Virtual Population Analysis

VPA analysis has been applied to Atlantic menhaden data collected since 1955. It includes quarterly estimates of fishing mortality and population size to accurately reflect the seasonal nature and sequence of the purse-seine fishery. The rate of exploitation is high for Atlantic menhaden, ranging from 26 to 80% and averaging over 60% for ages two and older in recent years. A variety of techniques have been employed to develop starting F values for the analyses. These include several iterative techniques to approximate slopes of catch curves. Pope's (1972) approximation method (cohort analysis) has been applied by Deriso et al. (1980) using M of .52. Very similar results have been obtained regardless of the method employed to select the starting F due to the high mortality experienced by all age groups (see Deriso et al. 1980 and SAW/84/MCH/1 for area and age specific values).

III.3.4. Stock Recruitment Analyses

Recruitment since 1970 has varied by a factor of five. Summaries of recruitment data are contained in Deriso et al. (1980), Nelson et al. (1977), and SAW/84/MCH/1. Environmental influences on recruitment are [very] great and may mask any existing spawner-recruit relationship. Present data do not suggest a strong spawner-recruit relationship during the period 1955-78 (SAW/84/MCH/1, Table MCH-5, Fig. MCH-4). Based upon historic behavior of other similar fishery resources, the data suggest a low spawning stock size in recent years. Data reflect typical clupeid variability (r strategist). Based upon cohort analysis and recent landings data, above average recruitment has been shown for 1975, 1979, and 1981 year classes.

III.4. Current Status

Recent descriptions are given in SAW/82/MCH/6. Stock abundance has apparently increased due to moderate to high levels of recruitment, especially the 1979 and 1981 year classes. The age composition is strongly truncated and the present fishery is heavily dependent upon age one and two fish (pre-spawners); thus, yield/recruit is now lower than it was during the 1974-76 period. Higher levels of yield per recruit are attainable with reduced fishing effort and increased age at entry.

National Marine Fisheries Service's forecast for the 1984 season is 402 KMT (975 vessel-week effort). This forecast is below most estimates of MSY for this fishery. The 1984 landings will contain a similar age composition in each area compared to recent years.

IV. EFFECT OF CURRENT MANAGEMENT PRACTICES

The independent coastal states from Maine to Florida have jurisdiction over the resource and fishery (see SAW/82/MCH/6, Section 3). Since the catch is made mostly in internal waters and the territorial sea, MFCMA provisions do not apply. The amount of regulation or control exercised varies from state to state. No state limits the amount of effort (vessels) or catch. Some states have closed seasons (Virginia, New Jersey, and New York) and two states (Maryland and Delaware) do not permit any fishing by purse seine. Mesh size is controlled only in Virginia and South Carolina, but most states do not restrict length or depth of the net. Most states have designated areas where purse-seine fishing is not permitted and, in general, waters near more highly populated urban areas are restricted.

No analysis of effects of management practices was performed by the working group. Area specific availability of the resource, company policy and economics have had an over-riding influence on the fishery. Stock assessments by NMFS provide the biological measures of resource response to the present harvesting practices throughout the range of the fishery. The management plan, approved by ASMFC, specifies that NMFS conduct stock assessment studies and that the Atlantic Menhaden Advisory Committee evaluate the effects of any management measures adopted and offer recommendations for management actions.

V. RECOMMENDATIONS

V.1. Data Needs

SAW/82/MCH/6 detailed general data requirements in support of the management program (see Section 10). Essential elements include age structure of the catch, size at age, and tagging programs; the purse-seine industry also provides daily catch records, plant production data and Captain's Daily Fishing Reports which comprise the landings and effort data bases needed for assessment purposes. The Captain's Daily Fishing Reports and spotter aircraft activity records are believed to be of potential value in the development of a measure of effective effort which would be adequate for management purposes (SAW/82/MCH/4).

V.2. Research

SAW/82/MCH/6 included an array of potential research topics. Essential components specified were development of a basis for measuring effective effort and development of a predictive capability for landings based upon fishery-independent estimates of abundance of young menhaden. The Atlantic Menhaden Management Board (AMMB) of ASMFC has also requested mesh selectivity studies to provide a basis for possible future mesh regulation. These studies are now in progress in Chesapeake Bay by East Carolina University, N.C. Further applications of the tagging data base should be made for refinement of stock assessment parameters. Additional research effort should be placed on identifying the causes of small sizes at age noted in SAW/84/MCH/1, and determine if any of these causes can be corrected through management. Uncertainty in the data collected, parameters estimated, and models selected for stock assessment should also be simulated using Monte Carlo approaches for determining the effects of these uncertainties on model predictions (SAW/84/MCH/7). Parameter uncertainty in MENSIM has already been used to assess managerial risks (SAW/84/MCH/6). Based on results from SAW/84/MCH/2, a trial sampling scheme will be applied in the 1984 Fall fishery.

V.3. Management

On 19 May 1982, the AMMB approved a reduction of the fishing season in each reporting area by four weeks to be effective in 1983. Y/R analyses projected a gain of yield for the entire fishery of 16.7 - 22.7 KMT. The "loss" to the North Carolina Fall fishery would be 6.3 - 8.5 KMT. With 1976-78 effort and age at entry Y/R would rise 5.7% to 55.28 grams. Opening and closing dates proposed are as follows:

	Opening Period	Closing Period
North Atlantic	5/17 - 5/23	10/04 - 10/10
Middle Atlantic	5/17 - 5/23	10/11 - 10/17
Chesapeake Bay	5/17 - 5/23	11/08 - 11/14
South Atlantic and North Carolina Fall Fishery	4/12 - 4/18	12/13 - 12/19

Implementation of the above measure will require a mixture of legislation and special regulations depending upon state fishery agency authority. To date, New Jersey, New York, and Connecticut have approved the measure. Rhode Island will respond with pending legislation. Maryland has prohibited menhaden purse-seining since World War II, and Delaware acted unilaterally and now prohibits all menhaden purse-seining in its territorial waters (3 miles). Virginia, North Carolina, and states to the South have taken no action.

AMMB adopted no other management recommendations at its 19 May 1982 meeting. The rationale being to take one action and evaluate the effects of that measure before confounding the interpretation of fishery and stock by adopting other concurent measures. The Atlantic Menhaden Advisory Committee (AMAC), through data collected and analyzed by NMFS, is to evaluate the effectiveness of the action after it is implemented.

The working group recommends that the various coastal states implement the season as called for by the AMMB and ASMFC action. Future actions should be directed towards additional increases in Y/R as called for in the management plan. Correction of the growth overfishing problem will increase potential long-term yield, broaden the age structure, increase prospects for good recruitment, and tend to stabilize landings.

GULF MENHADEN

I. DESCRIPTION OF FISHERIES

I.1. Catch Trends

Landings of Gulf menhaden caught by purse seine increased fairly steadily from 9 KMT in 1946 to 728 KMT in 1971. From 1972 to 1983 landings fluctuated between 447 and 923 KMT (Table MCH-6) with record landings occurring in 1982 and 1983. The bulk of the present day purse-seine landings occur in Louisiana (82%) and the remainder in Mississippi (18%). Historically, some landings were made in Florida and Texas. The landings currently occur from mid-April to mid-October with peaks occurring in June, July, or August depending on weather and other fishing conditions (Fig. MCH-5).

The reported landings of Gulf menhaden are from purse seines. A relatively small amount of unreported catch for commercial and recreational bait also occurs.

I.2. Effort Trends

During recent years (1964-1983) the number of vessels in the fishery has fluctuated between 65 and 82. During the development of this fishery, many changes toward modernization were made to the vessels and fishing gear. Spotter aircraft were introduced in the late-1940's, which greatly facilitated the locating of fish schools. Refrigerated holds were added in the mid-1950's, which allowed the carrier vessels to stay out longer and range farther from their home port. Vessels currently range from eastern Texas coastal waters to the Florida panhandle, but the bulk of the catch occurs in Mississippi and Louisiana waters. More detailed descriptions are contained in SAW/84/MCH/3 and Nicholson (1978b).

Nominal effort for the Gulf purse-seine fishery is expressed in terms of vessel-ton-weeks. Effort has gradually increased from 1964 through 1983, although the number of vessels has not. This is due to more vessels fishing the entire season and the progressive introduction of larger, more efficient vessels as older ones are retired.

II. STOCK STRUCTURE

The Gulf menhaden fishery is believed to exploit a single stock or population of fish. Although tagging of pre-emigration juveniles indicate little if any exchange of fish from east and west of the Mississippi River Delta (Kroger and Pristas 1975; SAW/82/MCH/2), unpublished meristic studies do not indicate separate populations on each side of the Mississippi Delta (SAW/84/MCH/3). The working group accepts the one stock hypothesis at this time for stock assessments of Gulf menhaden.

III. STATUS OF STOCKS
III.1. Population Parameters
III.1.1. Natural Mortality Rate

Recent analyses of Gulf menhaden tag-recovery data provided estimates of M ranging from 0.7 to 1.6/yr and averaging 1.1/yr (SAW/82/MCH/2). Current population dynamics analyses use the value of 1.1/yr.

III.1.2. Growth Estimates

SAW/82/MCH/8 fitted a von Bertalanffy growth equation to quarterly mean weight at age data. The fitted parameters were: L = 252.9 mm; K = 0.47/yr; and t_0 = 0.36 yr. The weight-length relationship is described by: $\log_e W = 3.2669 \log_e L - 12.1851$.

III.2. Catch Per Unit Effort Trends (CPUE)

Landings per vessel-ton-week range from 3.71 MT in 1946 to 0.78 MT in 1967. There are no consistent trends evident in the CPUE values in the Gulf fishery (Table MCH-6). The group noted potential limitations in the CPUE time series due to changes in vessel characteristics and fishing techniques.

III.3. Stock Assessment Analyses
III.3.1. Production Model Analyses

A number of MSY estimates are available from earlier studies. Chapoton (1972) obtained an estimate of 430 KMT for the 1946-1970 seasons using the Schaefer model; incorporating data from additional seasons, 1971 and 1972, Schaaf (1975) obtained an estimate of 478 KMT. More recently, SAW/82/MCH/8 obtained a Schaefer estimate of 553 KMT for the 1946-1979 seasons, and incorporating recent population fishing mortality rates, growth rates, and the spawner/recruit relationship into a population simulation model, obtained an MSY estimate of 585 KMT (Fig. MCH-6). Incorporation of 1980-83 season catch data would undoubtedly result in an even higher MSY estimate from the Schaefer model. The group cautions that MSY estimates are considered of limited value in fishery management for reasons given with Atlantic menhaden (III.3.1).

III.3.2. Yield Per Recruit (Y/R)

SAW/82/MCH/8 provides yield per recruit estimates obtained from a Ricker-type yield per recruit model (Epperly *et al*. 1979).

Under average fishing mortality rates observed for 1964-1977 as estimated from VPA, yield per recruit was estimated to be 17.09 grams. Y/R could actually be increased with higher rates of fishing, as maximum biomass is obtained at an age of 1.5 and the rate of natural mortality is quite high (Fig. MCH-7). Attempts to increase Y/R should not be taken, as results from population simulation studies by SAW/82/MCH/8 indicate that recruitment overfishing is likely to occur.

III.3.3. Recruitment Analysis

VPA estimates of annual numbers of Gulf menhaden recruited at age one range from a low of 7.5 billion to a high of 25.4 billion for the 1964-1977 year classes (SAW/82/MCH/8; Table MCH-7). Research has been conducted in Louisiana on environmental influences upon survival of young fish (SAW/84/MCH/3).

The spawner-recruit relationship is dome shaped, with a fair amount of scatter about the curve (Fig. MCH-8). Parameter estimates for a Ricker-type spawner-recruit equation are given in Figure MCH-8.

III.4 Current Status

The Gulf fishery is currently fully exploited and appears to be reasonably stable in view of the age composition, lifespan, and effects of environmental factors. Annual production, fishing effort, and fleet size appear reasonably balanced. NMFS forecast of landings for the 1984 season is 820 KMT. Caution is warranted since the forecast landing is about 250 KMT above recently estimated MSYs which range from 553 to 585 KMT. Although recent short-term harvests in excess of MSY do not appear to have been detrimental to the stock, long-term harvesting above MSY can not be maintained given the current understanding of the resource and uncertainties concerning MSY. Increases in effort could lead to problems in sustained yield from the population.

IV. EFFECT OF CURRENT MANAGEMENT PRACTICES

The Gulf fishery is conducted principally within the territorial sea of the five coastal states (Florida to Texas). All states voted in favor of a cooperative management system under the Gulf States Marine Fisheries Comission (GSMFC) in 1977 (SAW/82/MCH/7) and this system was revised and adopted in 1983 (SAW/84/MCH/3). Management authority is vested in the individual states. Some regulations, such as length of fishing season (open and close date) are common in all states, but other regulations are area-specific, on a state or county basis. No state controls or limits the catch or effort of vessels. The management plan established an advisory committee composed of state, industry and

NMFS representatives. This group reviews the status of the fishery periodically as the season progresses; and if desired, meets to resolve a specific issue or receive specific updates. This group reports to an implementation committee of the states and makes recommendations for changes in the fishery. The implementation committee acts upon recommendations and informs the management board (state fishery agency personnel) if and when any action is required.

No analysis of the effects of current management practices was performed by the working group. Area-specific availability of the resource, company policy and economics have had an overriding influence on the fishery. Stock assessments by NMFS provide the biological measures of resource response to the present harvesting practices throughout the range of the fishery. The management plan specifies that NMFS conduct stock assessment studies and that the Advisory Committee evaluates the effects of any management measures adopted and offer management recommendations as deemed necessary.

V. RECOMMENDATIONS

V.1. Data Needs

SAW/84/MCH/3 identified data needs and priorities regarding future projects covering biological, economic, social and fishery related matters in the Gulf menhaden purse-seine fishery. Top priority items include: (1) monitoring of the fishery for information on age, size, catch, juvenile abundance, fishing effort, migrations, and in general the status of the resource; (2) determining, if possible, an effective unit of fishing effort; and (3) assessing the effects of environmental factors on recruitment and future harvests. These items are being researched by NMFS and considerable progress appears to have been made. The states principally are monitoring the estuarine habitat and performing law enforcement activities. Louisiana and Texas also conduct juvenile surveys and other biological research as noted above. Louisiana's surveys are directed toward shrimp but do provide data on Gulf menhaden, while Texas' surveys are directed toward finfish including Gulf menhaden. The Captain's Daily Fishery Reports are judged prime data sources for refinements to the current estimates of fishing effort and location of origin of catch. Spotter aircraft data are believed to be of potential value in the development of a measure of effective effort which would be adequate for management application.

V.2. Research

Available data and analyses regarding the status of the Gulf menhaden stock and the fishery are deemed adequate for assessment purposes. Additional analyses of the historical tagging data are currently ongoing and should provide further insights to an understanding of the resource. The bycatch in the Gulf of Mexico shrimp fishery should be examined for menhaden.

Further research to examine the effects of the environment upon recruitment is critical due to the dependence of the fishery upon age 1 and 2 fish. Coupled to this topic is the need to develop a predictive capability (index) for landings based upon abundance of pre-recruits.

V.3. Management

Current landings are setting records. Earlier stock assessment analyses revealed that during some years levels of biomass in the stock were present to produce these landings. But since stock assessments are based on historical data, an updated analysis is recommended to determine if current high harvests are due to:

(a) the observed increase in fishing effort as well as increases in the stock availability due to improved fishing conditions and/or changes in fishing patterns and strategy since the assessment work was completed, or

(b) some exceptionally large year classes in recent years resulting from good environmental conditions for fish prior to recruitment, or

(c) a combination of (a) and (b).

Given any of the above conditions, we do not believe the fishery will sustain these high levels of harvest; catches will eventually be reduced. If condition "a" (above) is prevalent, stock damage may occur and harvests would drop below levels which could occur if condition "b" (above) is prevalent where stock damage is not expected to occur.

Recent levels of fishing effort exceed those of the late 1970's. It is probably too great now, but this would have to be evaluated by way of appropriate stock assessment methods for current population/recruitment levels. Unfortunately, these analyses will tend to lag events in the fishery by several years.

Unlike the Atlantic menhaden, the Gulf menhaden has a short life span (high natural mortality) which can result in rapid year-to-year changes in the fishable stock. Although increasing the number of year classes in the fishable stock is not biologically practical or suggested, caution is advised relative to the high F's evidenced and dependency upon very few age groups. Expansion of this fishery by effort or area is not recommended.

COASTAL HERRINGS

Several species of clupeids, anchovies and small carangids are abundant and collectively termed "coastal herrings". These species are a very important prey for reef and coastal pelagic piscivorous fishes. None of the species is presently exploited significantly although their potential has been recognized for 25 or more years (SAW/82/MCH/3). The underexploited species of major concern are thread herring, Spanish sardine, round herring, scaled sardine, anchovies, round scad, rough scad, and Atlantic bumper. Status of knowledge on these species is summarized in SAW/82/MCH/3, SAW/82/MCH/5, and SAW/84/MCH/4.

I. DESCRIPTION OF FISHERIES

Present catches (less than 4 KT annually) consist of landings in directed purse- and beach-seine fisheries. Bycatch (discard) on the Gulf and South Atlantic coast probably contribute in excess of 30 KT. Some bycatch in the menhaden fishery also occurs (Guillory and Hutton 1982). In the Gulf area additional harvest of about 5 KT may be made by Mexican and Cuban vessels. Data are principally developed from the Florida panhandle area where small directed bait fisheries occur.

II. STOCK STRUCTURE

Virtually no information is available for the group. The present assumption is that data developed off Florida may be applied throughout the Gulf of Mexico and extrapolation to the Atlantic coast may be required as a first approximation.

III. STATUS OF STOCKS

Collectively, it has been estimated that the coastal herrings might sustain an annual harvest in the range of 1-2 million tons based upon Gulf of Mexico estimated stock biomasses (Table 1 in SAW/82/MCH/5). The estimated total present day harvest is only a small fraction (perhaps 5%) of the combined sustainable yield of these species. Data for catch and effort trend analysis are lacking. Thus, with no well developed fisheries, there is little stock assessment information on coastal herrings in the Gulf or Atlantic areas. SAW/82/MCH/3 and SAW/82/MCH/5 caution against application of vital parameter estimates derived from fished stocks in other areas of the world to stock assessment in the southeast United States. Stock assessment and life history information are presently being developed through GSAFDF projects and NMFS, Southeast Fisheries Center.

Information available was summarized by SAW/82/MCH/3, SAW/82/MCH/5, and SAW/84/MCH/4. Species specific summations follow.

III.1. Anchovies
III.1.1. Bay Anchovy (Anchoa mitchilli)

This anchovy is a small (100 mm or less) and extremely abundant fish, considered important because it is a major prey for many commercial and recreational fishes. There is little information on this short lived fish relative to growth rates, mortality rates, or estimates of standing stock.

III.1.2. Striped Anchovy (Anchova hepsetus)

This anchovy is sommewhat larger (>150 mm) and faster growing than bay anchovy, but apparently less abundant. There is little information on this fish relative to growth rates, mortality rates, or estimates of standing stock.

III.1.3. Silver Anchovy (Engraulis eurystole)

This anchovy is found further from shore than the bay or striped anchovy. This anchovy grows to around 150 mm in length, but does not appear to be abundant. Little information is available relative to mortality rates, growth rates, or estimates of standing stock.

III.2. Clupeids
III.2.1. Round Herrings (Etrumeus teres)

This herring, which is commonly 150-200 mm in length, is probably one of the most abundant clupeids in the Gulf of Mexico. However, because it commonly occurs offshore and does not form surface schools, it is relatively unavailable for exploitation. There are directed fisheries for round herring in Japan and South Africa, but these are likely to be different populations. The estimated potential yield for round herring in the Gulf of Mexico (assuming M is between 0.5 and 1.0/yr) ranges from 150 to 1500 KMT (SAW/82/MCH/5).

III.2.2. Scaled Sardine (Harengula jaguana

This small fish (usually $\leq$ 200 mm in length) occurs in small schools in state jurisdictional waters. Small catches of this fish are made in the pet food and bait industry. Estimated potential harvest for this fish is from 140 to 275 KMT (SAW/82/MCH/5). No mortality rate estimates are available for this fish.

III.2.3. Thread Herring (*Opisthonema oglinum*)

This herring is relatively abundant in coastal waters and over the inner continental shelf of the Gulf of Mexico. Houde *et al.* (SAW/84/MCH/4) estimate maximum yield-per-recruit at 18.8 g with F_{max} = 3.3/yr, a recruitment length of 105 mm FL, and M = 0.82/yr. Little gain in yield is expected beyond F levels of 1.5/yr (SAW/84/MCH/4, Figure 2) where mean weight and age in the fishery would be 27.8 g and 1.2 yr, respectively. Size at age data and age distribution of landings for recent fishing levels are available (Table MCH-8); maximum size may be as long as 300 mm in length (SAW/82/MCH).

III.2.4. Spanish Sardine (*Sardinella aurita*)

This sardine, widespread in the tropical and subtropical oceans of the world, is abundant in the shelf and coastal waters of the Gulf of Mexico. About 2 KMT of this fish are landed annually by the bait and pet food industry. Houde *et al.* (SAW/84/MCH/4) estimate maximum yield-per-recruit at 26.5 g with F_{max} = 2.7/yr, a recruitment length of 105 mm FL, and M = 0.90/yr. Little gain in yield is expected beyond F levels of 1.5/yr (SAW/84/MCH/4, Figure 2) where mean weight and age in the fishery would be 42.0 g and 1.42 yr, respectively. Size at age data and age distribution of landings for recent fishing levels are available (Table MCH-8). Maximum size appears to be about 225 mm in the Gulf, while individuals in eastern Atlantic populations may exceed 300 mm (SAW/82/MCH).

III.3. Carangids

III.3.1. Round Scad (*Decapterus punctatus*)

The round scad is relatively abundant and widely distributed over the continental shelf of the eastern Gulf of Mexico. Based on larval occurrences, it is believed to be less abundant in the central and northwestern Gulf. A directed bait fishery in Florida lands less than 500 MT annually. Houde *et al.* (SAW/84/MCH/4) estimate maximum yield-per-recruit at 19.5 g with F_{max} = 5.2/yr, a recruitment length of 105 mm FL, and M = 0.92/yr. Little gain in yield is expected beyond F levels of 1.5/yr (SAW/84/MCH/4, Figure 2) where mean weight and age in the fishery would be 29.2 g and 0.95 yr, respectively. Size at age and age distribution of landings for recent fishing levels are available (Table MCH-8).

III.3.2. Rough Scad (<u>Trachurus lathami</u>)

This species is not fished in the Gulf of Mexico. Additionally, there is no accurate information on which to estimate potential production (rough estimates of 40 to 1,700 KMT have been given).

III.3.3. Atlantic Bumper (<u>Chloroscombrus chrysurus</u>)

This species occurs in the bycatch of the shrimp fishery, but has no directed fishery. There are no reliable estimates on abundance, age structure, growth, or mortality rates.

IV. EFFECT OF CURRENT MANAGEMENT PRACTICES

No management practices are in place. Authority is mixed between states and MFCMA depending upon species and area in which the fishery exists or might develop.

V. RECOMMENDATIONS

There is an obvious lack of stock assessment information for the "coastal herrings" species complex. The most critical needs are to continue determining population age structures, growth rates and natural mortality rates, particularly for those species likely to undergo increased harvesting in the near future. This information will be most valuable if obtained before significant fishing mortality occurs. Yield models then can be developed from which the stocks' abilities to sustain heavy fishing can be determined. From the standpoint of the fishery, lack of knowledge about availability and capture technology are major problems which retard development, in addition to uncertain social and economic factors. Catch and effort data should be obtained in the present small fishery and any expansion of the fisheries offshore should be carefully monitored to determine not only catch rates there but also to learn if different components of the stock are being exploited in the nearshore and offshore fisheries. There are important questions about stock identity for all of the "coastal herrings" which need to be addressed if significant fishing should begin. Finally, all of the "coastal herrings" are important as foods of predator fishes in the Gulf of Mexico. Their role in food chain dynamics and their importance in sustaining the predator populations need to be understood. The interactions among "coastal herrings", particularly the potential for competition or the possibility of species replacement, when one or more species is heavily fished, should be recognized.

Table MCH-1. Fishing effort and landings in the Atlantic menhaden fishery, 1955-83.

Year	Fishing Effort (vessel-weeks)	Total Landings (thousands of MT)	Landings per vessel-week
1955	2748	641.4	233.4
1956	2878	712.1	247.4
1957	2775	602.8	217.2
1958	2343	510.0	217.7
1959	2847	659.1	231.5
1960	2097	529.8	252.6
1961	2371	575.9	242.9
1962	2351	537.7	228.7
1963	2331	346.9	148.8
1964	1807	269.2	149.0
1965	1805	273.4	151.5
1966	1386	219.6	158.4
1967	1316	193.5	147.0
1968	1209	234.8	194.2
1969	995	161.4	162.2
1970	906	259.4	286.3
1971	897	250.3	279.0
1972	973	365.9	376.0
1973	1099	346.9	315.6
1974	1145	292.2	255.2
1975	1218	250.2	205.4
1976	1163	340.5	292.8
1977	1239	341.2	275.4
1978	1210	344.1	284.4
1979	1198	375.7	313.6
1980	1158	401.5	346.7
1981	1133	380.4	335.7
1982	948	382.4	403.4
1983	995	418.6	420.7

Table MCH-2. Atlantic menhaden purse-seine landings by area, 1940-1983.

	AREA					
YEAR	North Atlantic	Middle Atlantic	Chesapeake Bay	South Atlantic	Fall Fishery	TOTAL
	THOUSANDS OF METRIC TONS					
1940	16.8	91.1	35.3	37.9	36.6	217.7
1941	33.5	104.1	60.2	45.2	34.9	277.9
1942	14.6	77.7	21.9	32.9	20.1	167.2
1943	9.8	96.8	42.1	59.7	28.8	237.2
1944	27.5	122.6	32.2	46.9	28.7	257.9
1945	34.0	136.4	35.1	58.5	31.9	295.9
1946	42.9	183.8	57.6	40.8	37.3	362.4
1947	44.2	185.8	81.2	34.2	32.8	378.3
1948	44.4	137.4	68.3	55.8	40.6	346.5
1949	52.2	149.8	62.8	59.3	39.7	363.8
1950	49.3	143.0	63.1	20.0	21.8	297.2
1951	51.0	168.6	56.1	54.6	31.1	361.4
1952	58.1	193.7	45.7	86.0	26.4	409.9
1953	59.7	363.2	77.8	52.8	39.7	593.2
1954	64.9	335.7	126.0	39.6	41.9	608.1
1955	83.3	317.6	132.7	43.4	64.4	641.4
1956	98.5	378.3	94.0	68.6	73.7	712.1
1957	83.5	304.5	126.0	36.4	52.0	602.8
1958	36.0	211.1	151.3	41.3	70.3	510.0
1959	66.0	250.9	196.8	63.1	82.3	659.1
1960	66.4	256.0	108.5	36.7	62.2	529.8
1961	58.6	274.6	128.7	44.1	69.9	575.9
1962	64.7	249.9	155.1	42.2	25.8	537.7
1963	35.2	111.7	104.0	34.2	61.8	346.9
1964	15.0	35.2	134.1	46.5	38.4	269.2
1965	11.9	45.8	126.1	36.7	52.9	273.4
1966	1.8	6.0	115.6	24.5	71.7	219.6
1967	0.0	17.1	91.1	34.1	51.2	193.5
1968	6.7	26.2	115.5	33.6	52.8	234.8
1969	2.9	12.4	72.0	32.8	41.3	161.4
1970	4.3	11.5	182.9	42.4	18.3	259.4
1971	10.4	23.0	170.7	38.3	7.9	250.3
1972	14.5	54.6	245.5	45.9	5.4	365.9
1973	29.9	277.4[1] (Middle Atlantic and Chesapeake Bay combined)		37.2	2.4	346.9
1974	35.8	194.8		45.9	15.7	292.2
1975	23.1	149.8		59.5	17.8	250.2
1976	28.4	243.3		50.7	18.1	340.5
1977	15.0	244.1		49.8	32.2	341.1
1978	31.4	214.1		60.3	38.2	344.0
1979	29.4	230.7		61.6	54.0	375.7
1980	29.7	282.8		53.2	35.8	401.5
1981	21.8	215.9		79.1	64.5	381.3
1982	35.1	0.0	316.8[1] (Chesapeake Bay and South Atlantic combined)		30.5	382.4
1983	39.4	0.0	310.8		68.4	418.6

[1] Combined to retain confidentiality of landings data.
SOURCE: ASMFC 1981, added 1981 through 1983 values (R. Chapoton, NMFS, Beaufort)

Table MCH-3. Percent increase in yield per recruit for the Atlantic menhaden fishery based on average fishing mortality (F-multiple = 1.0) for the 1976-78 fishing season at an array of ages of entry, expressed as percentages of current yield per recruit. (Source: SAW/84/MCH/1)

Age at Entry	Percent Y/R at F-multiple				
	0.6	0.8	1.0	1.2	1.4
2.0	19	20	19	18	16
1.5	15	15	12	10	8
1.0	11	9	6	3	0
0.5	7	4	(55.34 g)*	-4	-8

* Base value for calculation of percentage change

Table MCH-4. Percent change in yield per recruit by area and for the overall Atlantic menhaden fishery at ages of entry of 1.0, 1.5, and 2.0 compared with yield per recruit (G) under the current age of entry (0.5) at average fishing mortality rate for the 1976-78 fishing season. (Source: SAW/84/MCH/1)

Area	Current (g)	Age of Entry 1.0	Age of Entry 1.5	Age of Entry 2.0
			Change (%)	
North Atlantic	7.86	9.4	23.0	48.0
Middle Atlantic	8.19	9.4	22.2	42.6
Chesapeake Bay	24.34	9.4	12.5	13.7
South Atlantic	11.17	6.7	1.5	2.4
N.C. Fall Fishery	4.72	-25.4	-16.1	-46.6
TOTAL	55.34*	6.1	12.3	19.0

* The sum of area is slightly different from the overall total due to the nature of the yield per recruit program, which calculates Y/R for individual area and then calculate overall Y/R instead of simply summing the areas. Thus, differences are due to rounding.

Table MCH-5. Estimated number of recruits by year class at age 0.5 and 1.0, estimated number of spawners that produced the year class, and estimated egg production from the spawning stock, for Atlantic menhaden (Source: SAW/84/MCH/1).

Year Class	Number of Recruits X10[3] Age 0.5	Age 1.0	Number Spawners X10[3]	Number Eggs X10[12]
1955	7,888,342	5,621,258	2,146,972.2	235.057
1956	8,999,656	7,153,549	1,358,982.4	147.047
1957	4,419,989	3,263,196	714,741.2	83.977
1958	18,612,316	14,767,294	549,652.3	57.768
1959	2,722,999	2,164,428	1,297,553.6	143.822
1960	3,786,692	2,958,923	793,658.0	76.642
1961	2,769,147	2,210,534	2,959,390.4	156.058
1962	2,841,268	2,222,880	1,293,097.0	106.781
1963	2,304,564	1,754,140	425,946.2	37.508
1964	2,764,796	1,938,001	255,156.0	21.466
1965	2,072,852	1,430,539	185,937.0	13.806
1966	2,879,544	2,001,871	116,018.6	7.552
1967	1,522,438	1,209,954	214,470.9	17.017
1968	2,319,215	1,710,666	172,444.5	13.053
1969	3,448,326	2,611,940	139,703.1	11.240
1970	1,755,217	1,382,032	152,402.4	12.056
1971	4,513,962	3,539,073	216,205.9	17.594
1972	3,516,016	2,760,443	298,055.5	31.279
1973	3,908,494	3,085,954	81,204.7	8.044
1974	5,197,484	3,866,593	87,491.6	6.076
1975	9,024,340	6,932,136	102,503.1	6.591
1976 [1]	6,953,329	5,297,439	156,147.7	7.575
1977 [1]	6,619,024	4,827,413	252,672.3	11.966
1978 [1]	6,040,678	4,404,267	563,449.0	18.864
1979 [1]	10,322,177	6,890,589	547,169.7	18.389
1980	NE[2]	NE	672,445.4	26.045
1981	NE	NE	576,473.7	22.294

[1] Preliminary estimates

[2] No estimate

Table MCH-6. Fishing effort and landings in the Gulf menhaden fishery, 1946-83.

Year	Fishing Effort (Thousands of Vessel-Ton Weeks)	Total Landings (Thousands of Metric Tons)	Landings/Vessel-Ton-Week
1946	2.4	8.9	3.71
1947	21.0	33.9	1.61
1948	40.7	74.6	1.83
1949	66.2	107.4	1.62
1950	82.2	147.2	1.79
1951	94.2	154.8	1.64
1952	113.3	227.1	2.00
1953	104.7	195.7	1.87
1954	113.0	181.2	1.60
1955	122.9	213.3	1.74
1956	155.1	244.0	1.57
1957	155.2	159.3	1.03
1958	202.8	196.2	0.97
1959	205.8	325.9	1.58
1960	211.7	376.8	1.78
1961	241.6	455.9	1.89
1962	289.0	479.0	1.66
1963	277.3	437.5	1.58
1964	272.9	407.8	1.49
1965	335.6	461.2	1.37
1966	381.3	357.6	0.94
1967	404.7	316.1	0.78
1968	382.3	371.9	0.97
1969	411.0	521.5	1.27
1970	400.0	545.9	1.36
1971	472.9	728.5	1.54
1972	447.5	501.9	1.12
1973	426.2	486.4	1.14
1974	485.5	587.4	1.21
1975	538.0	542.6	1.01
1976	575.8	561.2	0.97
1977	532.7	447.1	0.84
1978	574.3	820.0	1.43
1979	533.9	777.9	1.46
1980	627.6	701.3	1.12
1981	623.0	552.6	0.89
1982	653.8	853.9	1.31
1983	655.8	923.5	1.41

Table MCH-7. January 1 estimates of number of spawners, number of eggs produced by the spawning stock, biomass of the spawning stock, and biomass of recruits at age 1 for Gulf mehaden.

Year	Number at Age (Millions)			Total Spawners (Millions)	Number of Eggs (Trillions)	Spawning Biomass (Metric Tons)	Resultant Recruitment (Millions)	Recruitment Biomass (Metric Tons)
	2	3	4					
1964	2,696.3	206.4	7.2	2,909.9	36.1	305,468	12,896.7	410,630
1965	1,749.9	138.2	9.7	1,897.8	23.7	200,150	7,519.5	239,421
1966	1,463.9	55.1	6.8	1,525.8	18.4	156,705	12,138.2	386.480
1967	722.2	19.0	-	741.2	8.8	75,118	12,186.7	388,025
1968	1,644.3	62.6	0.4	1,707.3	20.5	174,454	25,424.7	809,522
1969	2,026.9	58.7	-	2,085.6	24.8	211,752	16,396.8	522,074
1970	5,026.0	78.2	-	5,104.2	60.0	513,461	20,898.9	665,134
1971	3,472.8	382.4	6.2	3,861.4	49.0	412,808	12,618.5	401,773
1972	3,565.3	127.7	33.7	3,726.7	45.2	384,521	20,796.4	662,157
1973	2,365.8	239.0	3.4	2,608.2	32.8	277,323	19,889.0	633,266
1974	5,067.7	131.1	-	5,198.8	61.7	526,725	13,456.1	428,442
1975	4,376.3	879.9	7.3	5,263.5	70.5	588,668	(15,097.7)	(480,711)
1976	2,917.7	573.5	-	3,491.2	46.6	389,073	(24,466.7)	(779,020)
1977	(2,090.0)	238.8	76.2	(2,605.0)	(34.3)	(286,686)		
1978	(5,258.5)	(90.6)	19.2	(5,368.3)	(63.6)	(543,194)		

( ) Preliminary Estimates
Source Nelson and Ahrenholz (1981)

Table MCH-8a. Estimated lengths and weights at age for coastal herrings, based on 1981 and 1982 samples. Lengths were back calculated from otolith-fork length equations (SAW/84/MCH/4, Table 3) and von Bertalanffy relationship (SAW/84/MCH/4, Table 4) and weights were determined separately by year from weight-length relationships using von Bertalanffy estimates of fork length (SAW/84/MCH/4, Table 2).

Species	Age	Fork Length (mm) Back-Calculated	von Bertalanffy	Weight (g) 1981	1982
Spanish sardine	1	130.4	131.0	29.5	27.6
	2	162.3	162.7	58.4	58.3
	3	179.2	179.5	79.6	81.9
Thread herring	1	108.2	113.9	22.7	25.4
	2	152.4	146.1	50.7	52.4
	3	171.0	168.0	79.5	78.6
	4	179.5	183.0	104.7	100.8
	5	186.8	193.3	124.9	118.2
	6	202.7	200.3	140.0	131.1
Round scad	1	136.0	135.2	29.9	30.0
	2	159.7	158.9	50.0	51.1
	3	176.9	176.1	69.3	71.7

Table MCH-8b. Age composition of 1981 and 1982 catches (pooled) of coastal herrings (from SAW/84/MCH/4, Table 5). Ages based on otolith annuli counts.

Species	Age	Number in Samples	Estimated Percent in Age Group
Spanish sardine	0+	378	21.8
	1+	779	45.0
	2+	502	29.0
	3+	73	4.2
		1732	
Thread herring	0+	62	7.3
	1+	477	56.1
	2+	174	20.5
	3+	87	10.2
	4+	29	3.4
	5+	13	1.5
	6+	8	0.9
		850	
Round scad	0+	1659	75.1
	1+	420	19.0
	2+	127	5.7
	3+	3	0.1
		2209	

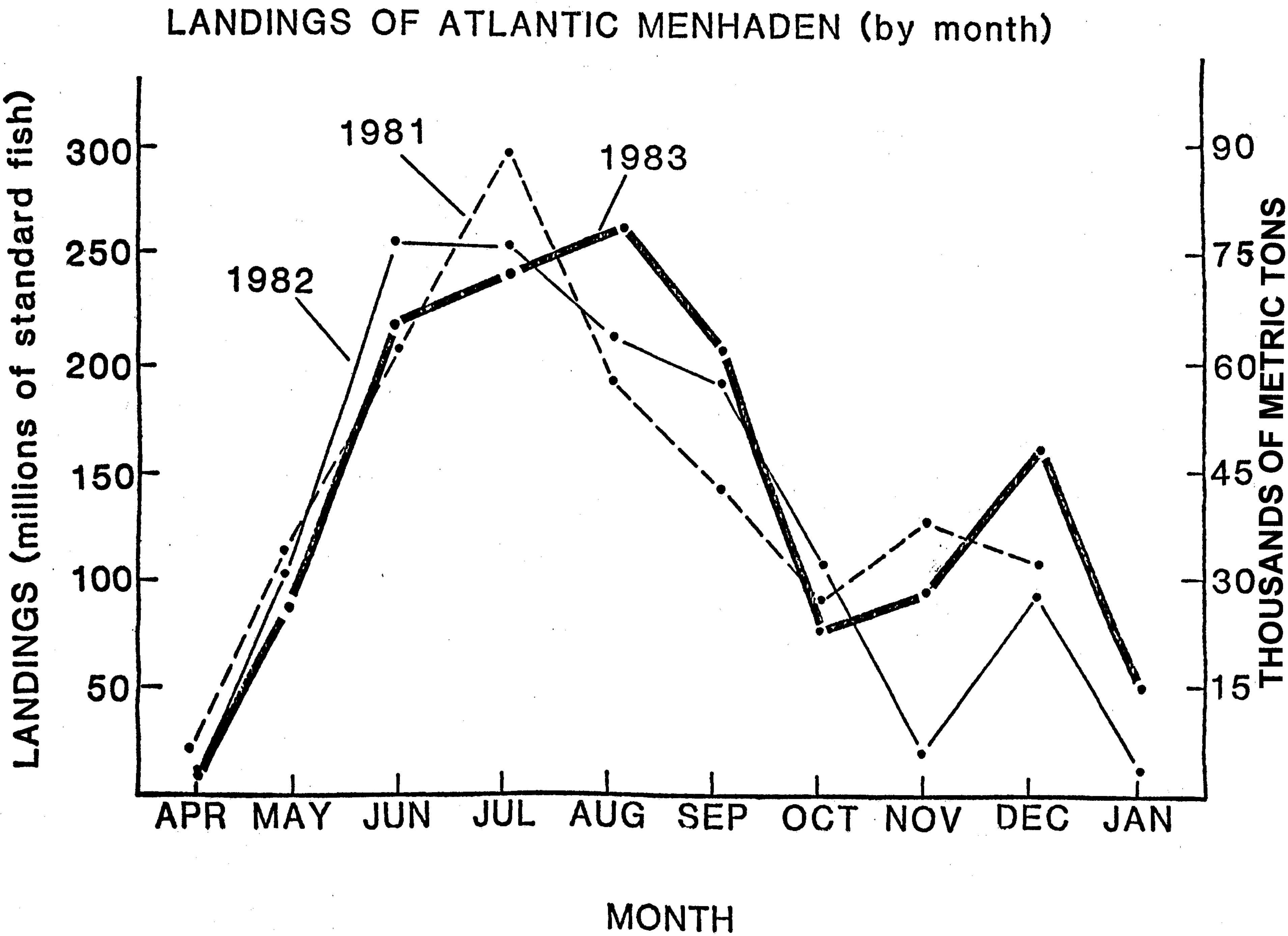


Fig. MCH-1. Landings of Atlantic menhaden by month in 1981-1983.

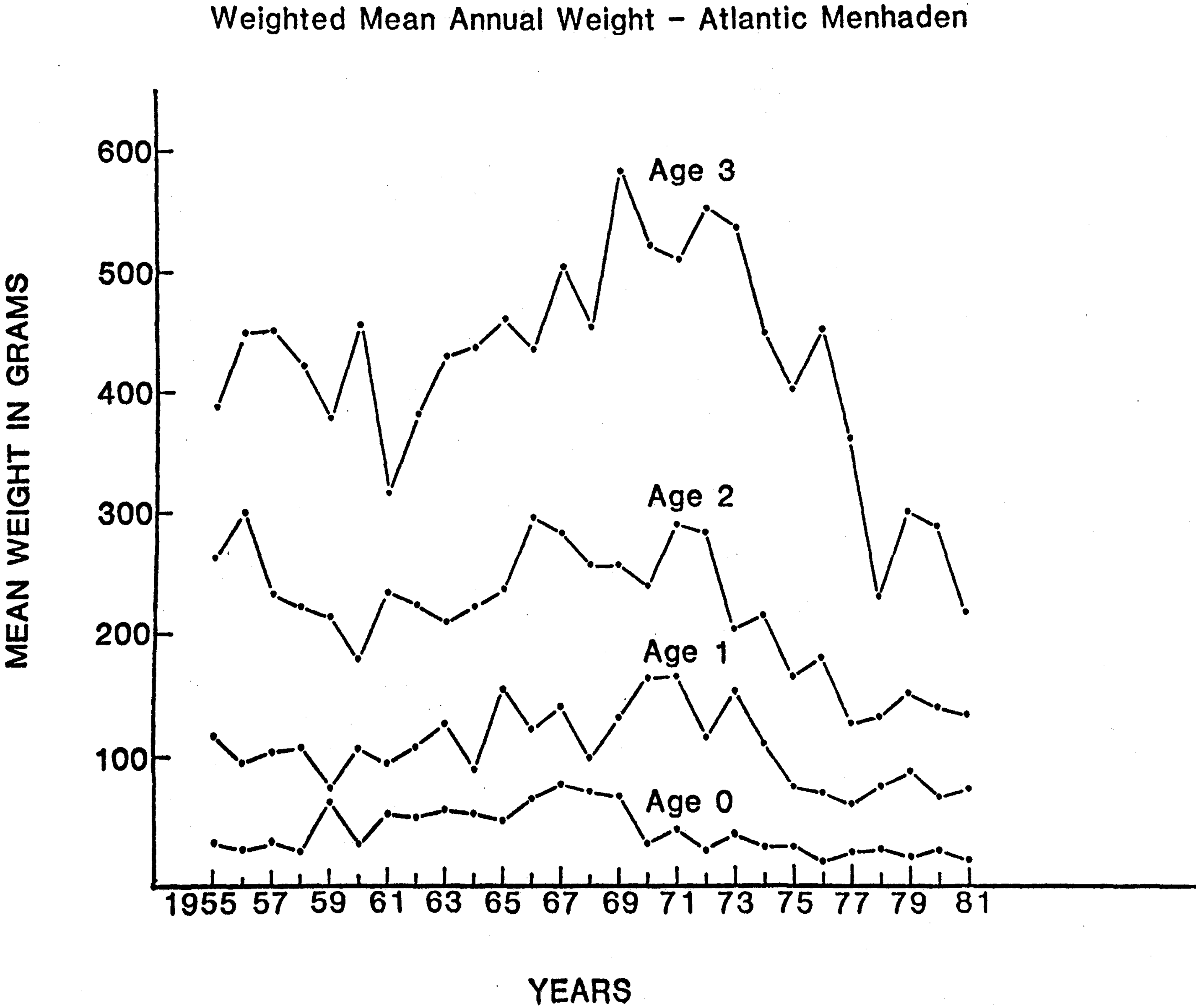


Fig. MCH-2. Mean weight of Atlantic menhaden (weighted) at ages 1, 2, and 3, 1955–1981.

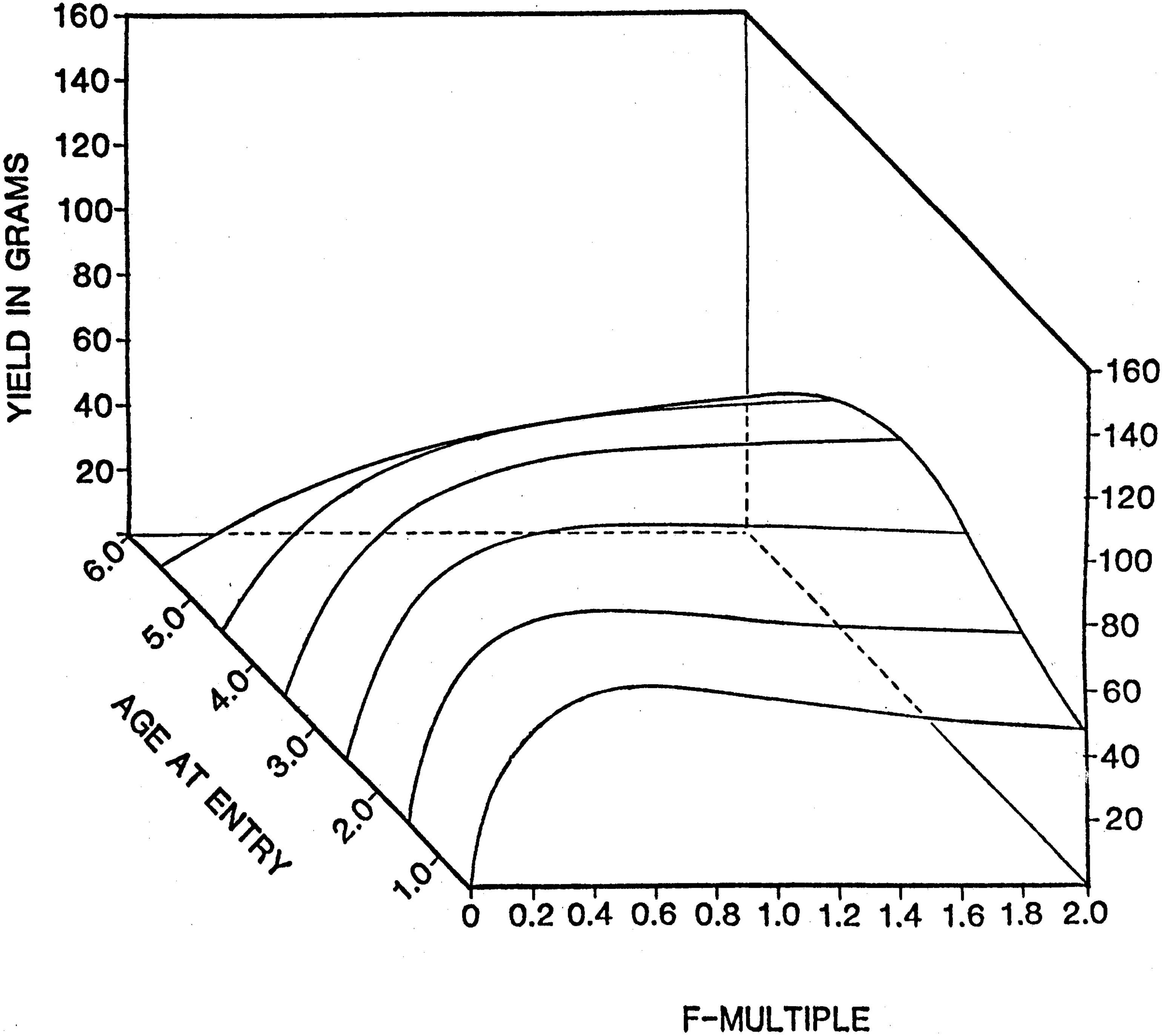


Fig. MCH-3. Overall yield per recruit of Atlantic menhaden under current conditions (F-multiple of 1.0, and age at entry of 0.5) using average fishing mortality values by quarter and area for the 1976–1978 fishing seasons.

Atlantic Menhaden Spawner Recruit Relationship

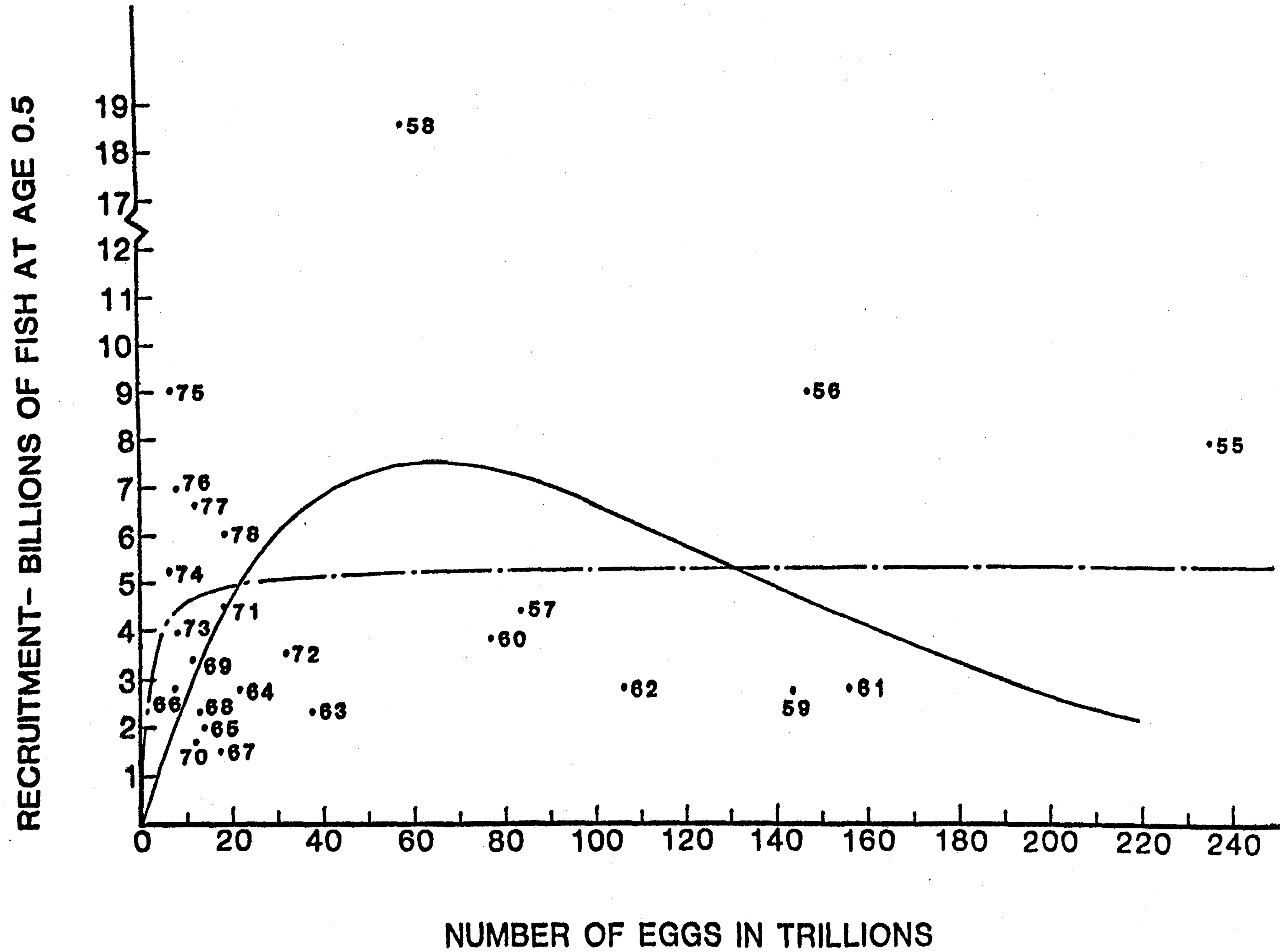


Fig. MCH-4. Numbers of Atlantic menhaden recruits by year class ploted against estimated egg production for year classes 1955–1978. Curves are nonlinear least squares results of fitting the Ricker (solid line) and Beverton–Holt (dot–dashed line).

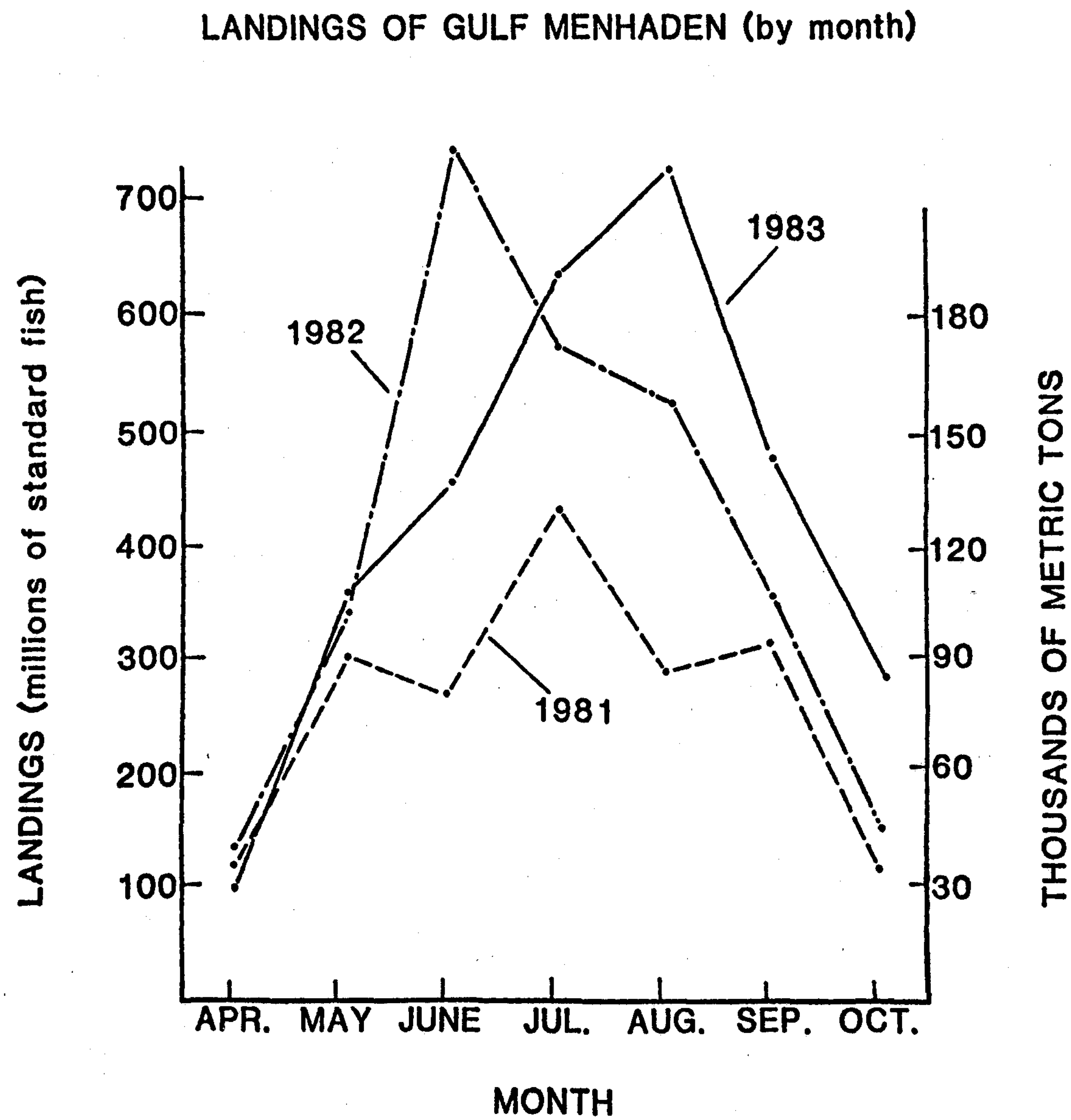
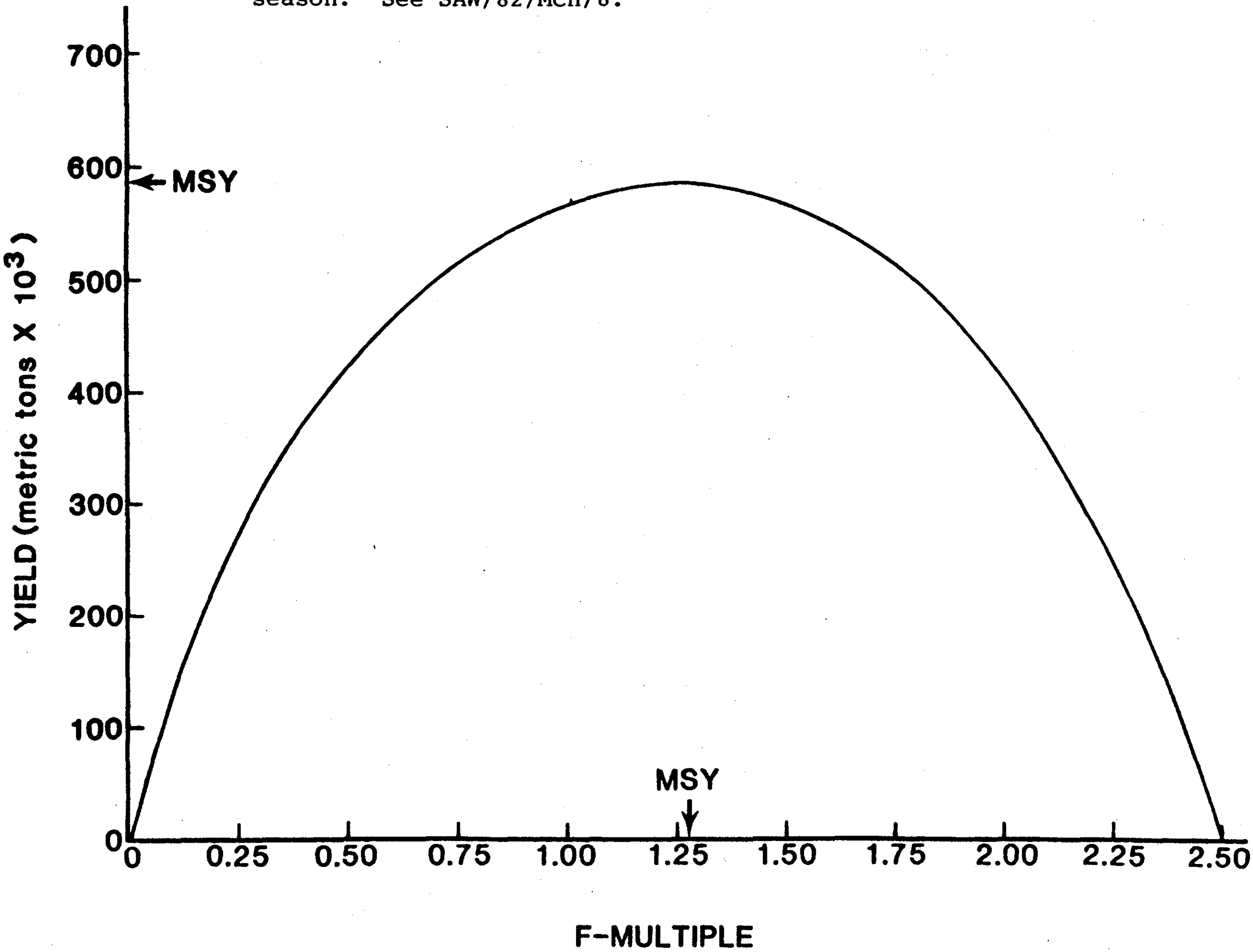


Fig. MCH-5. Landings of Gulf of Mexico menhaden by month in 1981-1983.

Fig. MCH-6. Sustainable yield predicted by a deterministic population simulation model of the Gulf menhaden fishery at multiples of the average fishing mortality (F-multiple = 1.00) for the 1964-1977 fishing season. See SAW/82/MCH/8.



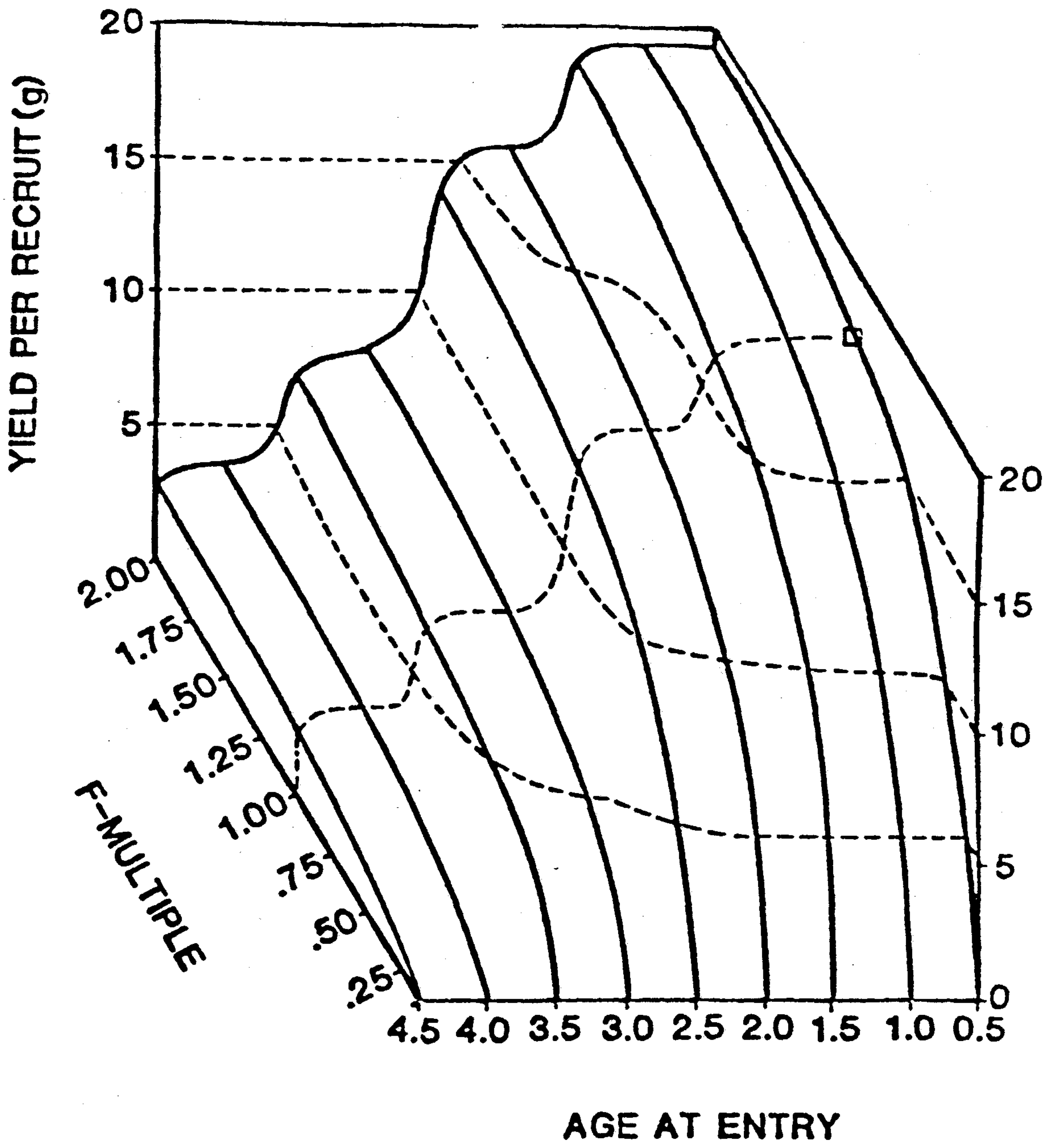


Fig. MCH-7. Yield per recruit of Gulf menhaden under average conditions of growth and with multiples of average fishing mortality by 3-month interval (F-multiple = 1.00) for the 1964-1977 fishing seasons (average conditions indicated by □).

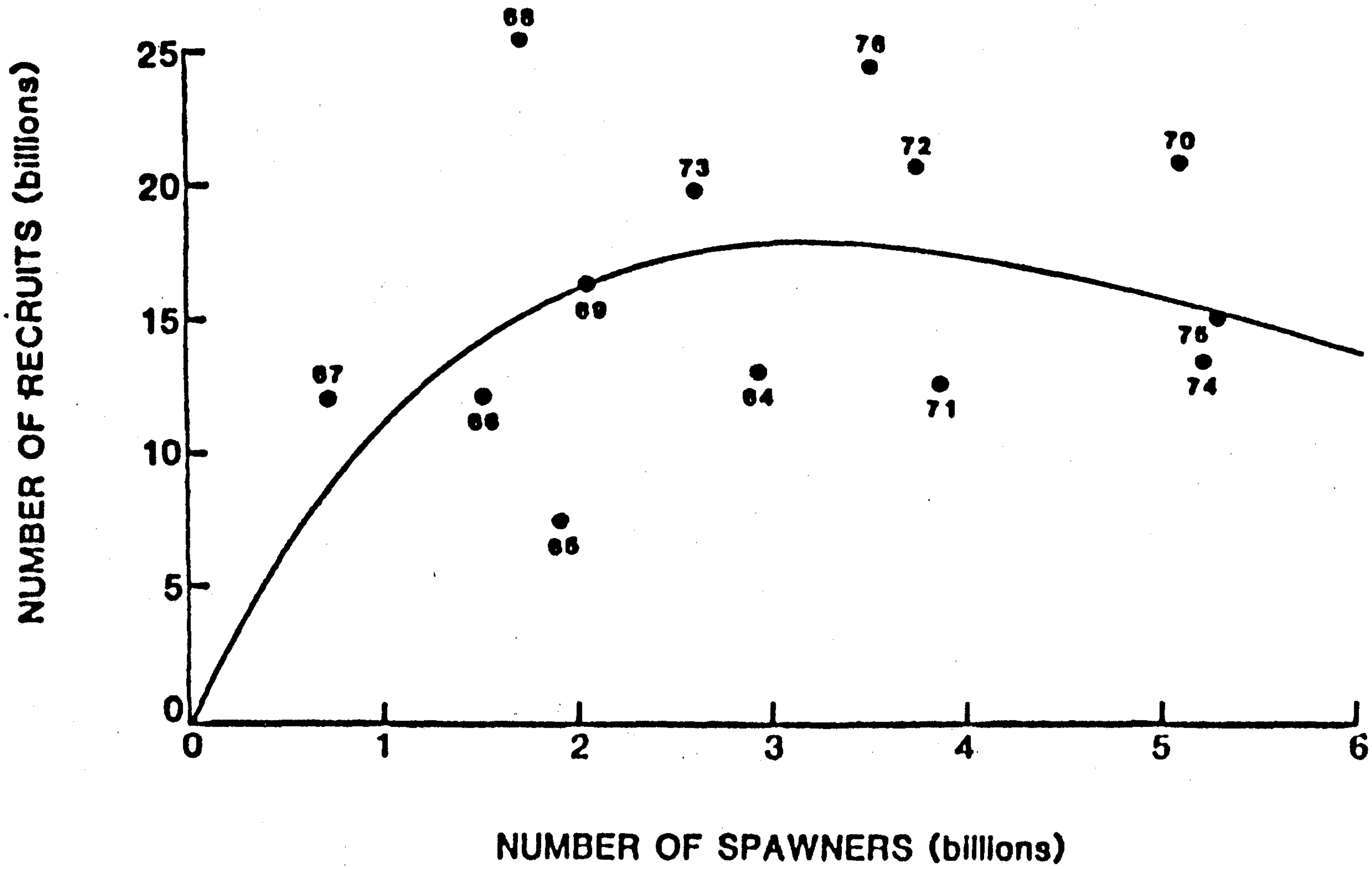


Fig. MCH-8. Ricker spawner-recruit relationship for number of spawners and recruits at age 1 of Gulf menhaden estimated as of January 1, for the 1964-1976 Gulf menhaden year classes. (R = S exp ((276.39-S)/38.72)).

REEF FISH AND REEF RESOURCES

REEF FISH OF THE SOUTH ATLANTIC COAST OF THE UNITED STATES

I. DESCRIPTION OF FISHERIES

Fisheries for reef fish and reef resources occur primarily between Cape Hatteras, North Carolina and Key West, Florida off the Atlantic coast of the continental United States. Reef resources are present due to the subtropical/tropical influence of the Florida Current and Gulf Stream. The majority of the fishing effort occurs anywhere from shore to 50 fathoms (300 ft.). Some effort for deeper-dwelling snappers, groupers and tilefish extends offshore to a depth of 133 fathoms (800 ft.).

I.1. Commercial

The commercial snapper-grouper fishery uses four major gears: (1) hook and lines, (2) traps, (3) trawls, and (4) bottom longlines. Additional minor commercial activities include (1) the use of spearguns and powerheads by open-circuit scuba divers, primarily to harvest various groupers and (2) a gill net (locally called "stab net") fishery off the east coast of Florida and, to some extent, the Florida Keys.

SAW/82/RFR summarized estimated number of hook and line, trap, trawl, and bottom longline vessels operating in North and South Carolina, Georgia, and Florida. More recent estimates are not yet available. Number of traps and vessels engaged in the trap fishery for groupers and snappers off the east coast of Florida and the Florida Keys, however, has increased since implemenatation of the South Atlantic Snapper-Grouper FMP in September, 1983.

SAW/84/RFR/10 and SAW/84/RFR/11 summarize recent commercial landings of snappers and groupers from the region. Figure RFR-1 displays total commercial landings of reef fish for the region and Figure RFR-2 commercial landings by state for 1977-1982. The increasing trend in total landings for the South Atlantic is due both to geographic expansion of traditional fisheries and development of the Florida bottom longline fishery for tilefish (SAW/84/RFR/11). Figures RFR-3 and -4, commercial landings of snappers and groupers respectively by state, illustrate a geographical change in snapper-grouper production. Florida landings of snapper have declined since 1977, while grouper landings have remained relatively constant. At the same time, grouper and snapper landings have increased rapidly in North and South Carolina, exceeding those of Florida since 1980 (SAW/84/RFR/11). Tilefish became the leading species group landed by commercial fishermen by 1982, with most of the landings coming from Florida and South Carolina (SAW/84/RFR/11).

I.2. Recreational

The recreational snapper-grouper fishery uses two major gears: (1) hook and lines, and (2) spears and powerheads. Hook and line are often hand-operated rods and reels, but also include electric reels, particularly for deeper-dwelling species. Most divers use open-circuit scuba and arbolets, although free diving, often with either Hawaiian slings or pole spears, is a significant component of diving effort. Diving comprises a relatively larger proportion of effort in the recreational than in the commercial fishery, but still produces a relatively small proportion of total recreational catch.

Three major categories of boats prosecute the fishery: (1) headboats; (2) private boats; and (3) charter boats. Although charter boats cater to recreational anglers, they sell the catch opportunistically on both a retail and wholesale basis. Similarly, numerous private boats sell portions of the catch to cover costs. Thus, an unknown proportion of the recreational snapper-grouper landings are "counted twice" in the data.

SAW/82/RFR gave estimates of the number of vessels in each of the three categories above. Substantial changes since that time are not suspected. SAW/84/RFR/10 summarizes landings of snappers and groupers recorded for private boats in the 1980 NMFS Recreational Fishing Survey. SAW/84/RFR/11 summarizes landings and effort for snappers and groupers by the headboat fishery during 1977-1982, and SAW/84/RFR/15 is a detailed summary of effort and catch by species and area by headboats for 1982.

Headboats comprise a relatively larger component of recreational effort for reef fishes between North Carolina and Northeast Florida because grounds are further offshore than in southeast Florida and the Florida Keys. Tables RFR-1 and -2, which summarize total headboat catches and effort respectively, are for the South Atlantic region, 1980-1982.

II. STOCK STRUCTURE

Little is known about the stock structure for reef fishes inhabiting coral reefs and various other forms of live bottom between Key West, Florida and Cape Hatteras, North Carolina. Possible factors regulating distribution and maintenance of populations of commercially exploited species in the region were reviewed in SAW/82/RFR. The three main (but not necessarily mutually exclusive) possibilities are that South Atlantic reef fishes: (1) are comprised of subgroups separable by genetic or other population characteristics within the South Atlantic region; (2) are themselves a portion of a larger definable unit, through significant interchange of genetic material with other regions; and (3) may be treated as a unit system where fishing in other areas has little or no effect on South Atlantic stocks and where subgroups within species have homogeneous population characteristics.

Although limited electrophoretic analyses have failed to reject possibility (2), conclusive evidence on either genetic characteristics of stocks within the same species or transport of larval reef fishes between the South Atlantic and other regions is not yet available. Therefore, the working hypothesis that reef fishes in the South Atlantic region may be assumed to be single stocks which constitute units independent of other stocks of the same species in other areas remains the premise of stock assessments for the region. The exception to this rule was the assessment of vermilion snapper (SAW/84/RFR/2) in which the northern area of the South Atlantic Bight was considered separately. The sensitivity of this choice is discussed in the document.

III. STATUS OF STOCKS

III.1. Population Parameters

III.1.1. Growth Rates

The von Bertalanffy growth model has been fitted for a number of reef fishes, many based on data from the South Atlantic Bight. A number of species have been analyzsed since SAW/82/RFR. Table RFR-3 lists all species for which growth parameters have been computed, with references. The sensitivity of the von Bertalanffy model to biases in the data may have caused some systematic errors in these estimates. An apparent bias in t_0 and K, for example, may be possibly explained by biased sampling of the larger individuals of any given year class (particularly younger year classes), which increases for longer lived, slower-growing species. The result in increasingly more negative t_0 values and artifically depressed values of K.

III.1.2. Mortality Rates

Table RFR-4 lists South Atlantic reef fish species for which natural, fishing, and/or total mortality rates (M, F, and Z) have been estimated, with references. SAW/84/RFR/5 lists a range of estimated natural mortality rates (M) for black sea bass, gag, scamp, speckled hind, snowy grouper, red snapper, vermilion snapper, red porgy, and white grunt, and the method(s) of estimation. Estimates of a range of M and total mortality rate (Z) for tomtate were given in SAW/82/RFR/4. The estimates of M for these species were derived from catch curve data, relationships between M and the growth constant of the von Bertalanffy growth equation (K), and published estimates (SAW/84/RFR/5). SAW/82/RFR/1 gave estimates of M for red grouper. SAW/84/RFR/2 estimated M = 0.23 for vermilion snapper in the South Atlantic Bight as well as F at age for the years 1973-1982.

Estimates of Z based on catch curves are made for 11 regional reef fish species in SAW/84/RFR/6 (Table RFR-4). This method assumes stable age distributions. Total effort in the fishery has increased over the time period during which data were collected, however, increasing the likelihood that this assumption does not hold. The direction of the bias produced is unclear. Similarly, the reliability of Z estimated for mutton snapper (SAW/84/RFR/7) is difficult to evaluate.

Similar problems are present for Z estimated from catch curves for scamp (SAW/84/RFR/8), speckled hind and snowy grouper (SAW/84/RFR/9). Z for scamp was quite different when estimated from commercial compared to recreational data. Difficulty of aging older fishes contributes to the uncertainty of the estimates for all three species.

Munro (1983) has recently estimated M, and, in some cases, Z and F using relationships between mortality rates and von Bertalanffy growth equation parameters for a number of species for which these estimates did not previously exist (Table RFR-4).

III.2. Catch Per Unit Effort Trends

SAW/84/RFR/11 summarizes both catch per angler-day for 1980-1982 (Table RFR-5) and average weights per fish landed (Table RFR-6) for 1977-1982 for the North and South Carolina headboat fisheries. Total catch per angler-day was variable or increased slightly, but average weight declined. Speckled hind (*Epinephelus drummondhayi*) in particular appear to have experienced marked declines in both average weight and frequency in the catch.

III.3. Stock Assessment Analyses
III.3.1. Yield Per Recruit Analysis

Beverton and Holt equilibrium yield per recruit relationships were computed for a range of values of age of recruitment, fishing mortality rate and natural mortality rate (SAFMC, 1983; SAW/84/RFR/5). Tables RFR-7 and -8 list parameters used and their origin for the analyses presented in SAFMC (1983) and SAW/84/RFR/5 respectively.

In addition to simple equilibrium computations, SAW/84/RFR/1 describes methodology and exemplary results from analyses which examine stepwise the attainment of equilibrium following changes in parameters, particularly age of size limit and fishing mortality, over time. The resulting time streams of yield are then used to quantitatively assess short term losses and long run gains to the fishery resulting from particular size limits. The method also incorporates both the probability that undersized fish will be released if captured and the probalility that released fish survive. SAFMC (1983) used these results to justify minimum size regulations for five South Atlantic reef species.

Table RFR-9 is a summary of equilibrium yield per recruit results from SAW/84/RFR/5. Figure RFR-5 illustrates the yield per recruit isopleths for scamp for M = 0.17 over a range of ages of recruitment and fishing mortalities. Table RFR-10, also from SAW/84/RFR/5 presents equilibrium yield per recruit results for different mortality rates computed by fishery. Table RFR-11 summarizes South Atlantic reef fish species for which yield per recruit analyses have been performed, with references.

Generally, results for the species analyzed were similar. When t_c remains constant at relatively low ages, yield per recruit increases with F less than or equal to approximately 0.3. Yield decreases thereafter, for increasing F. Ratios of M to K tend to be relatively high, consistent with the observed flat-topped curves of yield per recruit versus F.

Status of vermilion snapper stocks in the South Atlantic Bight has been more closely examined than that of any other reef fish from this or other regions. SAW/84/RFR/2 computed realized yield per recruit by using growth and length-weight equations to calculate yield in weight from stock size in numbers produced by virtual population analysis. Table RFR-12 summarizes potential yield per recruit by cohort compared to yield per recruit realized with present fishing patterns and with historical fishing mortalities, which were less than those at present. Table RFR-13 summarizes yield per recruit computed from age-specific average fishing mortality rates. Both analyses indicate substantial (20-30 percent) increases in yield per recruit would result from decreasing or eliminating mortality on young cohorts (ages 1, 2, and 3). The results are consistent with those of SAFMC (1983) and SAW/84/RFR/1.

The protogynous hermaphroditic life history strategy of groupers and black sea bass may further complicate stock assessments. Since virtually all individuals may potentially change sex, reproductive capacity of populations could be damaged by high exogenous mortality applied to older age classes. Possible instability in yield per recruit results from this source is unaccounted for in the analyses presented here. Enhanced growth rate in individuals following sexual transition could also significantly affect yield per recruit.

III.3.2. Stock and Recruitment Relationships

SAW/84/RFR/2 estimated abundance of the mature female stock of vermilion snappers using results of virtual population analysis and information on reproductive biology from the literature. No demonstrable relationship between spawning stock size and recruitment is apparent (Figure RFR-6), other than that expected as a result of a developing fishery. Decline in stock size and number of mature females with increasing effort corresponded with increased and more variable recruitment.

III.3.3. Virtual Population Analysis

Detailed VPA results from SAW/84/RFR/2 for vermilion snappers are presented in Table RFR-14 (age-specific fishing mortality rates), Table RFR-15 (age-specific abundance), Figure RFR-7 (stock abundance of 2 to 12 year olds), and Figure RFR-8 (recruitment of one year olds).

Fishing mortality rates were low from 1973 to 1978, increasing through 1982. Stock abundance reached a low in the middle 1970's, peaking in 1980, with some decline, thereafter. The 1982 stock size of fish 2 years old and older was approximately 40-50 percent higher than in 1977 and 15-20 percent higher than in 1973.

Recruitment reached a peak in the late 1970's and then declined. However, 1980-82 levels were still higher than those of 1973-75 when fishing effort was low. Note that 1981-82 recruitment estimates are very imprecise.

III.4. Current Status

Substantial increases in yield per recruit are predicted for increases in age of first capture for many exploited South Atlantic reef fish species, which indicates a state of growth overfishing. Virtually no data exist with which to assess the possibility that recruitment overfishing exists. However, possible population instabilities associated with heavy exploitation of protogynous hermaphrodities and presence of varying-degrees of growth overfishing suggest that recruitment overfishing is a potential problem. There may be cause for concern in the case of speckled hind in the South Atlantic Bight, as some data indicate sharp declines in both frequency of occurrence and average weight in the catch and sharp increases in Z from catch curves (G. Huntsman, personal communication).

Virtual population analysis showed an overall decline in number of mature female vermilion snapper in the South Atlantic Bight over 1973-1982 (SAW/84/RFR/2). Continued maintenance of high mortality rates will reduce survival of fish to the mature female ages. The number of mature females will continue to decline as the future population becomes dominated by younger age classes, and number of individuals belonging to older age classes diminishes. Although spawning stock abundance will increase as the strong 1978-80 year classes mature, it will subsequently decline if survival to maturation remains low.

Last, analyses of catch curves by area, pursuant to aggregated analyses presented by SAW/84/RFR/6, indicate substantially higher total mortality for all species examined in Florida compared to the South Atlantic Bight (G. Huntsman, personal communication). Eventual development of conclusions about current status of exploited reef fish in this region based on further analyses will likely be influenced by this factor.

IV. EFFECT OF CURRENT REGULATIONS

The South Altantic Snapper-Grouper FMP, passed into law September 28, 1983, promulgates a number of federal regulations governing fisheries for reef fish. These include a 12-inch (total length) minimum size for red and Nassau groupers, and red and yellowtail snappers, an 8-inch (total length) minimum size for black sea bass, a 4-inch minimum trawl mesh size, prohibition of fishing with poisons and explosives, prohibition of spearing of jewfish, and restrictions of specific gears in the vicinity of designated artificial reefs. The FMP specifies that fish traps may be used throughout the FCZ from Key West, Florida to Cape Hatteras, North Carolina, except shoreward of the 100-foot contour south of Fowey Light off Miami. Minimum mesh sizes and biodegradable panels are specified. Although few data exist, there appears to be a substantial increase in trap fishing, particularly off southeastern Florida and the Florida Keys (J. Bohnsack, personal communication). Actual impacts on snapper-grouper stocks have not been evaluated for this or other federal regulations.

The State of Florida imposes a 12-inch (total length) minimum size for red, black, and Nassau groupers, gags, and jewfish and prohibits the use of powerheads for taking groupers. Also, Florida, Georgia, the U.S. Department of Commerce Office of Coastal Zone Management, and the National Park Service have variously designated permanent sanctuaries in several areas of the Florida reef tract and South Atlantic Bight. Some preliminary data suggest measurable changes in reef fish community struture following closure to spearing and traps, but for the most part, the effects of these regulations remain similarly uninvestigated.

V. RECOMMENDATIONS

V.1 Data Needs

Continued improvement in collection of catch and effort statistics is needed. These improvements should include catch by species, size, and sex for various commercial gears. Size frequencies from commercial reef fisheries is particularly needed. Improvements in information on effort by time and area strata would allow valuable further assessments. Another weakness in current data is both catch and effort from non-headboat recreational sources. The recently-instituted Creel Survey and Biological Sampling Plan (CSBSP), a joint effort between NMFS and state agencies, addresses many of the described needs. Recording weight instead of length (after a species-specific length-weight relationship has been developed) is generally more expedient and could therefore generate more size frequency data per unit effort.

Collection of hard parts for anatomical aging from sub-samples should continue, according to a species-specific priority schedule.

V.2. Research

(1) A number of analyses are needed, some of which are possible with existing data. These include: 1) examination and adjustment of CPUE data taking frequency distribution into account: 2) use of the Robson (1966) general linear model to adjust for various factors, for example gear selectivity, which influence mortality estimates; 3) investigation of variation in oceanographic conditions associated with the Gulf Stream in relation to catchability coefficients in order to make appropriate adjustments; 4) models of adjusted CPUE by age or length to follow cohorts (virtual population analysis - note that this is in many cases possible with existing data); 5) investigation of the effect of protogynous life history strategies on results of standard yield models through simulation; 6) investigation of the impact of combining catch data from several reef species on production models; 7) research on the general problems of fishing on multiple species systems where shifts in species dominance and multiple equilibria are likely to occur; 8) re-examination of von Bertalanffy growth curves fitted to data primarily from the South Atlantic Bight, particularly with regard to possible bias in estimated growth parameters t_0 and K. The Thompson-Bell yield model should provide an alternative to Beverton-Holt yield computations. The results are not as sensitive to growth parameter misestimation since mean age-specific weight in the landings replaces a growth function. This model should be used where von Bertalanffy parameters appear to be biased.

(2) Resource survey approaches as described in SAW/82/RFR should continue.

(3) Estimation of age-reproduction relationships as described in SAW/82/RFR should continue. Protogynous hermaphrodites should receive greatest emphasis.

(4) Anatomical aging work should continue in conjunction with length frequency analyses in order to develop age-length keys useful for a number of analyses, for example, virtual population analysis.

(5) Research on stock definition is a continuing need. Larval surveys for reef species have been largely unsuccessful to date, primarily due to insufficient sample sizes. These

should continue only if an experimental design can be devised which will yield reasonable expectation of obtaining pre-calculated, sufficient sample sizes. Electrophoretic studies of selected species wold be desirable. Tagging programs, designed to address specific hypotheses about movement and transport of individuals, would also be useful.

(6) A number of current and proposed regulations have not been explicitey investigated. It would be useful to design experiments to assess the effect on species-specific catchability of various designs and mesh sizes of fish traps, including estimation of expected catch rates for different species. Similarly, analysis of existing data to predict expected effects of management by area closure, and further specific field experiments, would generate valuable information for this management strategy. The effectiveness of bag limits for selected species should be investigated. Studies on survivorship of released reef fish, for various species, depths, locations, conditions, and gears, should continue.

(7) Juvenile reef fish are a common component of the shrimp by-catch. This by-catch should be sampled according to a stratified survey design in order to: 1) develop indices of recruitment for selected species; 2) estimate the role of shrimping in total mortality of juvenile reef fish.

V.3. Management

Consideration of regulation by minimum size of reef fishes for which release survival is sufficient should continue, for both unregulated and currently regulated species. Analyses indicate that measurable increases in yield per recruit are possible for at least several currently unregulated species. Predicted population responses assume estimated parameters are relatively constant throughout the South Atlantic region, and that fishing and other activities outside this area have little or no effect on South Atlantic reef fish stocks.

Bag limits for reef fish species may constitute a viable alternative or complement to minimum sizes. Specific gear restrictions, in some cases in conjunction with geographic areas, may be required to reduce mortality on younger age classes of reef fishes, particularly snappers.

Development of federal regulations through FMP's should be more closely coordinated with data bases, research, and local knowledge of state agencies. Fishery Management Councils and state agencies should more closely coordinate regulations where possible to reduce inconsistences resulting in confusion to user groups and enforcement difficulties.

GULF OF MEXICO REEF FISH

I. DESCRIPTION OF FISHERIES

Fisheries for reef fish occur throughout the U.S. continental shelf of the Gulf of Mexico. Few well-developed coral reefs exist on the shelf region, although extensive areas of rocky live bottom with ledges and scleractinian coral heads occur off the west coast of Florida. The tropical influence of the Loop Current, flowing northward from the Yucatan Channel and around the eastern Gulf (clockwise), creates conditions favorable to the maintenance of live bottom communities featuring minor scleractinian corals, sponges, and octocorals along low-relief, rocky ledges and holes. The habitat is generally similar to the South Atlantic Bight region, and many of the same species are common to both regions. Offshore banks consisting of limited, relatively shallow areas, provide particularly productive fishing areas in the Gulf. The continental shelf, particularly off Texas and Florida, is generally more broad and gently-sloped than much of the the South Atlantic region, forcing fisheries in many cases to operate further from shore.

I.1. Commercial

Reef fish are the target of important commercial fisheries in the Gulf. These fisheries comprise approximately 1700 commercial fishermen (GMFMC, 1981). SAW/84/RFR/10 and SAW/84/RFR/16 summarize commercial landings data collected between 1957 and 1982, for various species groups. Figure RFR-9 gives total landings of snappers, groupers, and sea basses over this time period. Gulf data are influenced by closures of various Central and South American reef fishing grounds to U.S.-based fishing operations during the 1960's and 70's. Thus apparent declines between 1965 and the late 1970's are probably not representative of catch trends in the Gulf region (this is similar to the influence of closure of Bahamian spiny lobster grounds to U.S. fishermen on east coast of Florida landings data). The trends in the data may be further confused by the presence of a foreign fishery primarily for groupers, and to a lesser extent for snappers which operated off west Florida prior to 1976 and took an average of 1800 tons per year.

Commercial landings increased in 1982 for the fourth consecutive year. Therefore, although the 1978 catch was the lowest among the 26 years (1957-1982) examined, the 1982 catch was the highest since 1966 (Figure RFR-9). Landings of warsaw grouper, jewfish and other unspecified groupers increased from less than 5 million pounds in 1978 to a record 12.4 million pounds in 1982

(Figure RFR-11). By 1982, groupers represented nearly 59 percent of the commercial snapper-grouper catch (up from 43 percent in 1978). Red snapper landings increased from 4.5 to nearly 6 million pounds from 1978 to 1982 and reversed a long run decline that began in 1966 (Figure RFR-10). Nevertheless, in 1982 red snapper represented less than 29 percent of the overall catch, which was down from 39 percent in 1978 and 57 percent in 1966. Once, again it must be remembered that these landings contain unknown proportion which occurred outside U.S. waters.

Florida fishermen have captured an increasing share of the commercial snapper-grouper catch by landing over 81 percent of the commercial catch in each of the previous 5 years (1978-1982). In contrast, they landed: between 75 and 80 percent of the commercial catch during 1974-1977; between 68 and 71 percent during 1969-1973; between 62 and 68 percent during 1961-1968; and between 70 and 80 percent from 1957-1960. Data prior to 1957 were not examined.

Changes in the commercial fishery in recent years have included a shift of the commercial hand line fishery to deeper, offshore, or more distant waters and the introduction of bottom longlines as a new gear type in the fishery. Major commercial gears are now (1) hook and lines; (2) bottom longlines, and (3) traps. Divers harvest reef fish, particularly groupers, with spears and sell them commercially. Some gill netting, primarily for gray snappers, occurs on the Gulf side of the Florida Keys.

The introduction of bottom longlines represents the most significant recent change in commercial fishing for reef species in the Gulf. Groupers have become relatively more important in the overall reef fish catch primarily due to the increased use of bottom longlines, especially during 1981 and 1982. Prytherch[1] surveyed three major ports in the Gulf and found that approximately 300 vessels were engaged in bottom longlining during 1982 (Table RFR-16). Most vessels were converted shrimp trawlers, while some were traditional snapper-grouper boats and others were charter boats on commercial fishing trips. Prytherch sampled 90 bottom longlining trips which averaged approximately 3300, 3600 and 6000 pounds caught in the eastern, northern and western Gulf, respectively. Red, snowy, yellowedge and black grouper were the principal species landed in the eastern gulf, while yellowedge grouper and red snapper were the principal species caught in both the northern and western gulf. Prytherch reports that bottom longlining is labor intensive. Fishermen

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[1] The information contained in the ensuing discussion was obtained from: Prytherch, H. F. Draft manuscript titled "A descriptive survey of the bottom longline fishery in the Gulf of Mexico." Southeast Fisheries Center, Miami Laboratory, 75 Virginia Beach Drive, Miami, Florida 33149-1099.

set: 1140 hooks per day on an average trip of 8.7 days in the eastern gulf; 220 hooks per day for 4.8 days per trip in the northern gulf; and 1330 hooks per day for 8.5 days per trip in the western gulf.[2] Average crew size (including captain) was 3.5 in the eastern gulf, 3.8 in the northern gulf and 4.6 in the western gulf.[2]

I.2. Recreational

SAW/84/RFR/10 and SAW/84/RFR/16 summarize data available on recreational landings and effort in the Gulf. Recreational fishermen harvest significant quantities of snappers, groupers and sea basses in the Gulf of Mexico. During 1972-1974, the recreational harvest averaged approximately 26.5 million pounds (GMFMC, 1981) while the commercial harvest averaged 17 million pounds (Figure RFR-9). However, it is expected that the recreational harvest during those years was greatly overestimated. Recreational data were not available again until annual marine recreational fishing surveys were established in 1979. Currently, however, the results of the 1980 survey are the most recent available data (SAW/84/RFR/10). Results of the 1979 survey indicated that recreational fishermen caught approximately 9 million fish from species in the reef fish management unit (Table RFR-17). Red snapper and the sea basses were the principal species, with over 3.5 and 2.4 million fish caught, respectively. SAW/84/RFR/16 tabulates catch in number of fish by species and species groups by distance off shore, mode of fishing, and state. Most fish, particularly red snapper, were caught in oceanic waters by fishermen in boats out of Florida and Texas ports. In 1980, recreational anglers caught 6.3 million snappers and 2.1 million sea basses (SAW/84/RFR/10).

The 1979 survey indicated that recreational fishing effort for all species numbered 9.53 million trips (s.e. = 0.792 million) in Florida, 5.484 million trips (s.e. = 0.475 million) in Texas, 2.969 million trips (s.e. = 0.379 million) in Louisiana, 0.958 million trips (s.e. = 0.170 million) in Alabama and 0.640 million trips (s.e. = 0.087 million) in Mississippi. The number of trips on which snappers, groupers and sea basses were caught is unknown, but over 50 percent of recreational fishermen did not identify a target species. In addition, most fishermen rated the number of fish caught as the primary determinant of the level of satisfaction of a fishing trip. Other factors, such as species caught and the size of fish, were infrequently mentioned as primary determinants of satisfaction.

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[2]Prytherch does not indicate whether or not the 90 trips were randomly selected. Therefore, the averages from his sample may not be representative of the entire bottom longlining fishery.

Recreational fishermen and commercial-recreational fishermen who operate charter and headboats use hook and lines and spears. Charter operators sometimes employ electric-powered reels.

II. STOCK STRUCTURE

As with the South Atlantic region fishes, movements of adult and juvenile reef fishes have not been marked, and the distribution of larvae is not well understood. Northward movement of water through the Yucatan Channel into the Gulf would appear to make possible the transport of larvae from the Caribbean basin, particularly Mexico and Cuba. Also, possible transport of larvae from reefs and banks off the portion of the eastern coast of Mexico bordering the Gulf of Mexico to areas within the U.S. Fishery Conservation Zone has been little investigated. Both water movement patterns and geographical proximity create further potential for exchange of genetic material in the southeastern Gulf, particularly the Florida Keys. For lack of accurate information, and because of the regionalized nature of fishing effort in the Gulf, the working hypothesis that Gulf of Mexico reef fishes may presently be considered to operate as unit stocks is assumed. Like the stock structure hypothesis for the South Atlantic, this is largely conjecture.

III. STATUS OF STOCKS

Assessment of Gulf reef fish lags behind the South Atlantic region. GMFMC (1981) made gross estimates of maximum sustainable yield in biomass for all snappers and groupers combined and for sea basses based on aggregated data. Fairly extensive analyses, both stock assessments and other investigations bearing directly on status of Gulf reef fish population, are under way within the NMFS Southeast Fisheries Center. These are not yet completed. Some preliminary results are presented below.

III.1. Population Parameters

Few population parameters have been estimated directly for Gulf of Mexico reef fishes. However, it may be assumed that they are similar to those given for South Atlantic region reef fishes.

III.2. Catch Per Unit Effort Trends

CPUE for the snapper-grouper complex remained fairly stable over the years 1965-74 (GMFMC 1981).

III.3. Stock Assessment Analyses
III.3.1. Yield Per Recruit Analyses

Some preliminary equilibrium yield per recruit results, based on the Beverton and Holt model with adjustments made for survival probabilities for released fish, were presented to the workshop (J. Waters, personal communication). The analyses examined the expected effects of different minimum size limits under varying capture/release survival probabilities. Preliminary calculations suggest that when catch and release mortality is as low as 20 percent, minimum size limits could increase equilibrium yield per recruit for most species. Maximum yield per recruit, however, could be achieved only if fishing mortality rates were between 0.3 and 0.4.

III.3.2. Production Model Analysis

GMFMC (1981) fitted a simple parabolic production model to data on catch of all species of snappers and groupers combined and some gross effort data. Their cautious presentation of the results is consistent with the probable violation of assumptions underlying the model and the lack of any rigorous examinations of the effect of aggregating data for several species. A similar analysis was also completed for sea basses based on data for more than one species. These gross estimates of maximum sustainable yield were 51 million lbs for snappers and groupers and 500,000 lbs for sea basses. The results gave some indication that yields of snappers and groupers between 1965-1974 were: (1) fairly stable; and (2) near maximum sustainable yield, meaning that further increases in effort were unlikely to result in increased catch. Using similar data through 1982 would likely yield a different answer in view of the previously discussed increases in both total landings and effort in the Gulf. It should be noted, however, that much of the increase has been due to harvest of older age groups of relatively large, slow-growing species by bottom longlines in areas that were lightly fished until recently. Thus total landings could easily decline at present levels of effort in the near future.

III.3.3. Fishery Independent Indices

SAW/82/RFR describes indices developed from (1) bottom longlining and (2) trawl surveys conducted in the Gulf by NMFS. Estimates of catchability coefficients for fish traps on various species were also presented. This work has continued to date, but analyses were not yet available.

III.4. Current Status

The limited data and analyses available indicate that the resource of Gulf of Mexico reef fish is relatively stable. However, individual stocks have been impacted. Yield per recruit analyses indicate red snapper yields could be increased by changing the size at which they are first captured (J. Waters, personal communication). At the present time, the status of other individual stocks is either incompletely analyzed or unknown.

IV. EFFECT OF CURRENT REGULATIONS

States bordering the Gulf of Mexico have minimum size limits for groupers. Additionally, the Gulf Fisheries Management Plan defines several stressed areas in which power heads, traps, and roller trawls are prohibited. Also, the design and use of fish traps used within the FCZ is regulated. Finally, a minimum fork length of twelve inches is imposed for red snapper with an allowance of five incidentally harvested red snapper under twelve inches per person; all domestic vessels fishing trawls (with the exception of roller trawl vessels fishing in stressed areas) are exempt from the possession limit (GMFMC 1981). The effects of these regulations have not been evaluated.

V. RECOMMENDATIONS

V.1. Data Needs

Data needs for the Gulf of Mexico are generally similar to those described for the South Atlantic region. Data are generally less abundant for the Gulf. Given this lack of information, the greatest returns in terms of stock assessment would result from collection of size frequency data by species. It is important to collect this information for both the commercial and the increasingly important recreational fishery to insure the most representative sample possible. Collection of effort statistics by commercial gear type and recreational fishing mode should also be emphasized so that CPUE examinations will be possible in the near future.

V.2. Research Needs

Like data needs, most of the research needs described for the South Atlantic region apply equally to the Gulf of Mexico. In addition to those research requirements, investigations of particular value to the Gulf would include examination of CPUE data, including: (1) charter boat survey data; (2) Texas state headboat survey data; (3) bottom longline data; and (4) fish trap data. Bottom longline and fish trap information collected independent of the respective fisheries are important to examine. These CPUE examinations would lead to mortality estimates based on the Robson (1966) general linear model. Combined with catch data, the goal should be virtual population analysis and attendent assessment analyses, similar to SAW/84/RFR/2.

Estimates of capture/release survivability of selected species are particularly important to proposed minimum size regulations. As for the South Atlantic area, experiments on the relative species-specific catchabilities associated with fish traps of different designs and mesh sizes are needed to determine the effect of current regulations. Impacts of both bag limits and area closures should be evaluated.

V.3. Management

There is a potential for increasing the yield per recruit of several species by increasing the age (size) at first capture as suggested in SAW/84/RFR/16. These species include the red snapper. This potential can be realized for red snapper even if the mortality of released fish is relatively high. Therefore, management by a minimum size is an option that should be considered, if the management goal is to increase yield in weight per recruit.

PUERTO RICO AND U.S. VIRGIN ISLANDS REEF RESOURCES

I. DESCRIPTION OF FISHERIES

The fishery occurs from the edge of the island shelf at about 40 fathoms (240 feet) inshore to the waters edge. The edge of the platform is precipitous and sometimes falls from 10 fathoms to several hundred fathoms in a boat length. For this reason nautical charts indicate the 100 fathom contour as the edge of the shelf. Approximately two thirds of the shelf is within three miles of shore.

Of more than 300 species of reef fish inhabiting the nearby waters, some fifty species regularly enter the fishery in quantity. Of these only those primarily in the shallow water (40 fathoms or less) reef complexes are considered. The thirteen principal families and thirty five species which compose the bulk of the catch were enumerated in SAW/82/RFR. In addition, spiny lobster is an important segment of the reef resource catch.

The Puerto Rico and Virgin Islands local fisheries are composed of similar boats, gear and methods and are predominantly artisanal or small scale. Commercial fishermen interchangeably from the same boat use different gears such as traps, handlines, nets and spears, depending upon season and area. The present fleet has a few boats which are capable of setting strings of 1,000 fish traps or lobster pots, or of using electric or hydraulic reels. Some catches are taken by divers using spears. Some nets are set, haul seines are used from the beach and handlines are used from the shore and from boats. Recreational fishermen mostly use spears and hook and line.

I.1. Virgin Islands

A 1980 study shows that approximately 30% of the landings of the St. Thomas Fishermen's Cooperative was queen triggerfish. Squirrelfishes, hinds, trunkfishes, grunts and yellowtail snapper ranked next highest but each less than 10% of the total. Other studies fail to show such high landings of that particular species although it is always high on the list.

Most of the approximately 2,000 boats in the fishery are small (less than 26 feet) open and outboard powered. The older style wood, planked, wineglass-sterned designs are being replaced by plywood and fiberglass. Sails, oars and small horse-power engines are giving way to larger engines. There are a few larger inboard powered boats which fish farther afield, but the fishery remains predominantly small-scale and artisanal. An informal survey (1980) of seven U.S. mainland fishermen who had attempted to fish in the islands, revealed that they were unable to achieve an adequate return on their investment because of low catch rate, high local prices notwithstanding. All non-subsidized large boats fishing the region have failed to stay in the fishery.

The most common gear is the "fish pot" (approximately 21,000 units) with the West Indian "arrowhead" or "chevron" being preferred. Some comparative data on gear types used on St. Croix in 1975 and St. Thomas-St. John in 1977 to catch fish are available. A survey of fifty fishermen on St. Croix revealed that 72.3% of all fish were caught by trap. Line and bottom fishing each caught about 12% while nets were employed to harvest the remaining 3%. A survey of thirty eight fishermen on St. Thomas-St. John indicated that 67.7% of all fish were taken in traps. Nets were responsible for 18.5% and lines for 7.5%. Diving, bottom fishing and other methods accounted for the remaining landings. More recent data (1979/80 Annual Fishery Report) indicate that traps account for 77.2% of the total catch. The rest is distributed as follows: net 6.1%, hook and line 9.4%, spear 1.3%, by hand 6.0%.

Commercial catch of shallow water reef fish was relatively constant at approximately 900,000 pounds from 1974 to 1976 (Table RFR-4 SAW/82/RFR). Data show an approximate 100,000 pound increase in 1977/78 in landings.

I.2. Puerto Rico

Boats, gear, distribution of catch by gear type, and species composition of the catch are similar to the Virgin Islands.

Total catch of shallow water reef fish in Puerto Rico showed an increasing trend from 1971 to 1978. More recent data presented to this workshop (I. Morales-Santana, personal communication) indicate a decline in total landings of shallow water reef fish in Puerto Rico (Figure RFR-12). Total number of traps, on the other hand, increased markedly over the period 1977-1980 (Figure RFR-13).

II. STOCK STRUCTURE

As was discussed for South Atlantic region reef fishes, the scale of movement of adult and juveniles in Puerto Rico and U.S. Virgin Islands reef fish populations appears to be small relative to the shelf area. Also, the movement of larval fishes between shelf areas is largely unknown. In addition, the pelagic environment separating the shelves of Puerto Rico-U.S. British

Virgin Islands, St. Croix, Mona, Monito, and Desecheo may act as a barrier to mixing of reef resources (post larval fishes, spiny lobsters and conch) between shelves. However, there presently is no conclusive evidence for separating these resources into stocks. Therefore, a working hypothesis is that the reef resources of Puerto Rico and the Virgin Islands form single stocks.

III. STATUS OF STOCKS

Comprehensive stock assessment analyses have not been undertaken for the reef resources of Puerto Rico and the U.S. Virgin Islands due to the lack of detailed biological or catch and effort data. However, some data are available which may be indicative of the status of abundance in localized areas. These are now discussed.

III.1. U.S. Virgin Islands Reef Fish

SAW/82/RFR describes unpublished CPUE and effort data for the St. Croix and St. Thomas shelves. The data indicated declines in CPUE over time as effort increased, although an unreliable measure of effective effort was used (trap-year). Pointing out the local perception of decreased availability of reef fishes, SAW/82/RFR stated that the resource may have declined significantly.

SAW/84/RFR/3 reported data on length and weight for eight commercially important species in the Virgin Islands and Puerto Rico. Reasonable sample sizes were obtained for yellowtail snapper, Nassau grouper, queen triggerfish, and red hind. Forty two percent of yellowtail snappers and 31 percent of Nassau groupers were below the 12 inch minimum size proposed by the Caribbean Fishery Management Council. A large proportion of both red hinds and queen triggerfish were small relative to the maximum size of each species. The short time span (3 months) and relatively small sample size of the survey preclude broad conclusions. However, if the sizes recorded are indicative of the proportion of undersized fish in the catch, this observation is consistent with other evidences suggesting a state of decline in level of local shallow water reef fishes.

III.2 Puerto Rico Reef Fish

SAW/82/RFR states that the CPUE of trap fisheries in Puerto Rico are of a similar scale as those of the U.S. Virgin Islands. Total landings have declined during 1979-1982 (Figure RFR-12), gross effort (trap-year) increased during 1977-1980 (Figure RFR-13), and CPUE in lbs/trap-year has declined nearly 60% between 1977-1980. Levels of effort have appeared to be increasing with fishery productivity apparently declining since 1979.

Data on ranges of lengths and weights of yellowtail snapper, Nassau grouper, queen triggerfish, and red hind described in SAW/84/RFR/3 are generally similar between the Virgin Islands and Puerto Rico. Thus the results given above on data combined from both areas may in general hold for Puerto Rico and the Virgin Islands. The observation of disproportionate contributions of undersized fish to the catch coupled with declining landings is, again, consistent with the hypothesis of marked local depletion of shallow water reef fishes.

III.3 Spiny Lobster

SAW/84/RFR/13 summarizes recent spiny lobster landings information and gives the results of the most recent (October 1982-September 1983) size frequency survey on Puerto Rico. Reported annual landings were approximately 250,000 lbs. from 1970 to 1976, and over 400,000 lbs. for each year between 1977 and 1981, peaking at 512,000 lbs. in 1979. Landings were 359,000 lbs. in 1982 and 392,000 lbs. in 1983. Results of the size frequency survey show distribution of sizes and mean size to be fairly stable between months within the year. Average size in the catch has remained stable or increased slightly between years from 1979-1983. This may be partially explained by a belief among many fishermen that minimum size regulations proposed in the pending Caribbean Fishery Management Council have been implemented. The limited data available do not indicate any major declines in the spiny lobster resource.

Recently size frequency surveys were extended to the Virgin Islands. SAW/82/RFR references results of surveys conducted during 1978-1981. Average size was relatively constant and somewhat larger than that of Puerto Rico, possibly due to a local minimum size regulation. SAW/84/RFR/12 gives the results of the 1981-1982 survey, which show a marked decrease in the percent frequency of the largest size category (over 5.0 inch carapace length). The decrease was particularly apparent in St. Croix. Three possible explanations are: (1) a good recruitment year causing a decrease in the relative proportion of large lobsters; (2) change in selectivity of fishing effort, for example increasing recreational effort targeting larger individuals, and (3) increased fishing mortality. The former two explanations would be more consistent with constant or increasing total landings, the latter with decreased total landings. In the face of this uncertainty the fishery should be monitored closely.

IV. EFFECT OF CURRENT REGULATIONS

The U.S. Virgin Islands has a minimum carapace size limit of 3.5 inches on spiny lobsters and prohibits the use of hooks and chemicals. Both the U.S. Virgin Islands and Puerto Rico do not allow retention of berried lobsters and limit the use of spears and powerheads. Although the effects of these regulations have not been rigorously evaluated, the larger average size of lobsters in the landings of the U.S. Virgin Islands as compared to Puerto Rico may indicate the effectiveness of the minimum size limit.

A Shallow Water Reef Fish Plan is presently under development by the Caribbean Fishery Management Council. This plan will likely propose some minimum size and time/area closures. Initial evaluation of these management options are under preparation.

V. RECOMMENDATIONS

V.1. Data Needs

For both reef fish and spiny lobster resources, monthly data on size frequency, catch, and effort by species and gear would greatly enhance our ability to assess stocks. Size frequency data are the most attainable; all measurements should be taken in metric units to avoid confusion and inaccuracies resulting from conversion. While requiring more effort and expense, estimates of catch and effort by species, area, and gear can be obtained efficiently by using subsamples collected within the framework of a stratified survey design. It should be noted that smaller reef fish species more fully utilized in this area (e.g. scarids, acanthurids, balistids, holocentrids) should be emphasized along with other exploited species. A complementary stratified sampling of fishery-independent indices of abundance at periodic intervals using direct underwater observation and/or experimental fishing, would provide a valuable counterpart to the port sampling survey. Well-defined joint projects between the NMFS Southeast Fisheries Center, the Caribbean Fishery Management Council, CODREMAR, and Division of Fish and Wildlife (DCCA) at the U.S. Virgin Islands will provide expedient arrangements to address these data needs.

V.2 Research Needs

General research needs are similar to those described for the South Atlantic region. Special emphasis should be given to investigations of the effect of combined species categories on production model results and developing strategies for managing multispecies assemblages. The latter should include: (1) studies of the catchabilities associated with different fish trap designs; (2) the potential for management by a system of rotating closed areas; and (3) adaptation of existing yield per recruit models to incorporate possible effects of interspecific interaction on results predicted for minimum size regulations or regulation of fishing mortality rates. Investigation of the effect of ciguatera on the dynamics of the fishery, particularly with regard to size selective harvesting, is especially important in this region (particularly the Virgin Islands). The presence of offshore banks harboring essentially virgin populations of reef fish (due both to inaccessibility and occurrence of ciguatoxic fishes) off the Virgin Islands affords an excellent opportunity for: (1) investigation of effects of ciguatera on fishery dynamics; (2) estimation of natural mortality coefficient, M, for selected species, and (3) estimation of virgin standing stock size through standard population estimation techniques. Intensive experimental fishing over relatively short time periods could accomplish these three objectives. Another important local research need is an investigation of the influence of ghost traps on total mortality of reef fish species. All fish trap studies should treat separately the deep water fishery that operates outside the top of the insular shelf break and the shallow water fishery operating on the platform shoreward of the break. For spiny lobster, monthly estimates of effort and landings should be examined using a model similar to that used in SAW/84/RFR/4. Recursive estimation of fishing mortalities, under the described assumptions, are possible with even fairly weak data. Again, well-defined joint projects between the NMFS Southeast Fisheries Center, the Caribbean Fishery Management Council, CODREMAR, and Division of Fish and Wildlife (DCCA) at the U. S. Virgin Islands will provide expedient arrangements to address these research needs.

V.3 Management

Present data do not yet allow comprehensive scientific advice on the management of reef fish and spiny lobster resources in the U.S. Virgin Islands and Puerto Rico. However, the available evidence indicates that fishing may be excessive. SAW/82/RFR described apparent declines in total fishery productivity and CPUE with increasing effort in selected shelf areas. More recent data presented to the workshop (I. Morales-Santana) indicate similar trends for the Puerto Rican shelf. SAW/84/RFR/3 indicated a lack of older age classes in the catch of four commercially important fish species. SAW/84/RFR/12 showed a decrease in proportion of oldest spiny lobster year classes in the Virgin Islands. These, along with qualitative local perceptions, indicate that these resources may have surpassed their maximum productivity and that methods of reducing fishing mortality be explored.

Yield per recruit analyses for species of reef fish common to other regions suggest that yield per recruit could potentially be increased by increasing age of first capture in the Caribbean region. Area closures should also be examined. In the interim, reef fish and spiny lobster resources should be monitored carefully.

GULF OF MEXICO AND SOUTH ATLANTIC SPINY LOBSTER

I. DESCRIPTION OF FISHERIES

I.1. Area and Gears

Spiny lobsters have continued to be one of the most intensively exploited reef resources in the southeastern United States. In the five years since the fishery data were last examined, the number of traps used in the commercial fishery increased, recreational activity has been high and reported landings have been large.

U.S. commercial and recreational fisheries for spiny lobsters are limited primarily to southeastern Florida and the Florida Keys. Wood slat traps are the predominate gear in the commercial fishery. Boat sizes range from 16-55 feet, and most are constructed primarily of fiberglass.

Monroe County is by far the largest producer of spiny lobster. Craft in the lower Florida Keys (Marathon to Key West) tend to be larger than those fishing off the upper Florida Keys (Key Largo to Long Key). Lower Keys craft now average 50 feet in length and may fish up to 5000 traps, using a two-week soak time. Trips last up to 5 days and a craft may fish lines of traps many miles apart. A buddy system is often used so that one craft may watch another's trap line to reduce poaching. In the upper Florida Keys, small day boats still dominate the commercial fishery, fishing 500-800 traps per boat.

Considerable quantities of spiny lobster are also taken by hand by recreational and commercial divers using scuba, houka, or free diving. Commercial divers usually use scuba in the channels passing under the Overseas Highway and in various shallow natural and artificial habitats between the Keys and the offshore reef break. Significant commercial diving effort occurs in Florida Bay south of the Everglades National Park and into the Gulf of Mexico. Recreational divers exploit similar areas. In addition to diving, a small proportion of the recreational catch is from boaters using lights and bully nets at night on shallow flats and bays.

Little effort for spiny lobsters occurs north of Monroe County on the west coast of Florida. The majority of lobsters not caught in Monroe County come from Dade County. Like the upper Keys, small day boats dominate the fishery. Limited trapping occurs in South Biscayne Bay north of the spiny lobster preserve located west of Elliott Key. Commercial diving is not prevalent in Dade County. Recreational divers work the finger channels and flats between Cape Florida and Ragged Keys and the creeks from Ragged Keys to Key Largo, as well as numerous natural and artificial habitats on the shelf between the Keys and the offshore break of the Florida reef tract.

Commercial trapping is sharply curtailed north of Dade County. Limited diving effort, primarily recreational, is expended as far north as the West Palm Beach area.

I.2. Catch Trends

Commercial landings on the east coast of Florida peaked in the early 1970's (Table RFR-18); however, these contain an unknown portion of Bahamian catch. Presently the east coast fishery is operating at a low level. Landings on the west coast of Florida have remained high since 1979 (Table RFR-18) except for a large decline in 1983.

I.3. Effort Trends

No detailed within-season effort data are available for the spiny lobster fishery. Number of traps reported per year have increased until the 1980's on the west coast of Florida (Table RFR-18). However, it must be noted that these values are numbers reported by fishermen and do not denote the frequency of use.

II. STOCK STRUCTURE

The stock structure of spiny lobster is uncertain. Spiny lobsters range from North Carolina on the east coast of the U.S. south to Rio de Janeiro, Brazil, including Bermuda, the Bahamas, Gulf of Mexico, and throughout the Caribbean. Two sources of recruitment to the southern Florida fishery have been hypothesized: (1) larvae from local spawning are retained in the area by various eddies, meanders, and current velocity changes; (2) larvae spawned in the West Indies or Gulf of Mexico are carried by currents to southern Florida where they settle as postlarvae. The relative importance of the two sources is unknown. The stock assessments conducted to date assume that local spawning is the significant element of total recruitment.

III. STATUS OF STOCKS

III.1 Population Parameters

III.1.1. Growth Rate

Estimates of growth have been variable. Problems in separating growth of the tail from growth of the carapace, and complications caused by molting frequency and growth increment per molt make accurate estimates of growth rates difficult. GMSAFMC (1982) reviewed the available growth studies and concluded the von Bertalanffy growth coefficient, K, for carapace growth to be between 0.2 and 0.3 and the best estimate of $L_{(\lambda)}$ to be 190mm carapace length (CL).

III.1.2. Natural Mortality Rate

Natural morality rate (M) has been estimated by several studies reviewed in GMSAFMC (1982) and adopted M = 0.6 as the best estimate (also in SAW/84/RFR/4). Published estimates of natural mortality (M) range from 0.26 to 1.03.

III.1.3. Fishing Mortality Rates

SAW/84/RFR/4 estimated an index of beginning season abundance and monthly fishing mortality rate (F) based on monthly catch data from the west coast of Florida and the Florida Keys by two ad hoc methods (Table RFR-19). The seasonal fishing mortality rates for the period 1978-1984 have been high, from 1.10 to 1.75.

III.2 Catch Per Unit Effort Trends

Annual landings, number of traps available for use during the year and number of craft (boats and vessels) have shown a general increasing trend from 1952 to the early 1970's in the Florida west coast (Table RFR-8). (Note: number of traps fished per year are as reported and may not reflect actual usage.) Since the early 1970's landings have been variable with no apparent trend, while effort (traps) has continued to increase (Figure RFR-15). The number of craft in use in the fishery peaked in the middle 1970's, but the number of traps per craft has increased.

These effort data (number of traps) do not indicate the actual usage (soak time); therefore, it is unlikely that landings per trap is an unbiased index of abundance. However, landings per trap has shown a marked decrease in the west coast fishery (Table RFR-18).

III.3 Stock Assessment Analyses

III.3.1 Yield Per Recruit Analysis

The yield per recruit of spiny lobster was examined to determine the effects of fishing practices on the yield (SAW/84/RFR/4). Results (Figures RFR 16 and 17) show that at present annual fishing mortality rates (approximately 1.25 - 2.0), if the baiting mortality of short lobsters is 40 percent of the legal mortality, then the loss in yield per recruit is approximately 20 - 50 percent (assuming illegal short mortality is 40 percent or less of legal mortality). If the minimum size is increased, the potential yield per recruit is increased slightly, but baiting practices would more than use up this potential. If the baiting mortality is 20 percent of the legal mortality, then the percent loss in yield per recruits is approximately 10 - 30 percent.

Finally, baiting mortality appears to have the most impact on yield per recruit. This is because it is a non-harvested source of mortality which impacts the small lobsters. Additionally, even if an alternative baiting practice caused a reduction in effective effort, then this would further improve the yield per recruit. Therefore, reduction in the unharvested mortality of shorts has the most potential for improving yield over any other single management action examined in this study.

III.3.2 Abundance Indices

SAW/84/RFR/4 estimated abundance indices for the beginning of the season, the end of the season and for new recruits at the beginning of the season. The ending season index was interpreted as a spawning stock index, noting that the end of the legal fishing season corresponds to the beginning of the spawning season. The spawning stock index is currently at low levels, but there has been no apparent decline in recruitment. Even if the relationship were weak, highly variable recruitment levels would be expected to accompany the low number of spawners that appear to have occurred for some years. This is not the case. Recruitment has not been particularly variable. Therefore, the hypothesis that a major source of recruitment to this fishery comes from outside this area can not be rejected.

III.4. Current Status

The south Florida lobster fishery has become extremely intensive with high fishing mortality rates occurring over a short period of time. Almost all of the natural recruitment to the fishery is removed early in the fishing season. Thus, the fishery has come to rely on a single season's recruitment, which accentuates the problems of reduced levels of yield per recruit.

Although the adult abundance (lobsters surviving their first season) has declined noticably since 1970, there has been no strong indication of reduced recruitment. However, if the level of adults remains low and exogenous conditions cause reductions in recruitment, then the fishery could suffer lower yields. The intensity of the fishing that is presently occurring warrants close monitoring of recruitment levels.

IV. EFFECT OF CURRENT REGULATIONS

The Gulf of Mexico and South Atlantic spiny lobster resource is regulated by the FMP implemented jointly by the two regional Fishery Management Councils. Regulations include: (1) a minimum legal size of 3.0 inches (76mm) carapace length; (2) a closed fishing season corresponding to spawning season; (3) prohibition of capture by spear; and (4) prohibition of retaining berried females. The current regulations allow retainment of sublegal-sized lobsters (shorts) in traps as attractants. The effect of this latter practice was estimated by SAW/84/RFR/4 to result in significant losses in yield per recruit to the fishery. The minimum legal size is close to size of sexual maturity, but despite high rates of removal recruitment has apparently remained fairly constant. The closed season has resulted in a markedly uneven distribution of fishing effort over the year. Much of the annual fishing mortality appears to be inflicted during the first four (4) months of the season.

V. RECOMMENDATIONS

V.1 Data Needs

There are several weaknesses in the data base which must be improved by further data collection before the accuracy and precision of the results can be improved and the management advice made more certain. Several of these weaknesses could qualitatively change the results of the present assessment. Therefore, the improvements in data are imperative for further assessment work.

First, the unrecorded catch from all sources (recreational, shorts and unreported commercial catches) must be quantified, including the distribution of these catches within a season. In particular, the distribution and magnitude of recreational catch has the most potential for altering the above conclusions.

Secondly, effort data needs to be collected within the season to establish effort patterns and within-season abundance trends. These data are needed to insure that the fishing mortality rate estimates are precise. Collection of commercial effort is probably the easiest to do and should provide adequately precise estimates of fishing mortality rates.

Finally, monthly size distributions for both recreational and commercial catches should be collected so that the monthly catch in weight can be converted to numbers.

V.2 Research

Analytical research possible with the existing data has been essentially satisfied by SAW/84/RFR/4. Improved assessments await collection of improved data as outlined above.

The need for careful monitoring of recruitment could be partially fulfilled by biological surveys of larval settlement and juvenile abundance.

Several more practically oriented research needs were described in SAW/82/RFR. These were development of alternatives to using sub-legal sized lobsters as attractments in traps, research on regulations to minimize user conflict and systematize trap retrieval, and development of an escape panel in traps that would prevent retention of shorts.

V.3. Management

Analyses from SAW/84/RFR/4 critically examined four potentially controllable variables which contribute to yield per recruit. Specifically, these are: (1) the legal size; (2) the magnitude of fishing; (3) the distribution of fishing; and (4) mortality of sublegal lobsters, both those retained illegally for sale and those used as attractants in traps. Baiting mortality appears to have the most impact on yield per recruit; therefore reduction in the unharvested mortality of sublegal-size lobsters has the most potential for improving yield and should be considered for management action.

SAW/84/RFR

GULF OF MEXICO AND SOUTH ATLANTIC STONE CRABS

I. DESCRIPTION OF FISHERIES

Stone crabs are caught commercially in the Gulf of Mexico from the upper Florida Keys to the upper Florida west coast. Most landings are from southwest Florida and the Keys. The number of commercial fishermen has increased greatly over the history of the fishery and is presently estimated to be about 400. About 100 vessels (with three or more crew) and 200 smaller boats (2 or fewer crew) are operating in the commercial fishery. Traps are the only gear used commercially and fishing trips are usually one day long at intervals from a few days up to two weeks. The commercial catch has been 2 to 3 million pounds of claws in recent years. The recreational catch is believed to be small.

A minimum claw size of 2.75 inches and a closed season (May 15 to October 15) are the two major management measures designed to protect the stock. One other regulation instituted to end conflict between stone crabbers and shrimpers in the Gulf of Mexico defines a "line of separation" between shrimping and crabbing grounds.

II. STOCK STRUCTURE

Stone crabs are found in the northern Gulf of Mexico from Texas to Florida, south through the Dry Tortugas, and to North Carolina on the South Atlantic coast. Substantial numbers occur off the Carolinas, but commercially fishable abundances occur primarily in a contiguous area along the western coast of Florida through the Florida Keys to the Dry Tortugas. The majority of catch is from this area. Some evidence suggests that this commercial fishing zone corresponds to an area where more than one biological unit stock of stone crabs exists, raising the question of separate management strategies between areas. For the purpose of this stock assessment report, however, the fishery is considered to be directed at a single stock.

III. STATUS OF STOCKS
III.1. Population Parameters

No new estimates of growth, mortality, or claw regeneration rates were presented at this Workshop.

III.2. Catch Per Unit Effort Trends

The 1982-1983 season continued the strongly increasing patterns in both landings and effort (numbers of traps used) since

1962. Figure RFR-18 shows the trends in landings, effort and CPUE. In only two of the 21 seasons has effort declined from the previous year, and over half of the seasons have been "record breakers" in terms of pounds landed. The numbers of vessels, boats and crew indicate that increasing numbers of fishermen are participating in the fishery (SAW/84/RFR/14). There has been an increase in average size of fishing craft, with the ratio of boats (2 or fewer crew) to vessels (3 or more crew) decreasing from 3:1 in 1977-78 to 2:1 in 1982-83.

The annual average landings per trap per year (total landings divided by total traps) decreased by a factor of three since the 1962-63 season. However, it has remained relatively steady since 1974-75 (6 to 8 pounds per trap) although the number of traps has more than doubled.

Data for the most recent season (1983-84) are not yet available, though some dealers on the upper west coast have apparently spoken of much lower landings than last year.

SAW/82/RFR points out that pounds of claws per trap-year may not accurately reflect abundance of stone crabs because infrequently pulled traps and traps fished for only part of the season are weighted equally with all other traps. A number of socioeconomic and biological factors influencing number of pulls or length of season fished were mentioned. Also discussed was the marked decline in catch per trap pull during the 1981-82 season compared to lack of intraseasonal trends in other years.

III.3. Stock Assessment Analyses

III.3.1. Production Model Analysis

Production models have been previously fit to the landings and effort data through the 1979-80 season. However, use of the resulting curves and estimates of MSY were discouraged and the inadequacy of the available effort data was pointed out (SAW/84/RFR/14). Thus the MSY estimates proposed were averages of observed landings for recent seasons. The 1981-82 and 1982-83 seasons' landings exceed the MSY estimate in the Fishery Management Plan (2.4 million pounds). However, there is no evidence of overfishing on the basis of these data. The plot of yield versus traps in Figure RFR-19 suggests that MSY cannot be estimated with these data since the trend in yield is markedly linear.

The inadequacy of this effort measure makes it unlikely that this historical data base will be useful for estimation of production model parameters. Reasons that the effort data are inappropriate include: (1) the number of traps is estimated yearly by dealers and is probably the maximum used, or "traps owned", which does not reflect the amount of time that traps are actually fishing or the number of times they are harvested during the season; (2) it does not account for soak time; (3) the distribution of traps over the grounds is not known, while the abundance of crabs and size of claws varies among areas and months.

Other factors which contribute to the difficulty in interpreting and using these catch and effort data are: (1) there was expansion of the fishing grounds in the 1970s in the Everglades-Florida bay region, expansion to northern areas (Crystal River, FL) and a continual movement to fishing in deeper waters; (2) some crabs may live to be harvested more than once; even though this number is thought to be low, that is not well-documented; and (3) claw size and location of fishing are not reported in the catch and effort statistics. Therefore, a new production model fit to these data will not provide any additional insight into the status of the stock.

III.3.2. Other Analyses

SAW/84/RFR/14 estimated intra-seasonal trends in stone crab abundance by estimating CPUE (catch per trap pull) based on a general least squares linear regression model. Abundance, or CPUE, was the dependent variable. Dummy variables representing CPUE levels by year, month, county, and zone were the independent variables or main effects. All data were obtained from fisherman logbooks. In addition to the main effects model, various combinations of main effects and two-way interactions among months, counties, and zones were estimated. These regressions are essentially factorial design ANOVA's, whose purpose is to adjust effective effort (Robson, 1966). Zones are defined in SAW/84/RFR/14.

The regression models were significant, although amount of total variation explained was relatively low (SAW/84/RFR/14). Figure RFR-20 illustrates estimated CPUE by year, month, and county for selected zones from the main effects model. Parameter estimates from the main effects model and models incorporating interaction terms (see SAW/84/RFR/14) indicate the following trends: 1) decreasing CPUE from the beginning to the end of the season, with a slight rise in February; 2) lower CPUE in Collier than in Monroe county; 3) higher CPUE in zones 2 and 3 than in zone 1; 4) little annual variation among CPUE levels in the last four years, though CPUE in the 1981-1982 season was somewhat higher than in the other three seasons. Possible interpretations are: (1) for high sustained CPUE through the season and upturn in CPUE in early winter, that there is some correspondence of these factors with the molting of large numbers of females to the legal size after spawning in the fall; and (2) for variations in CPUE among zones during the year, that migrations, especially movement associated with mating, may occur.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

Current management procedures (GMFMC, 1979) include the minimum claw size and a closed season intended to protect a portion of the spawning stock. The Everglades National Park prohibits declawing female crabs. It is illegal to land whole crabs, except in the Park, where the whole crab must be held. Elsewhere, crabs must be kept alive and shaded on board the fishing vessels until they are declawed and returned to the water. Crab traps must have a biodegradable slot to allow escapement from lost or abandoned traps. There is a line separating crabbing areas from shrimping areas to protect crab gear from damage by shrimp trawls. However, crabbing is allowed in the shrimping area at the risk of the crabber, so there is essentially no closed area to crabbing.

Although no conclusive evaluation has been made of the effects of these regulations on the production of the fishery, some observations can be made. First, fishermen do not immediately declaw and return crabs to the water, because substantial periods of time on ice before cooking cause the meat to stick to the shell, which is unacceptable to buyers. Second, these crabs are usually declawed in route to landing ports. This practice may increase mortality of released crabs due to exposure and artifically redistributes a portion of the population. Impact of neither factor has been investigated.

V. RECOMMENDATIONS

V.1. Data Needs

Presently, three data collection systems target stone crabs and those who fish for or sell them: (1) fishermen and dealer logbooks required by the GMFMC FMP; (2) the NMFS port agent monthly landings reporting system; and, just recently being planned, (3) a State of Florida system of fishermen logbooks. The data collected by each system should be analyzed for its accuracy and usefulness to assessing the resource over an initial period of overlap, then one or more sampling schemes could possibly be partially or wholly eliminated, or replaced by a superior unified system. This evaluation should consider the following: (1) present coverage of catch from federally required logbooks filled out by fishermen and dealers is incomplete and probably not representative, thus more complete records and firmer resolution of catch areas and times are needed to more accurately estimate trends in abundance; and (2) NMFS port agents continue to report more catch than logbooks probably indicating more complete coverage by this system. Data on catch recorded by statistical grids similar to those used for shrimp would be highly desirable. In addition, institution of an observer system could be used to fulfill the following data needs: (1) tagging and recapture; (2) more detail on catch, including claw size sampling, proportion of declawed individuals caught, and proportion of one- and two-clawed crabs in the catch; and (3) sex ratios by area.

V.2. Research Needs

The following research needs have been identified:

(1) Estimation of natural mortality rates and mortality of released, declawed crabs, including increased mortality due to cannibalism by clawed crabs in traps.

(2) Study of the effect of redistribution of individuals by holding them on board for release just before landing. On a broader scale, investigation of the effect of clumped distribution of the population in space on fishing effort distribution over the season. Density of traps per unit area as a function of distribution patterns of stone crabs, and changes over the fishing season, could be useful for explaining patterns of CPUE.

(3) Relative catchability coefficients of crab traps for clawed versus declawed crabs has potential value for adjusting CPUE.

(4) Estimation of growth and claw regeneration rates.

(5) Continued investigation of methods for standardizing effort.

(6) Intensive experimental fishing in selected areas to estimate area-specific productivity through sustainable-yield asymptotes, followed by extrapolation to the total fishing area to estimate potential sustainable yields.

(7) Tag-recapture studies to determine seasonal movement patterns, to support definition of stock structure and to explain area-time trends in CPUE.

(8) Analysis of claw size frequencies by time and statistical area grid, and analysis of sex ratio by area, to help monitor population structure over time.

(9) Investigation of possible periodicity in observed CPUE over the history of the fishery for biological interpretation, which could in turn aid our ability to explain or predict current and future catch trends.

V.3. Management

Total landings data and vessel logbook data through the 1982-1983 fishing season indicate that recent high levels of fishing effort have not resulted in subsequent lower yields or catch per trap pull. Thus at present there is no basis for additional restrictions on fishing to protect the stock or to improve the yield. The minimum claw size regulation and closed season appear to be effective.

Table RFR-1. South Atlantic headboat catches of reef fish, 1980-1982[a]

Fishing area	1980	1981	1982
		- Million pounds -	
Cape Lookout, N.C.	0.321	0.332	0.436
Cape Fear, N.C.	0.168	0.170	0.196
Cape Romain, S.C.	0.835	0.782	0.991
Northeast Florida	0.617	0.804	0.867
Southeast Florida	0.409	0.442	0.340
Florida Keys	0.235	0.284	0.289
Total reef fish	2.585	2.814	3.119
Total all species	3.910	4.525	4.334

[a]Headboat catches were originally summarized by species and fishing area at the Beaufort Laboratory. Catches of reef fish in North Carolina, South Carolina and northeast Florida were calculated from the original summaries by subtracting catches of king mackerel from the total catch. For southeast Florida and the Florida Keys, the reef fish catches were calculated as total catch minus the catches of king mackerel and unspecified miscellaneous fishes.

Table RFR-2. Fishing effort (numbers of vessels, trips and angler-days) in the south Atlantic headboat fleet, 1981-1982

Fishing area	1981			1982		
	Vessels	Trips	Angler-days	Vessels	Trips	Angler-days
Cape Lookout N.C.	3	318	13,164	3	388	17,455
Cape Fear, N.C.	4	258	6,512	4	266	9,482
Cape Romain, S.C.	18	2,214	58,390	20	2,437	67,519
Northeast Florida	11	2,544	72,070	10	2,341	69,616
Southeast Florida	33	14,369	154,747	32	15,737	154,558
Florida Keys	16	4,182	55,875	15	3,980	55,072
Total	85	23,885	360,758	84	25,149	373,702

Source: National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, North Carolina 28516.

Table RFR-3. List of South Atlantic reef fish species for which the von Bertalanffy growth model has been fitted to age-length data. Specific parameters appear in the reference listed for each species.

SPECIES	REFERENCE
Serranidae - Groupers and Sea Basses	
Black sea bass, Centropristes stinatus	SAW/84/RFR/5
Gag, Mycteroperca mir colepis	SAW/84/RFR/5
Scamp, M. phenax	SAW/84/RFR/5
Red hind, Ephinephelus guttatus	SAFMC (1983)
Red grouper, E. morio	SAFMC (1983)
Graysby, E. cruentatus	SAFMC (1983)
Speckled hind, E. drummondhayi	SAW/84/RFR/5
Snowy grouper, E. niveatus	SAW/84/RFR/5
Lutjanidae - Snappers	
Mutton snapper, Lutjanus analis	SAW/84/RFR/7
Gray snapper, L. Griseus	SAFMC (1983)
Red snapper, L. campechanus	SAW/84/RFR/5
Yellowtail snapper, Ocyurus chrysurus	SAFMC (1983)
Vermilion snapper, Rhomboplites aurorubens	SAW/84/RFR/5
Sparidae - Porgies	
Red porgy, Pagrus pagrus	SAW/84/RFR/5
Haemulidae - Grunts	
Tomtate, Haemulon aurolineatus	SAFMC (1983)
White grunt, H. plumieri	SAW/84/RFR/5

Table RFR-4. List of South Atlantic reef fish species for estimates of natural, fishing and/or mortality rates (M, F and/or Z) have been made. Specific parameters appear in the reference listed for each species.

SPECIES	REFERENCE
Serranidae - Groupers and Sea Basses	
Black sea bass, *Centropristes stinatus*	SAW/84/RFR/5,6
Gag, *Mycteroperca mir colepis*	SAW/84/RFR/5,6
Scamp, *M. phenax*	SAW/84/RFR/5
Yellowfin grouper, *M. venenosa*	Munro (1983)
Red hind, *Ephinephelus guttatus*	Munro (1983)
Red grouper, *E. morio*	SAW/82/RFR/1
Graysby, *E. cruentatus*	Munro (1983)
Speckled hind, *E. drummondhayi*	SAW/84/RFR/5,6
Snowy grouper, *E. niveatus*	SAW/84/RFR/5,6
Nassau grouper, *E. striatus*	Munro (1983)
Lutjanidae - Snappers	
Mutton snapper, *Lutjanus analis*	SAW/84/RFR/7
Red snapper, *L. campechanus*	SAW/84/RFR/5,6
Yellowtail snapper, *Ocyurus chrysurus*	Munro (1983)
Blackfin snapper, *L. buccanella*	Munro (1983)
Black snapper, *Apsilus dentatus*	Munro (1983)
Sparidae - Porgies	
Red porgy, *Pagrus pagrus*	SAW/84/RFR/5,6
Haemulidae - Grunts	
Tomtate, *Haemulon aurolineatus*	SAW/84/RFR/4,SAW/84/RFR/6
White grunt, *H. plumieri*	SAW/84/RFR/5,6
Balistidae - Triggerfishes	
Gray triggerfish, *Balistes capriscus*	SAW/84/RFR/6

Table RFR-5. Catch per angler-day in the south Atlantic headboat fishery, 1980-1982

Fishing area	1980	1981	1982
Cape Lookout, N.C.			
Fish/day[a]	6.4	8.5	8.8
Pounds/day	21.2	25.3	25.0
Cape Fear, N.C.			
Fish/day[a]	7.5	11.7	8.8
Pounds/day	19.7	26.4	20.8
Cape Romain, S.C.			
Fish/day[a]	3.0	3.5	6.9
Pounds/day	13.1	13.4	14.7
Northeast Florida			
Fish/day[a]	5.4	4.7	4.5
Pounds/day	9.5	11.7	12.9
Southeast Florida			
Fish/day[a]	2.8	3.2	2.4
Pounds/day	9.7	12.7	9.0
Florida Keys			
Fish/day[a]	3.7	4.7	5.1
Pounds/day	7.5	7.7	7.6

[a]The headboat survey collects biomass, but not numbers, of black sea bass caught. Therefore, fish per angler-day excludes the number of black sea bass caught whereas pounds per angler-day includes the black sea bass catch.

Table RFR-6. Average weights per fish landed by North and South Carolina headboats, selected species, 1977-1982

Area/species	1977	1978	1979	1980	1981	1982
			- Pounds per fish -			
Cape Lookout, N.C.						
Red porgy	2.3	3.1	2.8	2.4	2.0	2.0
Vermilion snapper	3.1	3.2	3.2	3.0	2.2	2.0
Red snapper	6.8	15.3	11.5	7.1	7.1	14.6
Ephinephelus groupers	11.0	7.2	7.0	8.0	6.9	7.7
Mycteroperca groupers	10.6	13.4	10.5	10.3	7.8	8.9
Cape Fear, N.C.						
Red porgy	2.4	2.6	2.5	2.5	1.6	1.9
Vermilion snapper	2.3	3.8	1.8	1.6	1.3	1.1
Red snapper	7.1	9.9	12.0	4.0	4.2	9.0
Epinephelus groupers	4.1	6.8	7.4	4.7	2.0	5.4
Mycteroperca groupers	11.5	12.0	10.5	8.8	7.9	7.4
Cape Romain, S.C.						
Red porgy	2.3	2.7	2.3	2.0	2.0	1.4
Vermilion snapper	1.4	1.3	1.0	1.1	1.4	0.9
Red snapper	8.4	7.2	14.3	4.0	6.4	9.0
Epinephelus groupers	6.1	9.7	9.1	7.1	6.1	5.8
Mycteroperca groupers	14.1	11.8	10.7	10.4	7.2	5.9

Table RFR-7.

A. Yield-per-recruit parameters for snappers (Lutjanidae).

Species	t_c	t_r	t_o	t_x	K	Z	M	F	L_{oo} (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE*
L. campechanus (Red snapper)	2		0.10		0.175	0.80	0.30	0.50	950	$2.04 \times 10^{-5} TL^{2.953}$	Louisiana All areas	Nelson and Manooch (1982)
			-0.10		0.170	0.43	0.30	0.13	941		Panama City	
			-0.01		0.155	0.58	0.30	0.28	970	$1.36 \times 10^{-5} L^{3.017}$	Daytona, Florida	Nelson and Manooch (1982)
			-0.01		0.165	0.35	0.30	0.05	970	$3.15 \times 10^{-5} L^{2.887}$	North and South Carolina	Nelson and Manooch (1982)
	5			16	0.170				941		Gulf of Mexico	Nelson (1980)
			0	16	0.160				975			
L. griseus (Gray snapper)				18	0.101				890		Florida	Manooch (1982)
			-1.2745	21	0.0878				890	$2.4 \times 10^{-8} L^{2.9122}$	Northeast Florida, Gulf of Mexico	Manooch and Matheson (unpubl.)
O. chrysurus (Yellowtail snapper)			-0.305	14	0.288				600.2	$6.13 \times 10^{-5} L^{2.76}$	Southern Florida, East and West Coasts of Florida	Johnson (unpubl.ms.)
					0.160		0.20		529	$7.327 \times 10^{-5} L^{2.73927}$	Cuba	Piedra (1965)
R. aurorubens (Vermilion snapper)			0.1277		0.198				626.5	$1.722 \times 10^{-5} TL^{2.9456}$	North and South Carolina	Grimes (1976)
L. buccanella (Blackfin snapper)									470	Log W= 3.05 Log(FL)$^{-4.86}$	Puerto Rico	Boardman and Weiler (1980)
L. vivanus (Silk snapper)	2								1170	Log W= 3.10 Log(FL)$^{-5.0}$	U.S. Virgin Islands	Boardman and Weiler (1980)
L. analis (Mutton snapper)					0.120	0.87	0.20	0.67	807.5		Cuba	Baisre and Paez (updated)

*Reference are in Source Document for SAFMC (1983).

(Table RFR-7 cont.)

B. Yield-per-recruit parameters for sea basses and groupers (Serranidae).

Species	t_c	t_r	t_o	t_x	K	Z	M	F	L_{oo} (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE*
C. striata (Black sea bass)			0.1855	10	0.222		0.27		350	$2.654 \times 10^{-5}L^{3.0237}$	North and South Carolina	Mercer (1978)
						0.60-0.83	0.30	0.30-0.53			South Carolina and Georgia	Low (1981)
				10	0.088				625		South Carolina	Cupka et al. (1973)
E. morio (Red grouper)	1		-0.449		0.179	0.322			672	$4.3441 \times 10^{-5}L^{2.9287}$	Central West Florida	Moe (1969)
	3		0.090574	25	0.11269	0.48	0.20	0.28	928	$1.4791 \times 10^{-4}L^{2.5895}$	Mexico	Melo (undated)
					0.159	0.48	0.33	0.15	802		Mexico (updated)	Baisre and Paez (undated)
E. drummondhayi (Speckled hind)	3.3		-1.92	15	0.088		0.09-0.30	0.21-0.31	1105	$1.1 \times 10^{-8}L^{3.073}$	North and South Carolina	Matheson (1981)
E. niveatus (Snowy grouper)	3.3		-2.32	17	0.063		0.06-0.30		1350	$7.0 \times 10^{-8}L^{2.755}$	North and South Carolina	Matheson (1981)
E. guttatus (Red hind)	3		-0.44	8	0.180		.20		420		Caribbean, Florida Keys, Bermuda	Burnett-Herkes (1975)
	2				0.240	0.68-0.90			520	$1.76 \times 10^{-5}L^{2.960}$	South Jamaica Shelf	Thompson and Munro (1974b)
E. cruentatus (Graysby)			-0.94	10	0.13		0.13		415	$0.0121L^{3.0821}$	Curacao	Nagelkerken (1979)
E. fulva (Coney)					0.63				340	$0.729L^{2.574}$	Caribbean	Thompson and Munro (1974b)
M. microlepis (Gag)			-1.127	>13	0.122		0.20		1290	$1.2 \times 10^{-8}L^{2.996}$	North and South Carolina, Georgia, Northern Florida	Manooch and Haimovici (1978)
M. phenax (Scamp)	1		-3.91	21	0.067				1090	$2.4 \times 10^{-8}L^{2.996}$	North and South Carolina	Matheson (unpubl. data)
E. striatus (Nassau grouper)	4		0.488		0.185				974	$0.1393L^{3.112}$	St. Thomas, U.S.V.I	Olsen and LaPlace (1978)
					0.09		0.17-0.30			$0.0107L^{3.112}$	South Jamaica	Thompson and Munro (1974b)

(Table RFR-7 con't)

M. phenax (Scamp)	1		-3.91	21	0.067				1090	$2.4 \times 10^{-8} L^{2.996}$	North and South Carolina	Matheson (unpubl. data)
E. striatus (Nassau grouper)	4		0.488		0.185				974	$0.1393 L^{3.112}$	St. Thomas, U.S.V.I	Olsen and LaPlace (1978)
					0.09		0.17-0.30			$0.0107 L^{3.112}$	South Jamaica	Thompson and Munro (1974b)

C. Yield-per-recruit parameters for porgies (Sparidae)

Species	t_c	t_r	t_o	t_x	K	Z	M	F	L_{∞} (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE*
P. pagrus (Red porgy)	5		-1.88		0.096		0.20		763	$2.524 \times 10^{-5} L^{2.8939}$	North and South Carolina	Manooch and Huntsman (1977)
C. nodosus (Knobbed porgy)			-1.746		0.212	0.52			469	$e^{-28.6 + .0073L}$	South Atlantic Bight	Horvath and Grimes (unpubl. data)
C. leucosteus (Whitebone porgy)			-2.639		0.1739					$4 \times 10^{-5} FL^{2.907}$	South Atlantic Bight	Waltz et al. (in press)
S. caprinus (Longspine porgy)				2.5-3.0		1.77-4.61			256	Log W= -4.85 + 3.05 Log L	Gulf of Mexico	Geoghegan (1981)

*References are in Source Document for SAFMC (1983).

(Table RFR-7 cont.)

D. Yield-per-recruit parameters for grunts (Haemulidae).

Species	t_c	t_r	t_o	t_x	K	Z	M	F	L_{∞} (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE*
H. plumieri (White grunt)			-1.007	13	0.1084	0.46-0.71	0.40-0.60		640	$1.426 \times 10^{-5} L^{3.0229}$	North and South Carolina	Manooch (1977a)
H. aurolineatum (Tomtate)	4		1.28	9	0.22017	0.887			310	$0.86 \times 10^{-5} L^{3.0905}$	North and South Carolina, Georgia, Florida to Cape Canaveral	Manooch and Barans (1982)
					0.235				295		Campeche Banks	Sokolova (1969)
H. album (Margate)					0.196	1.0	0.33	0.67	621		Cuba	Baisre and Paez (undated)
H. sciurus (Blue striped grunt)					0.184	1.7	0.32	1.38	497		Cuba	Baisre and Paez (undated)

*References are in Source Document for SAFMC (1983).

Table RFR-8.

Parameter Esitmates for Yield per Recruit Models

	von Bertalanffy Parameters				Length-weight Parameters $W=aL^b$								
	K	L (mm)	t_o (yrs)	Source	(L-mm) a	(w-g) b	Source	M	Source	t_r (years)	Source	t_x (years)	Source
Red porgy <u>Pagrus pagrus</u>	0.096	763	-1.88	Manooch and Huntsman 1977	2524×10^{-8}	2.8939	Manooch and Huntsman 1977	0.35	Catch curves- (Manooch and Huntsman, 1977)	1	Manooch and Huntsman 1977	1	Manooch and Huntsman 1977
"	"	"	"	"	"	"	"	0.20	Relationship to K	"	"	"	"
Vermilion snapper <u>Rhomboplites aurorubens</u>	0.198	627	0.13	Grimes 1978	1722×10^{-8}	2.9456	Grimes 1978	0.25	Relationship to K	1	Grimes 1978	10	Grimes 1978
								0.40	For sensitivity analyses				
"	"	"	"	"	"	"	"	0.05	Catch curve minimum	"	"	"	"
White grunt <u>Haemulon plumieri</u>	0.108	640	-1.01	Manooch 1977	1452×10^{-8}	3.0214	Manooch 1977	0.57	Catch curves	2	Manooch 1977	13	Manooch 1977
"	"	"	"	"	"	"	"	0.30	Choice of lower values for sensitivity analysis	"	"	"	"

Table RFR-8. (con't) Parameter Esitmates for Yield per Recruit Models (SAW/84/RFR/5)

	K	von Bertalanffy Parameters L (mm)	t_0 (yrs)	Source	Length-weight Parameters $W=aL^b$ (L-mm) a	(w-g) b	Source	M	Source	T (years)	Source	(years)	T Source
Red Snapper *Lutjanus campechnus* *L. vivanus* *L. buccanella*	0.160	975	0.00	Nelson and Manooch	315×10^{-7}	2.887	Manooch and Nelson 1982	0.16	Relationship to K	1	Nelson and Manooch 1982	16	Nelson and Manooch 1982
"	"	"	"	"	"	"	"	0.25	Higher value sensitivity analysis	"	"	"	"
								0.34	Pauly 1981				
								0.40	Higher value for sensitivity analysis				
Black sea bass *Centropristes striatus*	0.219	350	0.183	Mercer 1978 (Based on standard length[1])	2654×10^{-8}	3.024	Cupka et al. 1973	0.30	Relationship to K and t_x	1	Cupka et al. 1973	10	Cupka et al. 1973
	"	"	"	"	"	"	"	0.50	For sensitivity analysis	"	"	"	"
Speckled hind *Epinepheius drummondhayi*	1100.088	1105	-1.92	Matheson and Huntsman	1.1×10^{-8}	3.073	Matheson and Huntsman	0.20	Pauly estimate Matheson and Huntsman (in review)	1	Matheson and Huntsman[2]	25	Matheson and Huntsman[2]
Snowy grouper *Epinephelus niveatus*	0.063	1350	-2.32	"	7.0×10^{-8}	2.755	"	0.13	"	1	"	"	"

Table RFR-8. (con't) Parameter Estimates for Yield per Recruit Models (SAW/84/RFR/5)

	von Bertalanffy Parameters				Length-weight Parameters $W=aL^b$								
	K	L (mm)	t_0 (yrs)	Source	(L-mm) a	(w-g) b	Source	M	Source	T (years)	Source	(years)	T Source
Gag *Mycteroperca mircrolepis*	0.112	1290	-1.13	Mannooch and Haimovici 1978	$12x10^{-7}$	2.996	Manooch and Haimovici 1978	0.20	Relationship to K	1	Manooch and Haimovici 1978	13	Manooch and Maimovici 1978
"	"	"	"	"	"	"	"	0.35	Higher value for sensitivity analysis.	"	"	"	"
Scamp *Mycteroperca phenex*	0.067	1090	-3.91	Matheson, Manooch and Huntsman[3]	2400x10-8	2.910	Matheson, Manooch, and Huntsman[2]	0.17	Pauly estimate Matheson, Manooch and Huntsman[3]	1	Matheson, Manooch and Huntsman[3]	25	Matheson, Manooch and Huntsman[3]

[1] TL = -11.2 + 1.34 sl, Ocpka et al. 1973.

[2] Unpublished manuscript, Growth, mortality, and yield per recruit models for speckled hind (*Epinephelus drummondhayi*) and snowy grouper (*E. niveatus*) from the U.S. South Atlantic Bight by R.H. Matheson, and G.R. Huntsman, Beaufort Laboratory, Southeast Fisheries Center, National Marine Fisheries Service, Beaufort, NC 28516-9722.

[3] Unpublished manuscript, Growth, mortality and yield per recruit models for the scamp, *Mycteroperca phenax* by R.H. Matheson, III, C.S. Manooch, II and G.R. Huntsman, Beaufort Laboratory, Southeast Fisheries Center, National Marine Fisheries Center, NC 28515-9722.

* NOTE: All references are listed in SAW/84/RFR/5

Table RFR-9. Summary of Yield Per Recruit Models for South Atlantic Reef Fish.

Species	For the model with N =	Maximum Y/R (g) is	Where F =	And t_0 =	At F =	and t_0 =	Y/R is (g)	Which is Percent of Maximum Y/R	At F =	and t_0 =	Y/R is (g)	Which is Percent of Maximum
Red porgy	0.35	150	0.80	2.9-4.0	0.50	< 5.5	130	87	0.50-0.30	1.0-5.6	110	73
	0.20	300	0.50	5.5-7.3	0.10	3.0-7.5	225	75				
Vermilion snapper	0.50	100	1.75	3.5-4.0	0.70	2.5-4.0	90	90	0.40	2.5-4.0	20	80
	0.40	140	1.50	4.0-4.5	0.65	1.5-3.5	130	93	0.45	1.5-3.5	120	86
	0.25	250	0.55	4.5-5.0	0.30	2.5-5.5	200	80				
White grunt	0.30	180	0.60	4.0-5.0	0.30	2.5-5.0	160	88	0.20	2.0-5.0	140	78
	0.57	30	0.55	4.5	0.25	2.7-5.0	25	83				
Red snapper	0.16	1600	0.50	6.5-8.0	0.30	5.5-7.5	1500	94	0.20	4.0-7.5	1300	81
	0.25	900	0.50	> 5.0	0.30	4.0-5.0	800	88	0.20	3.0-5.5	700	78
	0.34	550	0.60	4.0-4.5	0.38	3.5-4.5	500	91	0.20	2.0-5.0	400	73
	0.40	400	0.45	3.0-4.5	0.20	2.0-5.0	300	75				
Black sea bass	0.50	50	0.90	2.5-3.5	0.30	2.5	40	80	0.20	1.0-3.5	30	60
	0.30	100	0.70	4.0	0.30	2.5-5.0	80	80				
Speckled hind	0.20	1200	0.50	5.0-7.0	0.25	4.0-7.0	1100	92	0.19	3.0-7.0	1000	83
Snowy grouper	0.13	1300	0.38	9.0-11.0	0.20	7.0-10.0	1200	92	0.15	5.0-11.0	1100	85
Gag	0.35	900	3.25	4.5	0.70	3.5	850	94	0.30	2.0-4.8	700	78
	0.20	1875	2.20	7.0	0.70	5.5-7.0	1800	96	0.35	4.0-7.0	1600	85
Scamp	0.17	900	0.72	6.5	0.23	3.0-7.0	800	89	0.15	1.0-8.0	700	78

Table RFR-10

Species	M estimate	Z estimate	Z period	Z source	Status of Fishery: fishery	Recruitment Age: size (mm)	Recruitment Age: age (years)	Y/R available: F =	Y/R available: Amount (g)	Percent of maximal
Red porgy	0.20	0.65	1972-74	Manooch & Huntsman '77	headboat	300	4.1	0.30	120	80
	0.36	"	"	"		or	"	0.45	280	93
					"	325	4.3	0.30	120	80
								0.45	290	97
					commercial handline	300	4.1	0.30	120	80
								0.45	280	93
					commercial trawl	200	2.1	0.30	125	83
						or		0.45	225	75
					"	250	2.6	0.30	125	83
								0.45	250	83
Vermilion snapper	0.25 0.40	0.67	1972-73	Grimes,[1/] personal	headboat	225	3.5	0.32	225	90
						or		0.27	100	71
	0.50			communi-cation				0.17	60	60
					"	250	3.8	0.32	225	90
								0.27	100	71
								0.17	60	60
					commercial handline	300	4.5	0.32	225	90
								0.27	100	71
								0.17	60	60
					commercial trawl	200	3.3	0.32	225	90
								0.27	100	71
								0.17	60	60

Table RFR-10 (Con't)

Species	M estimate	Z estimate	Z period	Z source	Status of Fishery: Fishery	Recruitment Age: size (mm)	Recruitment Age: age (years)	F =	Y/R available Amount (g)	Percent of maximal
White grunt	0.30	0.73	1972-75	Manooch, 1977	headboat	250	4.4	0.43	175	92
						or		0.16	15	50
	0.57				"	300	5.9	0.43	170	90
								0.16	15	50
					commercial handline & trawl	species rarely taken				
Red snapper	0.16	0.38	1974-78	Nelson & Manooch 1982	headboat & commercial handline	500	6.0	0.22	1300	81
	0.25							0.13	575	64
	0.34 2/							0.04	200	40
					commercial trawl	450	5.0	0.22	1300	81
								0.13	500	56
								0.04	200	40
Black sea bass	0.30	0.83 (depth <40m)	1978	Low, 1981	headboat	400	4.0	0.53 shallow	98	98
								0.30 deep	80	80
		0.60 (depth >40m)	"	"	commercial handline & trawl	species rarely taken				
	0.50				headboat	400	4.0	0.33 shallow	35	70
								0.10 deep	10	20

Table RFR-10 (Con't)

Species	M estimate	Z estimate	Z period	Z source	Status of Fishery: Fishery	Recruitment size (mm)	Recruitment age (years)	F =	Y/R available Amount (g)	Percent of maximal
speckled hind	0.20	0.35	1976-79 headboat	Matheson and Huntsman	all fisheries	365	3.3	0.15	950	79
	"	0.25	1976-79 commercial handline	"		"	"	0.05	600	50
snowy grouper	0.13	0.38	1976-79 headboat	"	all fisheries	"	3.3	0.25	950	73
	"	0.24	1976-79 commercial handline	"		"	"	0.11	920	70
gag	0.20	no estimate[3/]		Manooch & Haimovici	headboat	-	1.0	0.36[3/]	1,050	58
					commercial handline	750	6.6	0.68[3/]	1,800	100
						800	8.0	0.68[3/]	1,700	94
	0.36	"	"		headboat	-	1.0	0.36[3/]	650	67
					commercial handline	-	6.6	0.68[3/]	650	72
							8.0	0.68[3/]	480	53
scamp	0.17	0.53	1976-79 headboat	Matheson and Manooch & Huntsman	headboad 1972-75	500	5.4	0.36	850	94
				"	headboat 1977-79	350	3.1	0.36	800	89
	"	0.85	commercial handline 1976-79	"	commercial handline	400	4.0	0.68	900	100

1/ Churchill B. Grimes, Dept. of Horticulture and Forestry, Rutgers University, P.O. Box 231, New Brunswick, New Jersey 08903.
2/ M of 0.40 omitted because it was greater than estimated F.
3/ F for gag assumed to be same as for scamp which occupies same habitat and is taken simultaneously with same gear.

Table RFR-11. South Atlantic reef fish species for which yield per recruit analyses have been performed. Specific results are given in the reference(s) listed for each species.

SPECIES	REFERENCES
Serrandae - Groupers and Sea Basses	
Black sea bass, *Centropristis striatus*	SAFMC(1983), SAW/84/RFR/1, 5
Gag, *Mycteroperca microlepis*	SAFMC(1983), SAW/84/RFR/1, 5
Scamp, *M. phenax*	SAFMC(9183), SAW/84/RFR/1, 5
Red hind, *Epinephelus guttatus*	SAFMC(1983)
Red grouper, *E. morio*	SAFMC(1983), SAW/84/RFR/1
Graysby, *E. cruentatus*	SAFMC(1983)
Speckled hind, *E. drummondhayi*	SAFMC(1983), SAW/84/RFR/1, 5
Snowy grouper, *E. niveatus*	SAFMC(1983), SAW/84/RFR/5
Lutjanidae - Snappers	
Red snappers, *Lutjanus campechanus*	SAFMC(1983), SAW/84/RFR/1, 5
Vermilion snapper, *Rhomboplites aurorubens*	SAFMC(1983), SAW/84/RFR/1, 2, 5
Yellowtail snapper, *Ocyurus chrysurus*	SAFMC(1983), SAW/84/RFR/1, 5
Gray snapper, *L. griseus*	SAFMC(1983), SAW/84/RFR/1, 5
Sparidae - Porgies	
Red porgy, *Pagrus pagrus*	SAFMC(1983), SAW/84/RFR/1, 5
Haemulidae - Grunts	
Tomtate, *Haemulon aurolineatum*	SAFMC(1983)
White grunt, *H. plumieri*	SAFMC(1983), SAW/84/RFR/5

Table RFR-12. Realized yield per recruit by cohort of vermilion snapper in the northern South Atlantic Bight.

Year of Cohort's Recruitment as One Year Old	Number of Years in Fishery	Realized Yield Per Recruit(g)	Percent of 1/ Present Yield Per Recruit	Percent of 2/ Maximum Yield Per Recruit
1973	10	192	110	85
1974	9	173	99	77
1975	8	169	97	75
1976	7	158	90	70
1977	6	146	83	65
1978	5	111	63	49
1979	4	80	46	36
1980	3	51	29	23

1/ Present yield per recruit assuming age of first capture equals 2 years old and the fishing mortality rate equals 0.4 for all ages.

2/ Maximum yield per recruit assuming the fishing mortality rate equals 0.4 for all ages and age of first capture equals 4 years old.

Table RFR- 13. Yield per recruit of one year old vermilion snapper in the northern South Atlantic Bight assuming 1979-81 average fishing mortality rates.

Age	$\bar{F}$ (1979-81 Ave)	Yield (g)	Percent Yield	Cumulative Percent Yield
2	0.172	10.7	5.8	5.8
3	0.149	16.8	9.1	14.9
4	0.137	19.7	10.7	25.6
5	0.166	25.1	13.6	39.1
6	0.188	25.7	13.9	53.1
7	0.220	24.6	13.3	66.4
8	0.347	27.9	15.1	81.5
9	0.274	14.7	8.0	89.5
10	0.322	11.3	6.1	95.6
11	0.193	4.6	2.5	98.1
12	0.222	3.6	1.9	100.0

Total Yield Per Recruit 184.7 g

Table RFR-14. Instantaneous fishing mortality rate at age estimated by VPA for vermilion snapper in the northern South Atlantic Bight, 1973 -1982 (assumes M = 0.23).

Age	73	74	75	76	77	78	79	80	81	82
1	.0007	.0002	.0003	.0002	.0001	.0003	.0068	.0353	.0219	.02
2	.0045	.0302	.0403	.0248	.0103	.0036	.0534	.1700	.2945	.17
3	.0460	.1030	.1626	.0905	.0299	.0266	.0838	.1813	.1830	.40
4	.0672	.0920	.1199	.1364	.0472	.0943	.0598	.1636	.1874	.40
5	.0682	.0616	.1298	.1268	.0815	.0931	.0522	.1592	.2880	.40
6	.0596	.0729	.0968	.0966	.0517	.0811	.0837	.2058	.2746	.40
7	.0360	.0327	.0664	.0569	.0680	.0585	.1508	.1937	.3164	.40
8	.0720	.0246	.0559	.0626	.0537	.1259	.1826	.5052	.3536	.40
9	.0685	.0489	.0240	.0334	.0693	.0892	.2410	.2712	.3106	.40
10	.0573	.0365	.1009	.0301	.0532	.1747	.1919	.5657	.2286	.40
11	.1157	.0298	.0840	.0556	.0306	.1060	.1332	.2224	.2240	.40
12	.0656	.0559	.0933	.0765	.0539	.0944	.1288	.2742	.2629	.40

Table RFR-15. Population size at age of vermilion snapper in the northern South Atlantic Bight, 1973-82, estimated by VPA (assumes M = 0.23).

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	5551626	668070	614916	632452	809273	1338904	1551796	954571	1487860	819197
2	578033	437960	530696	488417	502415	642905	1063479	1224648	732132	1156495
3	367665	457215	337621	404991	378564	395114	508973	801043	820923	433306
4	353494	278974	327723	227984	293917	291936	305682	371903	530119	543150
5	225949	262599	202175	230957	158045	222753	211087	228766	250882	349759
6	231560	167685	196168	141078	161645	115744	161248	159178	155008	149451
7	240599	173340	123866	141480	101770	121965	84796	117828	102949	93582
8	106271	184412	133290	92090	106193	75542	91397	57945	77133	59592
9	89450	78567	142960	100142	68728	79963	52917	60498	27778	43030
10	70111	59691	59391	110891	76951	50951	58112	33041	36651	16178
11	31217	52603	45726	42657	85497	57969	33992	38881	14910	23170
12	13946	22093	40566	33403	32058	65885	41427	23640	24731	9469

Table RFR-16. Number of vessels using bottom longlines in the commercial snapper-grouper fishery in the Gulf of Mexico, 1982.

VESSEL AND BOAT OPERATING UNITS BY AREA

AREA	TYPE CRAFT	NO. ENGAGED	SIZE RANGE	AVERAGE LENGTH	AVERAGE CREW SIZE*
			(feet)	(feet)	
EASTERN GULF	SHRIMP TRAWLERS	72	55-85	60	4.0
	SNAPPER/GROUPER BOATS	70	30-50	40	3.5
	CHARTER BOATS	20	30-50	40	3.5
	TOTAL	162			
NORTHERN GULF	SHRIMP TRAWLERS	25	50-75	60	4.0
	SNAPPER/GROUPER BOATS	19	30-45	40	3.5
	CHARTER BOATS	7	30-45	40	3.5
	OUTBOARD	4	24	24	2.0
	TOTAL	55			
WESTERN GULF	SHRIMP TRAWLERS	85	55-85	65	4.6
	TOTAL	85			

* Includes Captain

Source: Prytherch, H.F. 1983. A descriptive survey of the bottom longline fishery in the Gulf of Mexico. Southeast Fisheries Center Report.

Table RFR-17. Estimated number of snappers, groupers and sea basses caught by recreational fishermen in the Gulf of Mexico, 1979.

Species group	Total number caught (millions)	Rank among all groups[b]	Type A fish caught (millions)[a]	Rank among all groups[b]	Type B1 fish caught (millions)[a]	Rank among all groups[b]	Type B2 fish caught (millions)[a]	Rank among all groups[b]
Groupers	0.880 (0.197)	27	0.321 (0.075)	22	0.135 (0.043)	28	0.424 (0.177)	28
Sea bass	2.440 (0.409)	12	0.709 (0.116)	13	0.512 (0.94)	15	1.219 (0.341)	9
Gray snapper	1.088 (0.187)	24	0.590 (0.035)	15	0.491 (0.183)	17	0.007 (0.016)	-
Red snapper	3.567 (0.791)	8	1.773 (0.545)	6	1.168 (0.303)	7	0.626 (0.487)	22
Vermilion snapper	0.358 (0.117)	38	0.305 (0.116)	23	0.021 (-)	-	0.032 (0.017)	47
Other snappers	0.620 (0.487)	31	0.027 (0.017)	-	0.082 (0.060)	30	0.511 (0.483)	26

Source: Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1979 (U.S. National Marine Fisheries Service, 1980, pp. 94-101).

[a] Standard errors are presented in parentheses.

[b] Species groups were ranked according to estimated number caught, but actual rankings may differ slightly because catch totals are estimates based on a sample rather than an enumeration of each fish caught.

Note: Type A fish were available in whole form for inspection by sampler, type B1 fish were used for bait, discarded dead, filleted, etc., before the interview was conducted, and type B2 fish were released alive.

Table RFR-18. Reported landings (whole weight), number of traps fished and number of craft fishing in the south Florida spiny lobster commercial fishery 1952-1983 (calendar year)

	East Coast of Florida			West Coast of Florida			Florida Total				
Calendar Year	Reported Landings (lbs x 10^3)	No. Traps x 10^3	lbs/trap	Reported Landings (lbs x 10^3)	No. Traps x 10^3	lbs/Trap	Reported Landings (lbs x 10^3)	No. Traps x 10^3	lbs per Trap	No. Craft	Traps Per Craft
1952	1156	10	112	447	5	99	1603	15	108	80	186
1953	1421	19	74	574	7	88	1995	26	77	147	175
1954	1223	19	65	722	12	62	1945	30	64	157	194
1955	1079	26	41	1210	13	93	2289	39	59	166	235
1956	799	16	49	2309	17	137	3108	33	94	128	257
1957	651	14	46	3384	22	154	4035	36	112	161	223
1958	623	11	56	2328	23	100	2951	34	86	187	184
1959	543	18	30	2635	34	78	3178	52	61	254	204
1960	719	19	38	2126	55	39	2845	74	39	221	333
1961	702	13	53	2100	39	54	2802	52	54	195	268
1962	672	16	42	2434	58	42	3106	74	42	248	300
1963	815	20	40	2770	60	46	3585	80	45	246	326
1964	786	40	20	2844	74	39	3630	114	32	341	333
1965	1329	49	27	4379	90	49	5708	139	41	332	418
1966	1686	76	22	3650	75	49	5336	151	35	488	309
1967	1677	94	18	2719	92	30	4396	186	24	528	352
1968	2234	70	32	3892	99	40	6126	168	36	452	373
1969	2929	68	43	4621	97	48	7550	165	46	440	374
1970	3018	69	44	5235	150	35	8253	219	38	492	445
1971	3418	79	43	4653	147	32	8071	226	36	520	434
1972	6267	98	64	4640	174	27	10907	272	40	599	455
1973	5622	133	42	4993	172	29	10615	304	35	671	454
1974	4139	144	29	5631	227	25	9770	371	26	690	538
1975	2319	92	25	4472	428	10	6781	520	13	823	632
1976	987	32	31	4136	315	13	5123	346	15	549	630
1977	1501	47	32	4693	408	12	6194	455	14	-	-
1978	891	43	21	4711	529	9	5602	572	10	-	-
1979	841	29	29	6939	564	12	7780	594	13	666	892
1980	999	35	28	5696	570	10	6695	605	11	595	1017
1981	880	31	28	5014	591	8	5894	622	9	563	1105
1982	857	40	21	5640	502	11	6497	542	12	539	1006
1983 1/	675	35	19	3850	520	7	4525	555	8	-	-

1/ Preliminary

Table RFR-19. Seasonal fishing mortality rates (F) in the south Florida spiny lobster fishery using two methods of estimation (SAW/84/RFR/4).

Season	Method A Minimization of Residual Sum of Squares of Observed and Predicted Monthly Catch in Weight F	Method B Recursive Estimation Using Catch Equation in Weight Using Ad Hoc Approximation for Instantaneous Growth F
1959-60	----	0.10
1960-61	----	0.13
1961-62	----	0.06
1962-63	----	0.12
1963-64	----	0.15
1964-65	----	0.09
1965-66	----	0.15
1966-67	----	0.19
1967-68	----	0.14
1968-69	----	0.22
1969-70	----	0.20
1970-71	----	0.46
1971-72	----	0.42
1972-73	----	0.49
1973-74	----	0.41
1974-75	----	0.84
1975-76	----	0.83
1976-77	----	0.99
1977-78	----	1.56
1978-79	----	1.26
1979-80	----	1.49
1980-81	1.37	1.52
1981-82	1.34	1.53
1982-83	1.10	1.75
1983-84	1.49	1.44

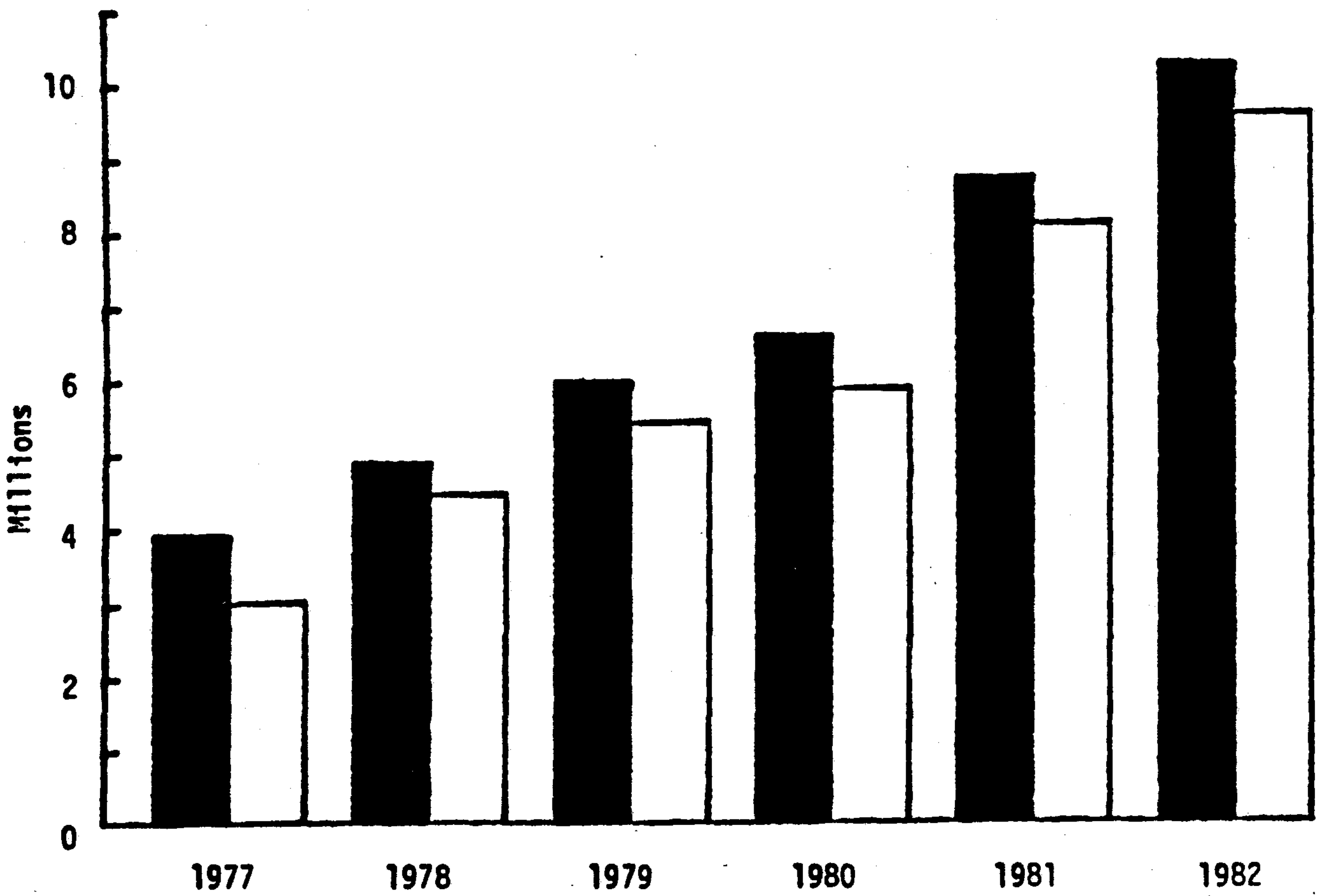


Figure RFR-1. Commercial landings and ex-vessel value in the south Atlantic reef fish fisheries, 1977-1982. Landings (shaded bars) are in millions of lbs. Value (unshaded bars) is in millions of dollars.

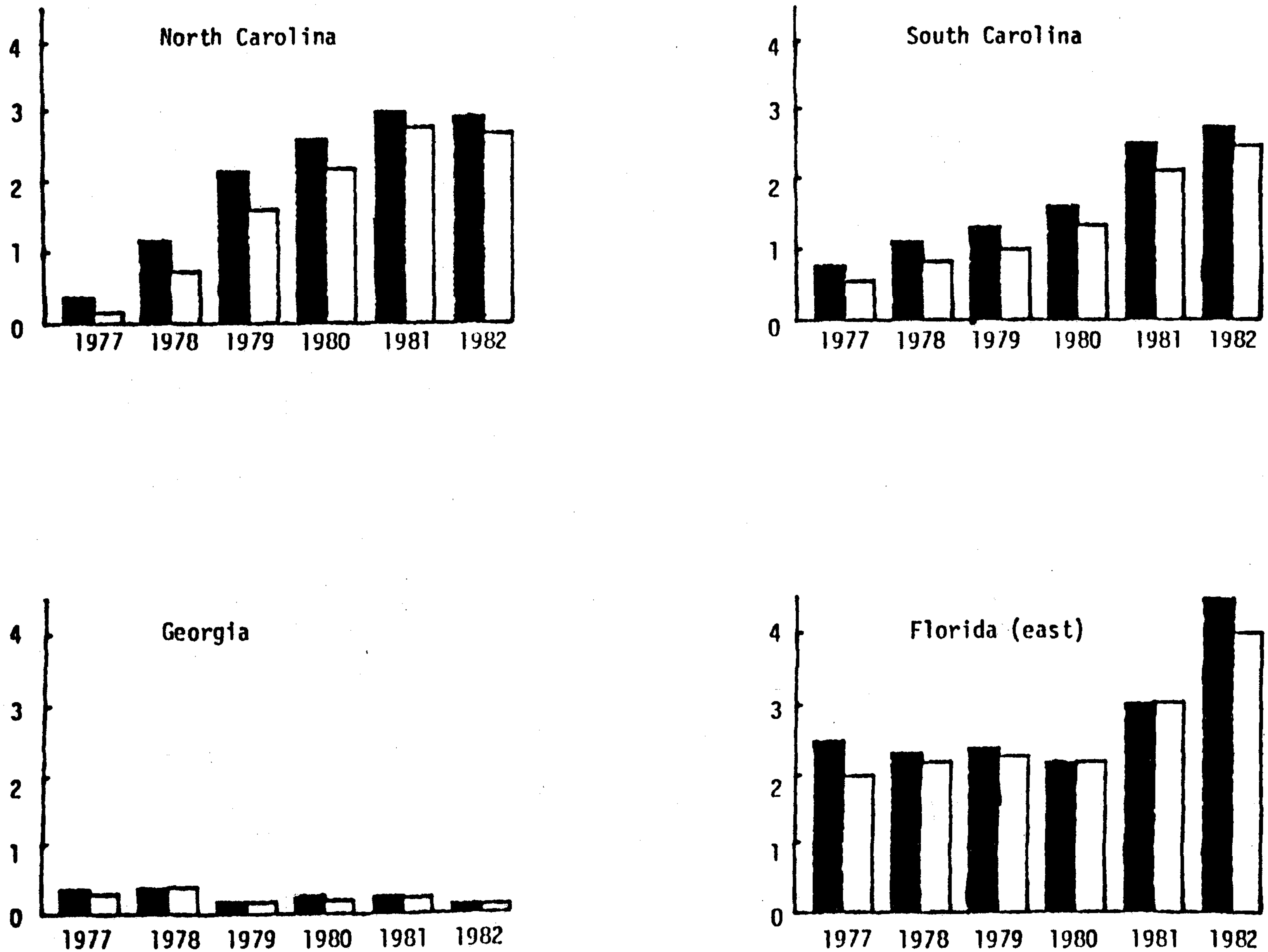


Figure RFR-2. Commercial landings and ex-vessel value in the south Atlantic reef fish fisheries by state 1977-82. Landings (shaded bars) are in millions of lbs. Value (unshaded bars) are in millions of dollars.

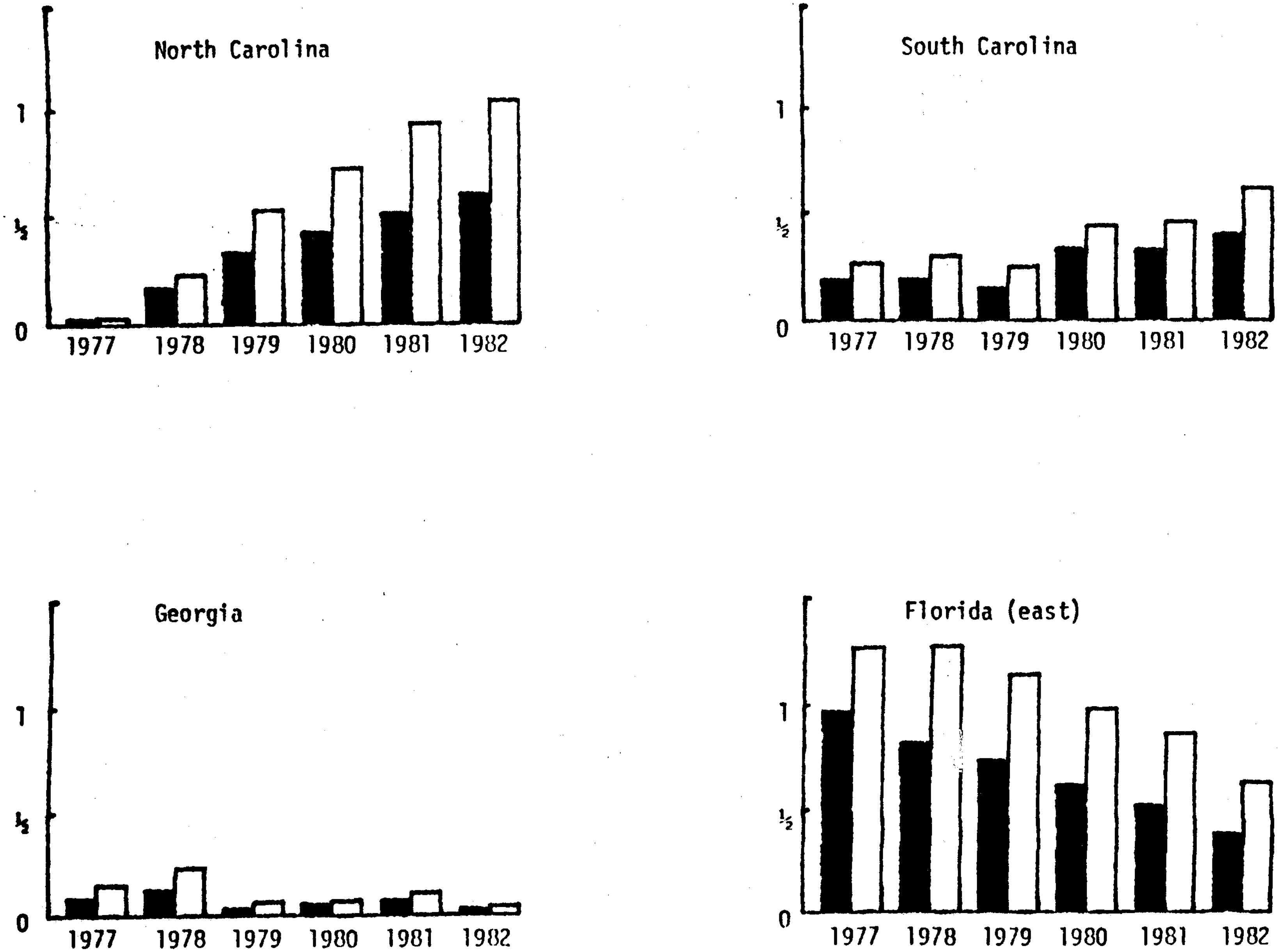


Figure RFR-3. Commercial landings and value of snapper in the south Atlantic by state 1977-82. Landings (shaded bars) are in millions of lbs. Value (unshaded bars) is in millions of dollars.

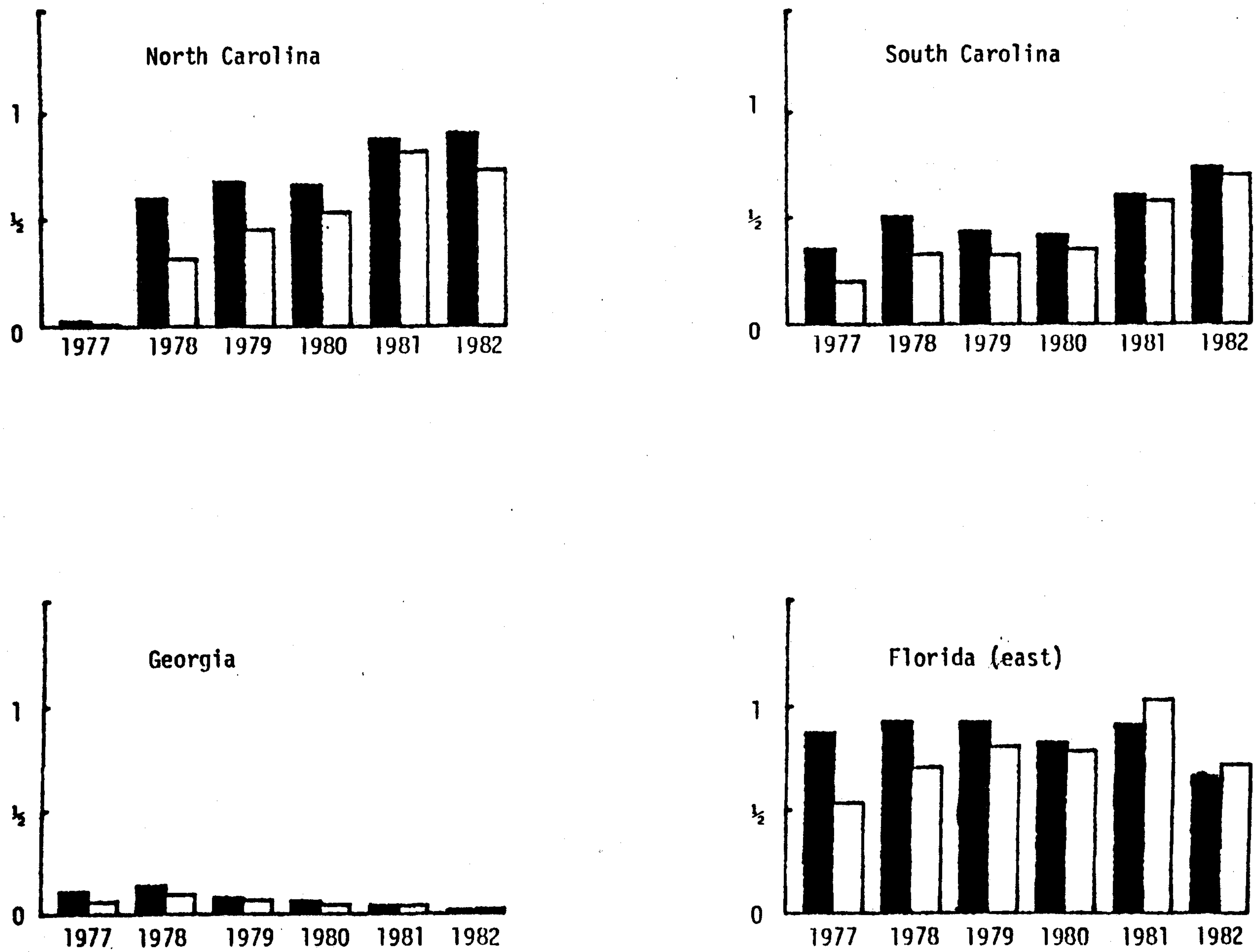


Figure RFR-4. Commercial grouper landings and value in the south Atlantic by state 1977-1982. Landings (shaded bars) are in millions of lbs. Value (unshaded bars) is in millions of dollars.

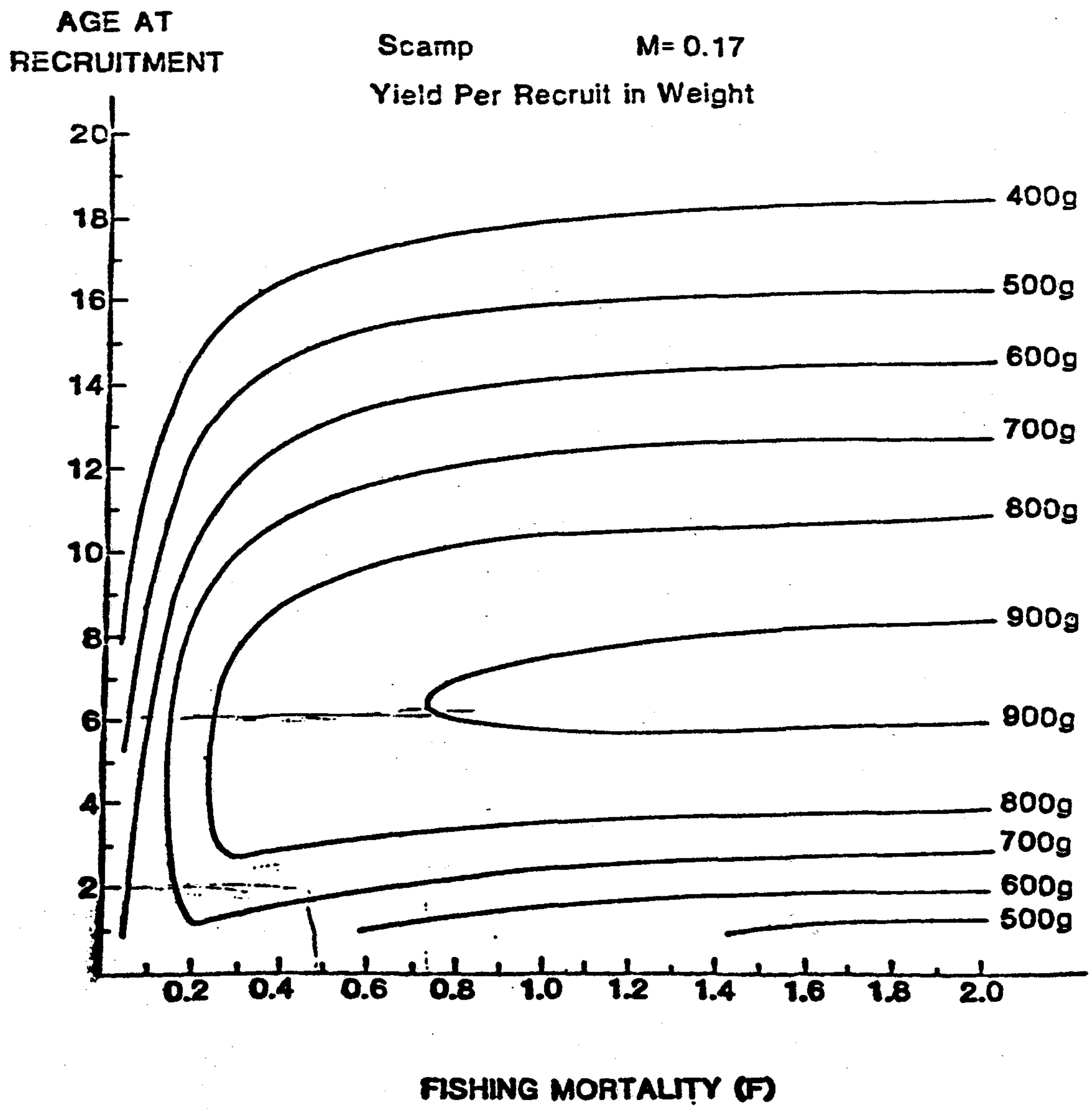


Figure RFR-5. Yield per recruit isopleth for scamp, *Mycteroperca phenax*.

Figure RFR-6. Number of vermilion snapper recruits in the northern south Atlantic Bight versus number of mature females. Data points are labeled by the year in which the recruits became one year old.

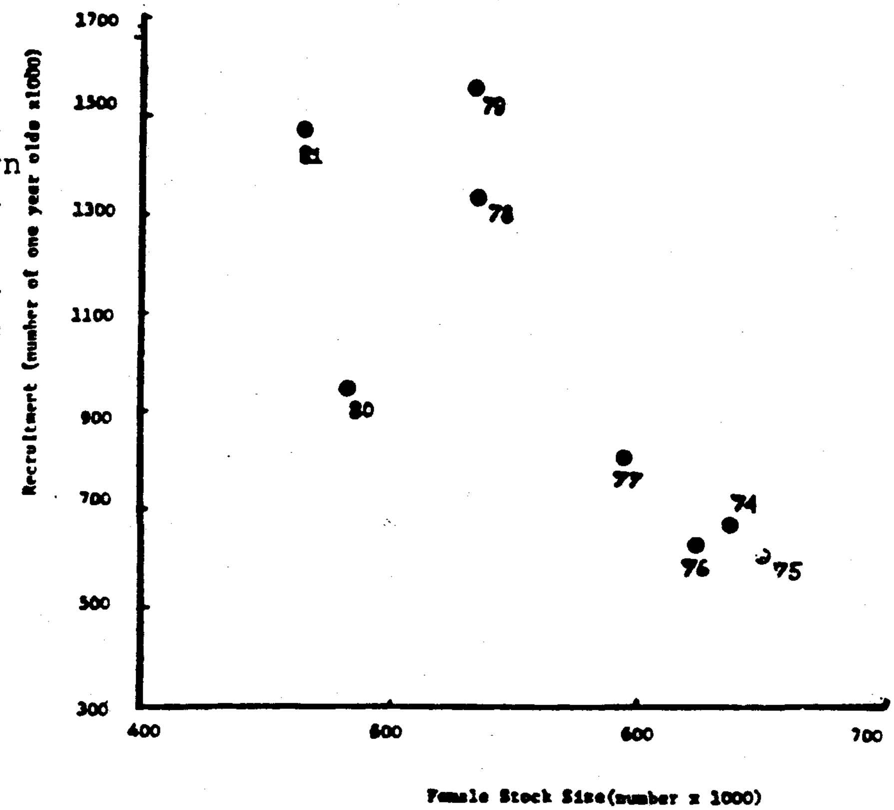


Figure RFR-7. Number of 2 through 12 year old vermilion snapper in the northern south Atlantic Bight.

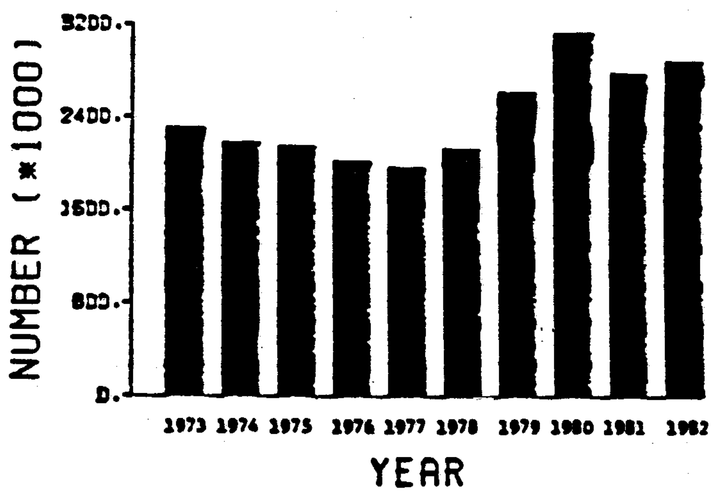
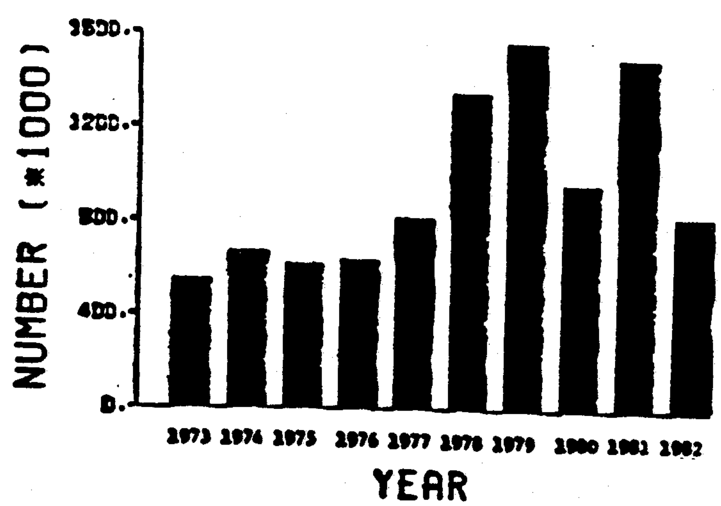


Figure RFR-8. Number of one year old vermilion snapper (recruits) in the northern south Atlantic Bight.



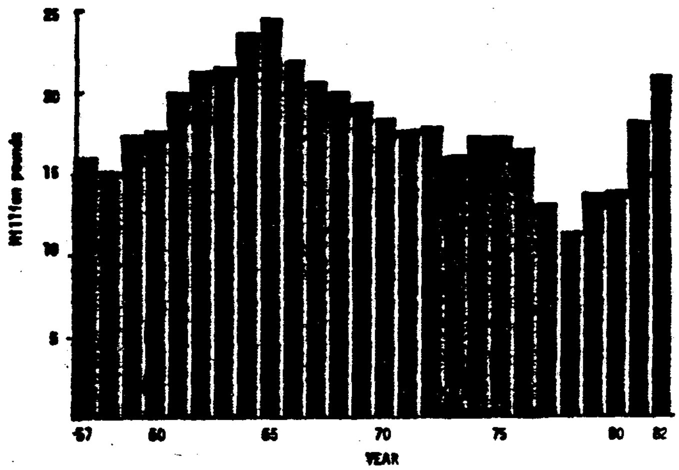


Figure RFR-9. Commercial landings of snappers, groupers and sea basses in the Gulf of Mexico 1957-1982.

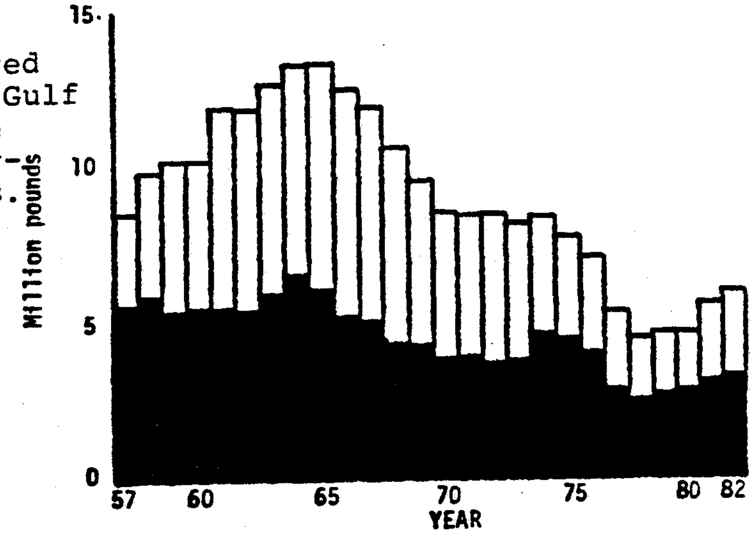


Figure RFR-10. Commercial red snapper landings in the Gulf of Mexico 1957-1982. The shaded area are the Florida red snapper landings.

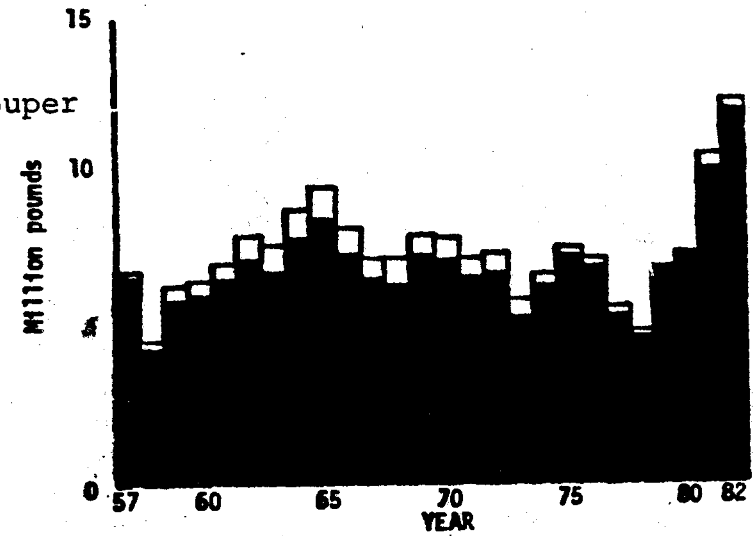


Figure RFR-11. Commercial grouper landings in the Gulf of Mexico 1957-1982. Shaded areas are the Florida grouper landings.

Figure RFR-12. Total catch of reef fish from the insular shelf of Puerto Rico 1975-1982.

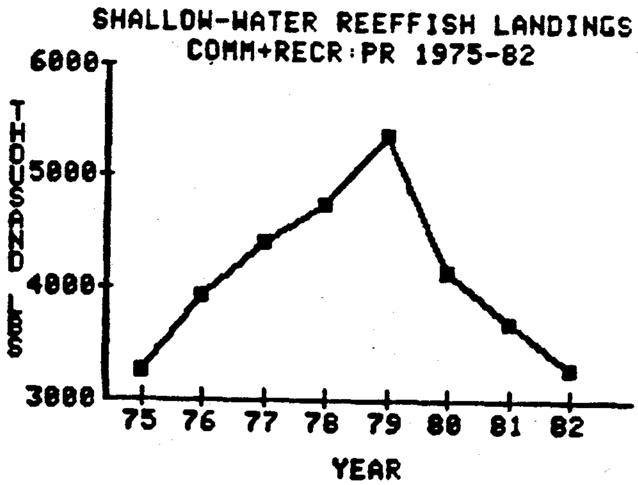


Figure RFR-13. Total number of traps reported per year on the insular shelf of Puerto Rico 1971-1980.

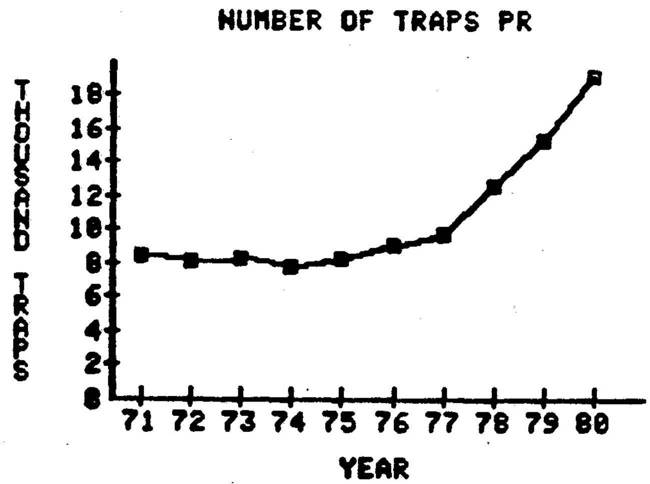
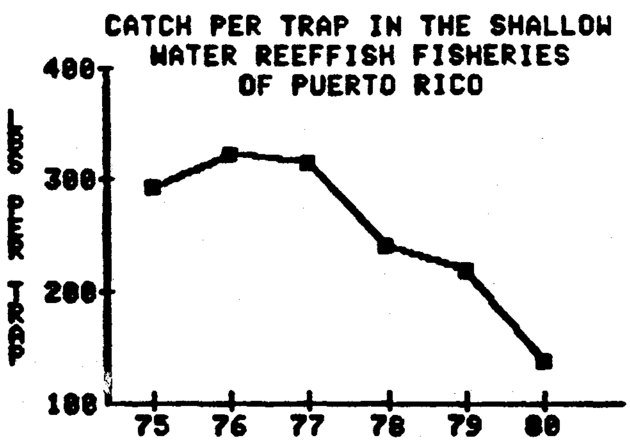


Figure RFR-14. Catch per unit effort in lbs per trap-year from the insular shelf of Puerto Rico 1975-1980.



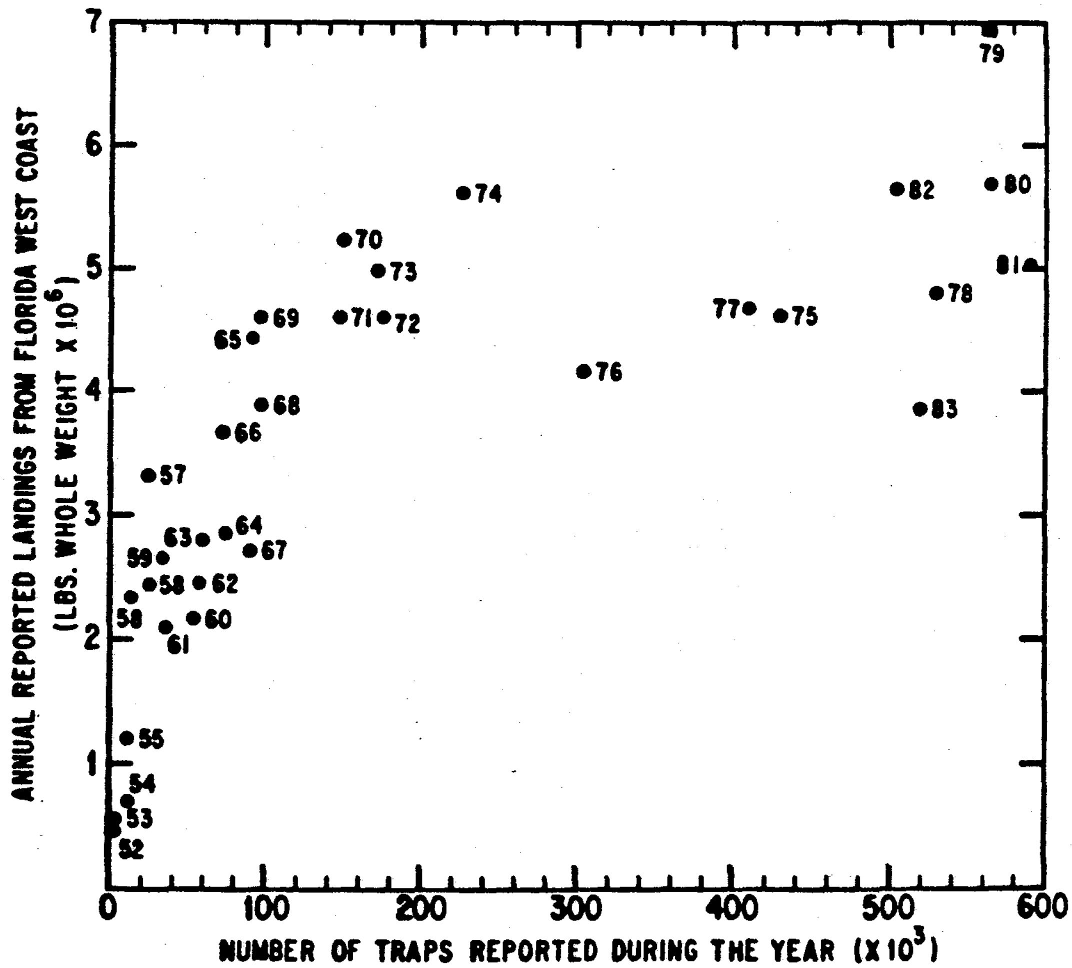


Figure RFR-15. Annual reported landings of the Florida west coast commercial spiny lobster fishery versus number of traps reported by year.

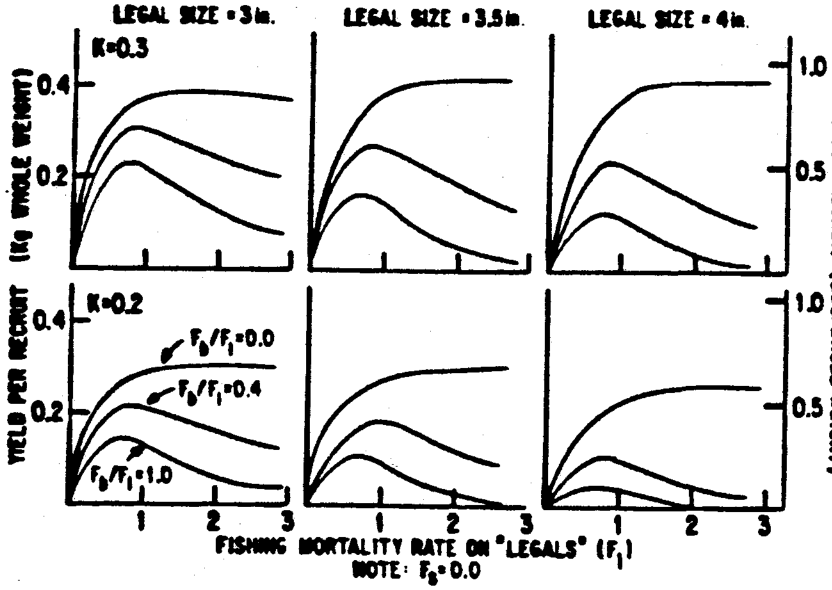


Figure RFR-16.

Yield per recruit calculated with two alternative growth coefficients (K's) and three different minimum legal carapace length (CL). Yields per recruit are plotted against the fishing mortality rate on legal size lobster (F_l) using alternative ratios of the mortality due to baiting with sublegal lobsters (F_b/F_l). No other sublegal fishing mortality is included ($F_s = 0$). F_l is the cumulative sum of the monthly fishing mortality rates.

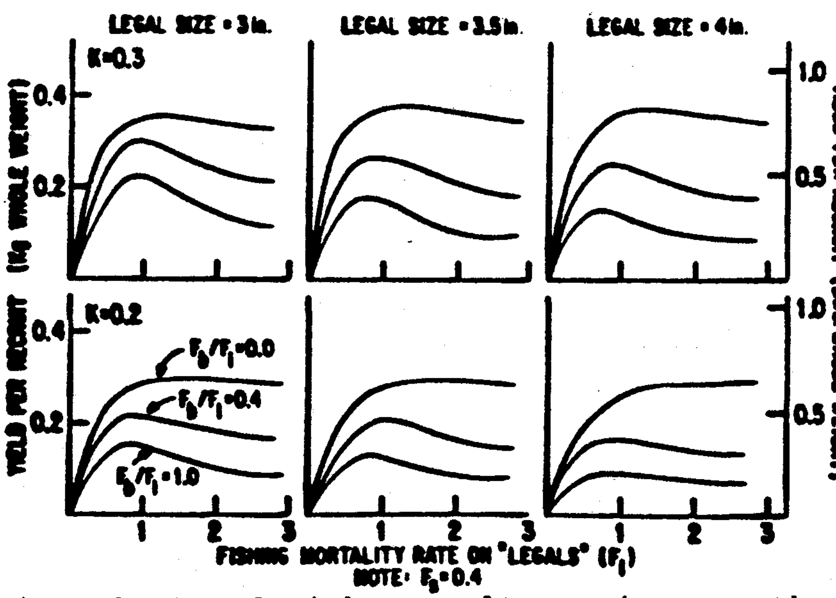


Figure RFR-17.

Yield per recruit calculated with two alternative growth coefficients (K's) and three different minimum legal carapace length (CL). Yields per recruit are plotted against the fishing mortality rate on legal size lobster (F_l) using alternative ratios of mortality due to baiting with sublegal lobsters (F_b/F_l). This figure also assumes that the ratio of landed mortality of sublegal to legal lobsters is 0.4 (F_s=0.4).

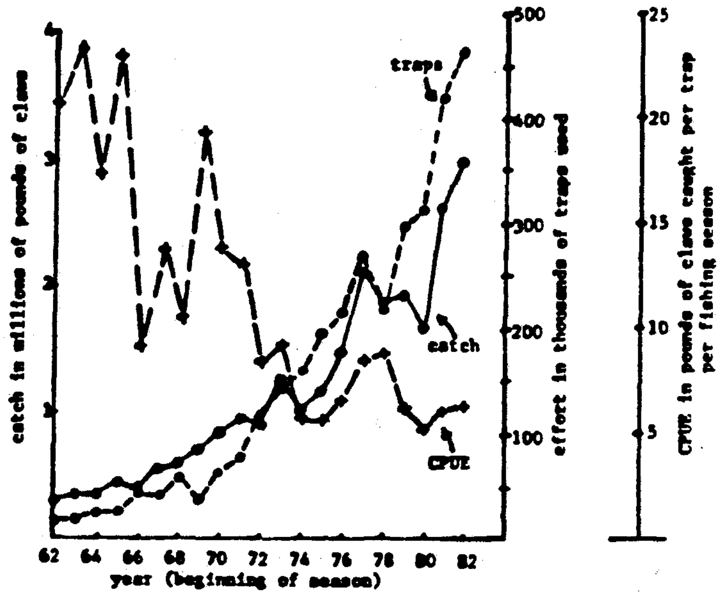


Figure RFR-18. Trends in annual catch, effort and catch-per-unit-effort for the Florida stone crab fishery 1962-82. Both catch and effort are as reported from Florida Landings and the General Canvass data, respectively.

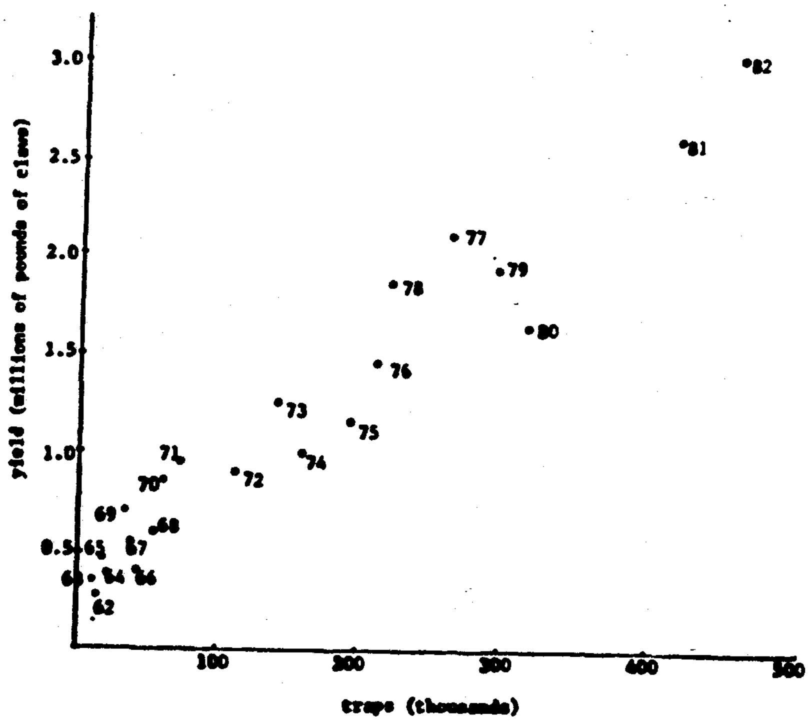


Figure RFR-19. Annual yield (by fishing season) versus effort (traps reported) in the Florida stone crab fishery 1962-82.

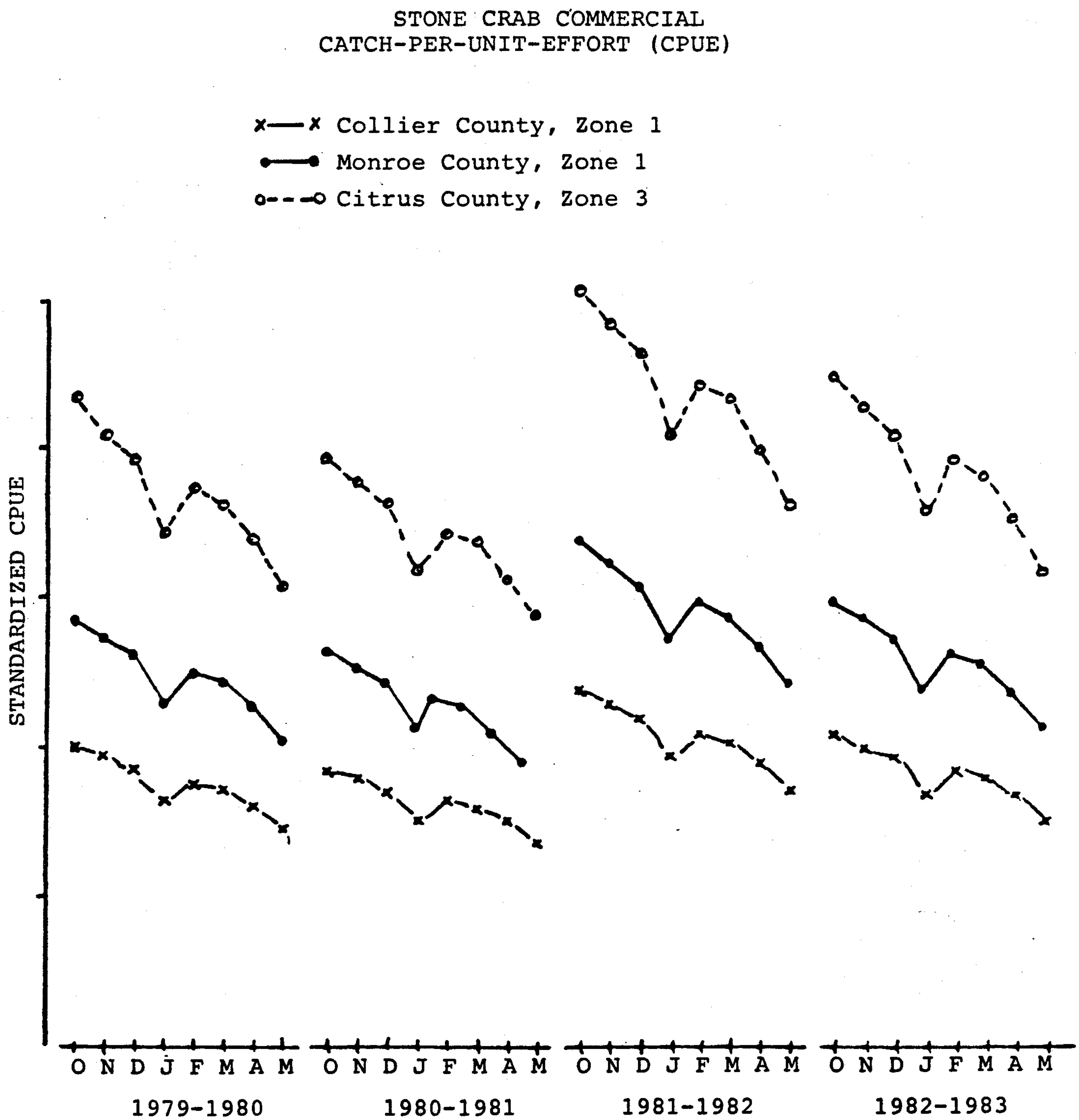


Figure RFR-20. Standardized catch (lbs) per trap pull estimated from the main effects general linear model (SAW/84/RFR/14). Collier and Monroe County CPUE's are standardized to depth: Zone 1; year: 1979; month: October. The Crystal River area was standardized to depth: Zone 3; year: 1979; month: October; and county: Citrus.

SHRIMP

I. DESCRIPTION OF FISHERIES
I.1. Seasonality, Areas and Gear

Extensive shrimp fisheries exist along the Atlantic coast of the United States from North Carolina to Florida, and along the coast throughout the Gulf of Mexico. The principal species fished are *Penaeus aztecus* (brown), *P. setiferus* (white), and *P. duorarum* (pink). A directed fishery for *Sicyonia brevirostris* (rock shrimp) exists off the Atlantic coast. Intermittent directed fisheries exist for *Xiphopenaeus kroyeri* (seabob) in nearshore waters, and for *Hymenopenaeus robustus* (royal red) in deeper waters of the Gulf and South Atlantic. Several additional penaeid species are reported in the landings, although apparently are not generally targets of directed fisheries. Large quantities (the amount varying spatially and temporally) of finfish and other demersal organisms are caught, but most are discarded.

The shrimp fishery is customarily subdivided into commercial, recreational, and bait fisheries, although a sizeable component exists that is somewhere between the usual concepts of commercial and recreational. The otter trawl is the usual gear employed in both commercial and recreational components of the fishery. Commercial vessels pull one, two, or four trawls, and the proportion of vessels pulling two, and then four, trawls has increased with time. Other gear (used primarily inshore) includes haul seines, push nets, wing nets, channel nets, and cast nets.

In the Gulf of Mexico, brown shrimp are fished mainly in the late spring and summer with a peak inshore fishery in May and June, and peak offshore catches in July and August. Peak landings (by weight) are taken from inshore waters, and offshore between 10 and 20 fathoms. Peak production has come from the area between Mobile Bay and the Atchafalaya River, and from the Texas coast between Freeport and Port Aransas. In the Atlantic, brown shrimp are mainly captured in the sounds and nearshore waters of North or South Carolina.

The white shrimp fishery in the Gulf is primarily a fall fishery, with a small secondary peak in the spring. Most landings come from inside 10 fathoms. Peak catches extend from the Mississippi River to near Port Aransas, Texas. In the Atlantic, white shrimp dominate the landings in most years, with seasonal patterns similar to those in the Gulf.

The primary pink shrimp area in the Gulf is off southwest Florida, in 6 to 20 fathoms. The fishery is year-round, with minimum landings in the summer. In the Atlantic, pink shrimp are taken mainly in North Carolina waters in the spring and summer.

Comprehensive descriptions of the fishery have been presented in the Gulf of Mexico Fishery Management Plan, and the Profile of Penaeid Shrimp Fishery in the South Atlantic.

1.2. Catch and Effort Trends

1.2.1. Gulf

Landings for Gulf brown shrimp have shown a generally rising trend, roughly doubling over the past 24 years, with considerable short term fluctuation (Fig. SHR-1). Directed effort (in nominal days fished) has also shown a generally upward trend (Fig. SHR-2).

Gulf of Mexico white shrimp landings have shown considerable (about three-fold) fluctuations from 1960-1981 (Fig. SHR-3). Peak catches of "good years" have been relatively constant, but the catches in the "poor years" between have been increasing. Directed effort for white shrimp has more than doubled, with substantial short term fluctuations (Fig. SHR-4).

Landings of pink shrimp have fluctuated since 1960, without much trend (Fig. SHR-5). Directed effort (Fig. SHR-6) appears to have fluctuated around two levels, with a transition between, during the early 1970's (SAW/84/SHR/2).

No standardizations of fishing effort for vessels or gear were performed in any of the analyses submitted. The most recent analysis involving effort standardization (Brunenmeister 1981) indicated that fleet efficiency increased about 20% through the 1965-1977 period. No data are available to update Brunenmeister's analysis. Because the 1965-1977 increase in efficiency is small relative to increase in nominal effort, results from analyses relying on nominal effort should be reliable.

1.2.2. Atlantic

Annual landings of Atlantic white shrimp, 1957-1980 were presented in SAW/84/SHR/1. The landings fluctuated considerably (about 4-fold), but no continuing trend is evident (Fig. SHR-7). Brown shrimp landings have fluctuated about 5-fold (1957-1980), but no continuing trends are apparent (Atlantic Profile).

II. STOCK STRUCTURE

Existing evidence supports recognition of single stocks for each species (brown, pink, and white) throughout the Gulf of Mexico, and single stocks for each species in the South Atlantic. The "continuum" nature of the resource is recognized, i.e. that stocks are not spatially homogeneous units, and that some management concerns require analysis below the stock level. The possible existence of a boundary or discontinuity at the Mississippi River, the absence of verifiable tag returns across the River, and the differences in timing of recruitment on either side have been considered, but high concentrations of brown and white shrimp on either side suggest that substantial interchange is likely. Consequently, postulating a stock boundary at the Mississippi does not appear justified at present for brown and white shrimp. The stock structure for Gulf pink shrimp is less clear: a marked minimum in abundance may occur in western Louisiana, and commercial statistics for shrimp landed in Texas do not distinguish between pink and brown shrimp. Thus, there may be a separate stock in the western Gulf, but no fishery data are available for assessment of pink shrimp in the western Gulf under either a one- or two-stock assumption.

III. STATUS OF STOCKS

One paper was submitted on the status of Gulf brown, white and pink shrimp (SAW/84/SHR/2), summarizing descriptive statistics, and developing population models based on virtual population analysis (VPA) of commercial landings data. One paper was submitted (SAW/82/SHR/3) describing commercial CPUE trends for newly recruited brown shrimp.

From the Atlantic region, papers were submitted on the effects of severe winters on the white shrimp stock (SAW/84/SHR/1) and on the interjurisdictional mark/recapture program now being conducted (SAW/84/SHR/4). One paper was submitted summarizing assessment techniques used on pandalid shrimp in the northwest Atlantic (SAW/84/SHR/5).

Gulf of Mexico

All Gulf brown shrimp analyses were conducted using catch statistics nominally recorded as brown shrimp, which includes an unknown quantity of pink shrimp in the western Gulf.

III.1. Population Parameters

III.1.1 Natural Mortality Rates

Estimates of natural mortality rate (M) for brown and white shrimp were made using commercial catch and effort statistics

(SAW/84/SHR/2), updating estimates made for SAW/82. The estimates were again found to be sensitive to assumptions made about catchability, with most estimates falling between 0.2 and 0.35 per month for both species. For subsequent analysis, the range of 0.2 and 0.35 was used to test sensitivity, and the mid-point of the range, 0.275 per month was used as the "best estimate" of M for both species.

A meaningfuly estimate of M from commercial catch and effort statistics could not be determined for pink shrimp, so the estimate of 0.3 per month derived from mark/recapture data was used (SAW/84/SHR/2).

III.1.2. Growth Estimates

No new growth estimates were reported. Analyses for SAW/84 used same growth parameters used in SAW/82.

III.2. Catch Per Unit Effort Trends

Annual CPUE of Gulf brown shrimp (sum of annual landings divided by sum of annual effort) has shown considerable fluctuation with no discernable trend (Fig. SHR-6). CPUE for Gulf white shrimp has shown sizeable short term fluctuations (Fig. SHR-9). The relationship of CPUE versus time of Gulf pink shrimp appears to lack any continuous trend since 1961 (Fig. SHR-10).

III.3. Stock Assessment Analyses

All Gulf of Mexico analyses are based on commercial catch statistics from the Gulf Coast Shrimp Data series, available from FIMD, Miami Laboratory, SEFC. Substantial unreported catches occur for which no time series data are available: recreational, commercial but not sold through canvassed dealers, bait fisheries, and discards.

III.3.1. Production Model Analysis

No traditional surplus production models were fitted to the shrimp data. Surplus yield results were instead determined from population models linking yield per recruit and stock/recruitment models (section III.3.5.).

III.3.2 Virtual Population Analysis

Virtual population analyses (VPA's) were performed using the commercial landings data for brown, white, and pink shrimp in the U.S. Gulf of Mexico (SAW/84/SHR/2). These analyses produced monthly estimates of age-specific stock sizes and fishing mortality rates from January 1960 through December 1983. These estimates are used to produce the summary statistics (recruitment, yield per recruit, parent stock size, percent exploitation) and further analyses (Ricker yield per recruit, stock/recruitment, population models) that appear in the subsequent sections of report.

III.3.3 Yield Per Recruit Analysis

Based upon virtual population analysis (SAW/82/SHR/2), realized yield per recruit of Gulf brown shrimp has remained fairly constant (Fig. SHR-11). Yield per recruit of Gulf white shrimp has varied (Fig. SHR-12), but no striking trends are evident after 1960. Realized yield per recruit for Gulf pink shrimp has hardly varied at all (Fig. SHR-13).

Analyses based on Ricker-type yield models indicate no real potential for increasing yield in pounds simply by increasing fishing effort for brown shrimp: however, some potential exists for increasing yield per recruit by delaying the onset of fishing on new recruits. Current effort levels and seasonal closures are at or near optimal levels for maximizing yield per recruit of white shrimp. Only minimal gains in yield per recruit of pink shrimp are projected both with simply increasing fishing, and with further delay on fishing for new recruits. "Best estimates" of percent gain in yield for each species with optimum opening are presented in Table SHR-1. These estimates are most sensitive to uncertainty about natural mortality rate, so bounds are also presented using M=0.2 and M=0.35 per month.

III.3.4 Recruitment Indices

Annual brown shrimp recruitment estimated by VPA shows an increasing trend (Fig. SHR-14). Since yield per recruit has remained fairly constant, this indicates that most of the increase in yield over the past 24 years is attributable to improving recruitment. Indices based on CPUE for newly recruited shrimp generally support the conclusion that recruitment has increased (SAW/84/SHR/3).

Annual recruitment of white shrimp (estimated by VPA) has shown considerable short term fluctuation (almost five-fold) from 1960-1983 (Fig. SHR-15). The similarity in pattern between recruitment and landings is apparent. No long term trend was evident.

Pink shrimp recruitment (estimated by VPA) has been fairly stable from 1960-1982 (Fig. SHR-16).

These indices are all computed stockwide. Local areas may show more variability, e.g. apparent low recruitment in the Tortugas fishery since summer, 1981.

III.3.5. Stock/recruitment relationships

Evidence for a meaningful stock recruitment relationship for brown shrimp is not convincing. Fits to the Beverton-Holt stock recruitment model are poor (Figs. SHR-17 andd SHR-18). The minimum points were observed in the early 1960's at effort levels much lower than those seen recently. Evaluation of the "current situation" with respect to maximum surplus recruitment is sensitive to how parent stock is defined, with two models presented indicating that exploitation is still well below, or just now approaching, levels providing maximum surplus recruitment. Thus, present indications are that recruitment overfishing is not a problem for Gulf brown shrimp, but the possibility of recruitment overfishing in the future should not be dismissed.

An apparent relationship is seen in plots of white shrimp recruitment vs. parent stock (Figs. SHR-19 and SHR-20) which may be fit with the Beverton-Holt model. As with brown shrimp, the minimum points occurred early in the data history, with effort levels near half recent levels. As such, variation in stock and recruitment not directly associated with fishing may have been important in establishing the form of the relationship, but conservative interpretation of the available data indicates that exploitation is at or above the maximum surplus recruitment level.

Recruitment is a year-round phenomenon for pink shrimp, but there appears to be two broad peaks a year, in fall and spring. For neither peak does there appear to be much relationship between recruitment and parent stock level within the range of the data (Figs. SHR-21 and SHR-22). Recruitment overfishing does not appear to be an immediate concern with pink shrimp.

III.3.6. Population models

"Closed-loop" population models were produced for all 3 species by linking Ricker-type yield per recruit models to the above stock/recruitment relationships. Although the stock recruitment relationships are not necessarily definitive or convincing, population models based on the relationships provide reasonable, albeit conservative, interpretations of the available data, and allow estimation of MSY, using considerably more information than can be accommodated in traditional surplus production models.

"Best estimates" of MSY for the commercial component of the fishery were 74 and 80 million pounds for brown shrimp, 38 and 49 million pounds for white shrimp, and 13.6 and 13.9 million pounds for pink shrimp. The two estimates for each species were based on the different stock recruitment relationships displayed in Figs. SHR 17-22 or presented in SAW/84/SHR/2.

III.3.7 Other Fishery Indices

Trends in exploitation are summarized by changes in the fraction of recruits captured by the fishery. For brown shrimp, the fraction captured has risen fairly steadily across the 1960-1983 time series (Fig. SHR-22). Neither white nor pink shrimp show continuing trends across the time series (Figs. SHR-24 and SHR-25).

Average size of brown shrimp landed has decreased (Fig. SHR-26). Average size of white shrimp landed has declined (Fig. SHR-27). Average size of pink shrimp landed (Fig. SHR-28) has shown fairly large fluctuations, with some decline possible since an apparent maximum in the early 1970's. Multiple interpretations exist for a decline in average size, including economic factors. Declining size alone need not mean that a "problem" exists.

South Atlantic

Shrimp populations along the Atlantic coast appear to be more heavily dominated by environmental variation than Gulf populations, and research along the Atlantic coast has generally had a more "environmental" than traditional "assessment" flavor.

SAW/84/SHR/1 concentrates on the effect of severe winters on the spring fishery for white shrimp. Spring landings in South Carolina were found to be predictable from preceding fall catches (indexing year class abundance) and duration of temperatures below 8°C. There are also indications of a stock recruitment relationship in the South Carolina landings data, as a poor spring season (relying on potential spawners) often foretells a poor fall season (relying on new recruits) (Fig. SHR-29). An inverse relationship between shrimp size in the commercial catch and amount landed was reported (Fig. SHR-30). A similar inverse relationship has also been seen in Georgia (Shipman _et al_. 1983).

Mark-recapture experiments conducted with white roe shrimp in southeastern Georgia and northeastern Florida (SAW/84/SHR/4) confirmed emigratory behavior related to peak reproductive activity in May and June, with spatial and temporal variability within this spawning period. Offshore directional movements of tagged shrimp from bordering estuaries indicates a potential for southward and northward interjurisdictional recruitment of spawners betwen Georgia and Florida waters. However, the relatively minimal mean distances traveled regardless of days at large suggest minimal migratory behavior of roe shrimp in this area of the south Atlantic and/or a concentration of fishing effort on these spawners at emigration such that this potential is minimized. The possibility exists for recruitment of spawner from unidentified offshore white shrimp populations.

Recapture results indicate the influence of environmental parameters on spawning white shrimp. While increasing water temperature is closely related to the maturation process (Fig. SHR-31), precipitation appears to be a dominant factor influencing adult emigratory behavior during the spring and summer spawning season. Additional environmental factors, including lunar phase and directional wind components (and consequent tidal influence) probably coupled with salinity to influence offshore movement (Fig. SHR-32).

There appears to be a greater correlation between spring spawner abundance and subsequent fall production for the South Carolina component of the south Atlantic white shrimp fishery. Limited statistical attempts have yielded poor predictive relationships between Georgia fall production and the preceding roe shrimp production (indicative of spawning stocks), salinity, and August white shrimp assessment abundance (Shipman et al. 1983).

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

The individual states conduct extensive monitoring and management programs, basically aimed at determining proper seasonal (and area) openings to achieve objectives related to size of shrimp captured. These objectives vary from state to state, but generally include considerations of minimum marketable size and potential economic yield. In the Atlantic, protection of spawners is also an objective. Summaries of regulations (gear restrictions, license requirements, etc.) were presented in the Gulf Shrimp FMP and the South Atlantic Shrimp Profile.

Two major measures in effect in the FCZ are the Texas closure and the Tortugas closure. Both these actions have been the subject of recent research, and were evaluated in separate reports submitted to the Gulf of Mexico Fishery Management Council. The Texas Closure analyses showed that increased yields were attained with the FCZ closure in 1981 (about 4 million pounds), and that changes in yields were below practical detectable levels in 1982 and 1983. The combined effects of the Texas Territorial Sea and FCZ closures were also evaluated, and were estimated to have increased yields by 9 million pounds in 1981 and 4 million pounds in 1982. Direct "impact" analyses for the Tortugas Closure were not performed, but yield per recruit results were reviewed, again indicating an increase in yield by delaying fishing from first recruitment.

No new data relative to these actions were submitted to this workshop.

V. RECOMMENDATIONS

V.1. Research and Data Needs

We considered two types of recommendations for further research: a set of more immediate, prioritized requirements needed in the context of present assessment strategies (done at the population level) and longer range needs that will be important in developing new strategies. The items cited are most appropriate to the Gulf of Mexico, for which stock-wide assessments were reported. We recognized that development of the Profile of the Penaeid Fishery in the south Atlantic is continuing and expect that an expanded list of requirements specific to South Atlantic stocks will be developed in the near future.

V.1.1. Highest Priority

(1) Design and implement sampling and research programs to:

a. estimate currently unreported components of the catch on a a continuing basis;

b. improve estimation of effective effort.

Unreported catch:

These components are recreational landings, commercial landings not sold to dealers currently canvassed, and shrimp caught and discarded. Existence of unreported catch could seriously affect conclusions regarding status of the stocks with respect to recruitment overfishing and growth overfishing, and could bias evaluations of the effects of management measures.

Effective effort:

Three areas were seen as particularly in need of further work: obtaining effort and craft/gear characteristics for components of the fishery not now covered; timeliness of the vessel characteristics data files; and thorough investigation of the utility of the effort data collected by current procedures.

Data required:

Data required are catches by species, size (and, if possible, by sex), time and location of catches, with associated fishing effort estimates, including characteristics of the fishing craft and gear for all components of the fishery. These data are required stock-wide.

(2) Develop techniques for improving natural mortality rate estimates.

The limited precision of existing estimates of natural mortality rates (M) restricts confidence in conclusions involving yield per recruit. Additionally, no data are available to evaluate the variations in M that are frequently conjectured with size, season, location, or over years.

(3) Develop a coordinated (stock-wide) research program to measure and study causes of variations in recruitment, preferably by fishery-independent approaches.

The research should incorporate long term trends in recruitment (including possible effects of habitat alteration), relationships between recruitment and parent stock size, and seasonal variations in environmental variables important in controlling recruitment strength. This research will require expanded state-state and state-federal coordination to develop sampling programs suitable for obtaining fishery-independent indices of recruitment strength, and measurements of appropriate environmental variables on a stock-wide basis.

V.1.2 High priority

(1) Develop models of fleet behavior suitable for predicting and evaluating biological impacts of management actions.

Evaluation of the effectiveness of any management action usually requires assumptions about what fishing patterns will be (or would have been) after the action is taken (or had the action not been taken). That is, one must predict behavior of the fishery in response to simultaneous changes, biological, economics, and regulatory conditions. Descriptions of fleet behavior are the first step. The types of data required are characteristics of the fishing craft, information on movement of vessel among areas, and information on catch rates and economic returns on a per trip basis.

(2) Design and implement a data collection program to improve resolution about species, sex, size composition, and reproductive condition on a continuing basis.

Absence of detailed information on these items restricts the quantitative conclusions that may be made using existing analyses, and inhibits evaluation of variations in seasonal patterns of recruitment.

Recommendations involving data requirements fall in two categories:

a. insure that the maximum species and size resolution available for each item of data as it is collected in the marketplace is maintained in the data collection and processing system.

b. design and implement a sampling program to determine actual species, sex, size (length) composition, and reproductive condition of the commercially reported market categories on a continuing basis.

(3) Continue development of research cruise programs to evaluate spatial distributions and relative abundance of adult and juvenile shrimp.

Fishery-independent information about size structure of the stocks and abundance fluctuations should be considered vital for long term stock assessments. Such information is also vital where management measures alter past fishing patterns in a major way, or exclude fishing over part of the stock, either in space or time, as with the Texas and Tortugas closure measures in the Gulf.

The SEAMAP program developed in 1982 was recognized as an excellent beginning. Continued development of this valuable program is expected.

V.1.3. Next priority

(1) Develop quantitative models of shrimp migrations.

(2) Determine growth by sex patterns for ages and sizes of shrimp not currently well defined in existing growth data.

(3) Improve temporal resolution to reported catch data.

(4) Determine patterns and quantity of bycatch from shrimping operations.

V.1.4. Longer range

Longer range research needs center primarily on assessing shrimp in a community and ecosystem context. Careful evaluation of research needs in this area should be conducted separately, but probably considerable progress in data development can be realized simply with close coordination among existing research programs, taking advantage of opportunities for data collection. Other items recognized as important in the longer range were: identification of recruitment strength by geographic area, development of information on early life population dynamics, better development of information of spawning biology at the population level, and study of effects of oceanographic conditions on the shrimp and shrimp fishery.

V.1.5. Some Specific Research Suggestions

Three detailed areas of research (integrating the research and data needs just listed) were identified as being particularly valuable, based on findings presented at this workshop:

1) brown shrimp recruitment processes

2) white shrimp stock/recruitment relationships

3) problems in natural mortality estimation.

The need for concentrated study of brown shrimp recruitment processes was highlighted by the apparent reliance on increasing recruitment as the source of the increasing landings over the last 24 years. Research is required on utilization of estuarine habitats by pre-recruits; stockwide habitat mensuration and measurement of recruitment; long term, fishery-independent estimation of spawning stock size via a SEAMAP-type survey, and oceanographic influences on egg and larval transport.

White shrimp recruitment processes will require a research plan similar to that for brown shrimp, but the apparent spawner/recruit relationships seen in both the Gulf and Atlantic suggest that research should focus particularly on the stock/recruitment question. Analytically, procedures for indexing spawning stock, and fitting techniques for stock/recruitment models should be explored. Developing a time series of fishery-independent estimates of spawning stock size is considered vital, and can be accomplished by adding nearshore sampling to the June/July SEAMAP cruises. Limited data available before 1960 suggest that landings may have been higher in the late 1930's than at present. Possible incorporation of these older data with more recent data for stock/recruitemnt modeling should be investigated.

Research on natural mortality rate may have struck technical limits for precision and accuracy, while falling short of the levels desired for management purposes. A thorough evaluation of problems in measuring natural mortality appears necessary, which may best be accomplished through a workshop devoted to natural mortality estimation. Topics should include estimation by mark/recapture, by analysis of catch/effort statistics, and by any new approaches suggested.

V.2. Management

No new management recommendations are made at this time.

Table SHR-1. Results of Ricker-type yield per recruit models for Gulf of Mexico Shrimp. "Optimum" opening is the month for season opening (or time in months past recruitment for pink shrimp) that will produce maximum yield in pounds at 1981-1983 fishing mortality levels. Optimum F is the fraction of the current (1981-1983 average) level of fishing mortality rate that will maximize yield in pounds given the current seasonal openings and fishing patterns (evaluated to 4x current levels). Because results are most sensitive to uncertainty about natural mortality rate (M), models were also run at lower and higher M values.

	OPTIMUM OPENING	% GAIN IN YIELD	OPTIMUM F	% GAIN IN YIELD
Best estimates:				
Brown Shrimp	July	16	1.2	< 1
White Shrimp	Oct	2	4.0	5
Pink Shrimp	2	6	1.5	2
With M = 0.2				
Brown Shrimp	Aug	40	0.7	3
White Shrimp	Nov	11	0.6	3
Pink Shrimp	3	21	0.7	2
With M = 0.35				
Brown Shrimp	July	2	4.0	15
White Shrimp	June	0	4.0	23
Pink Shrimp	1	3	2.3	9

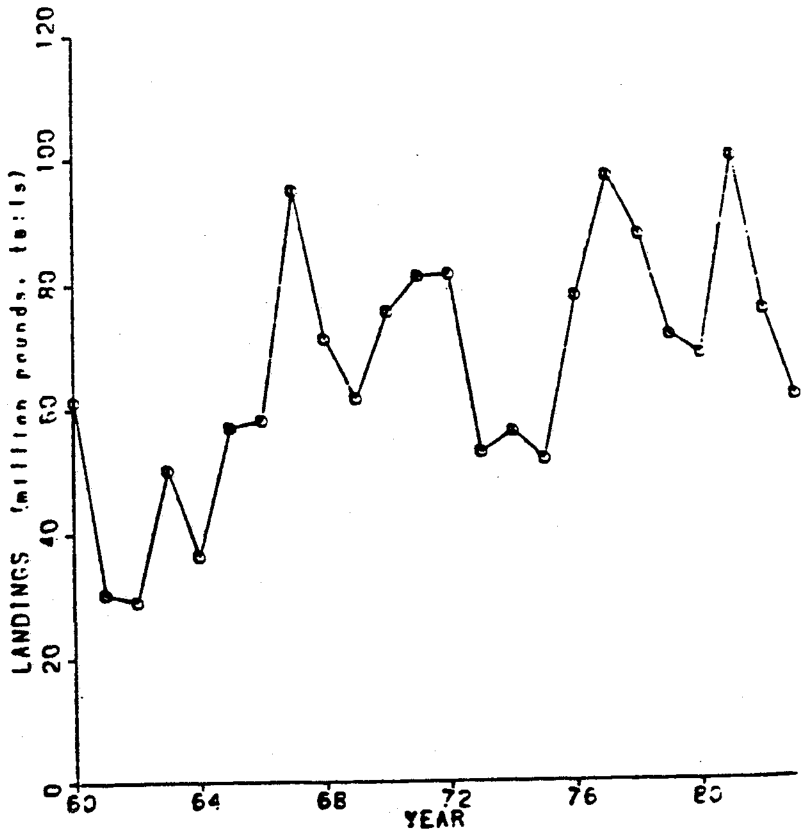


Figure SHR-1. Reported annual landings of brown shrimp from the U.S. Gulf of Mexico.

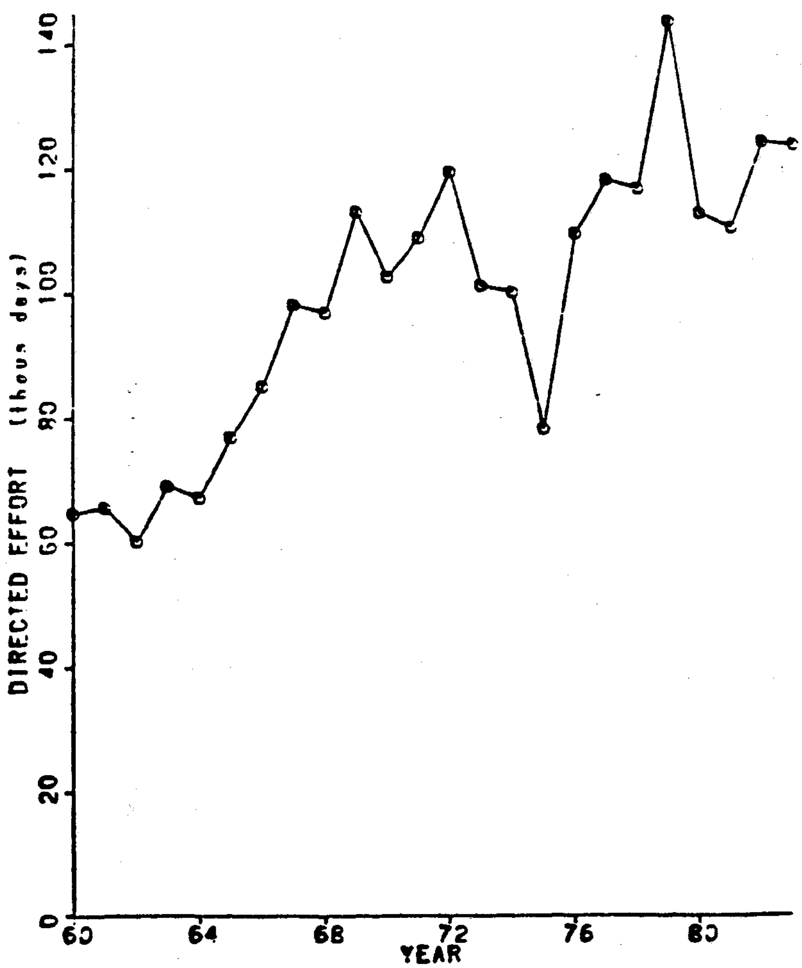


Figure SHR-2. Estimated annual directed effort for brown shrimp in the U.S. Gulf of Mexico.

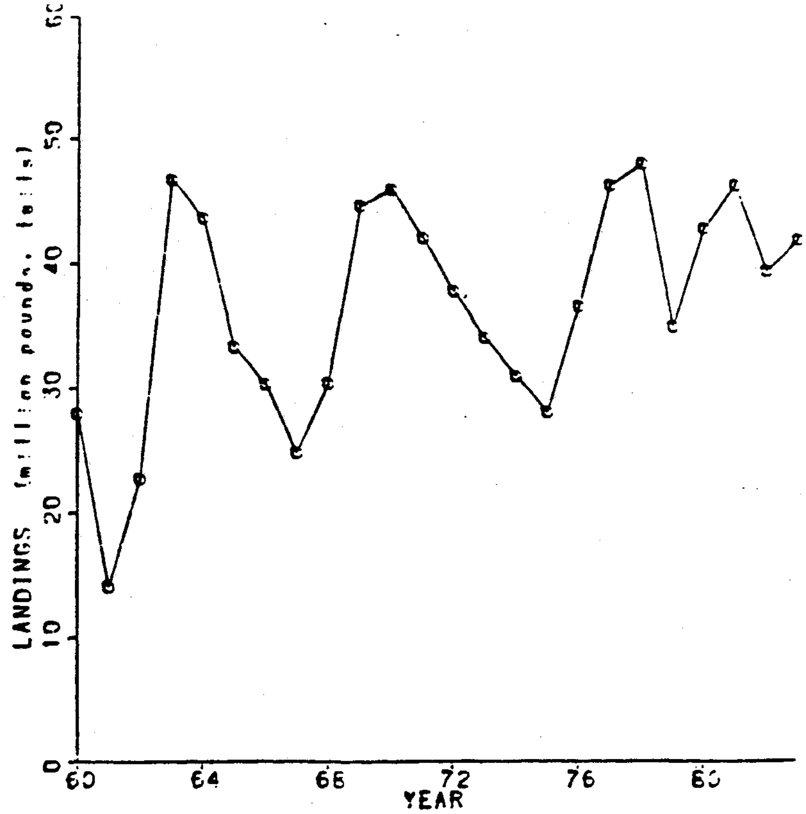


Figure SHR-3. Reported annual landings of white shrimp from the U.S. Gulf of Mexico.

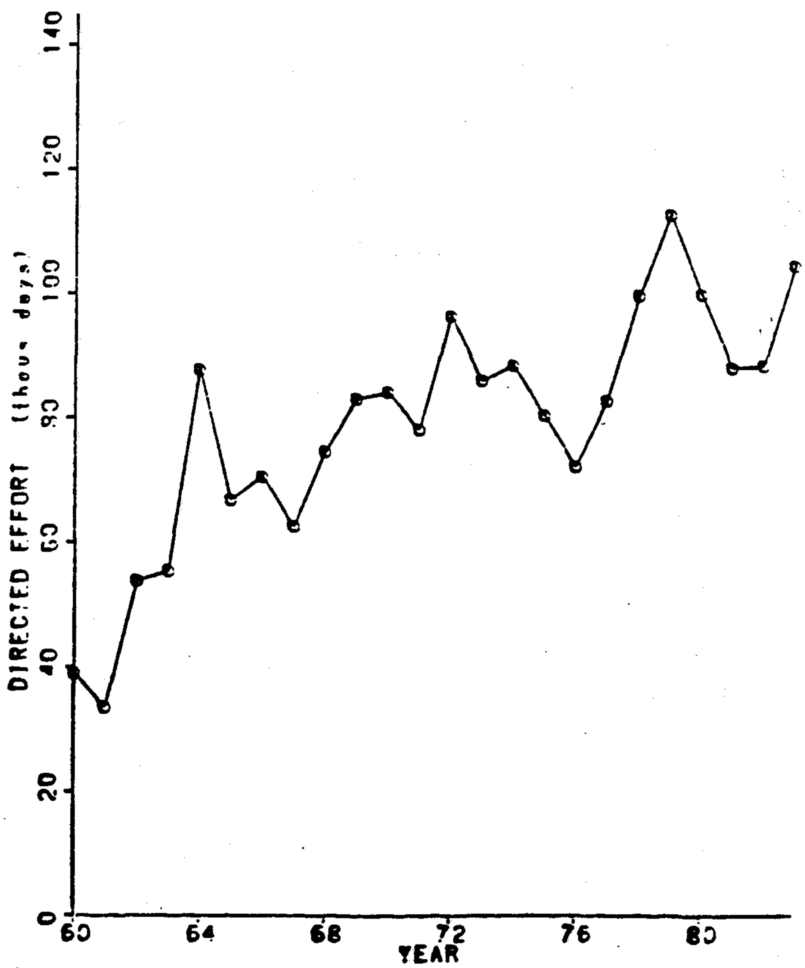


Figure SHR-4. Estimated annual directed effort for white shrimp in the U.S. Gulf of Mexico.

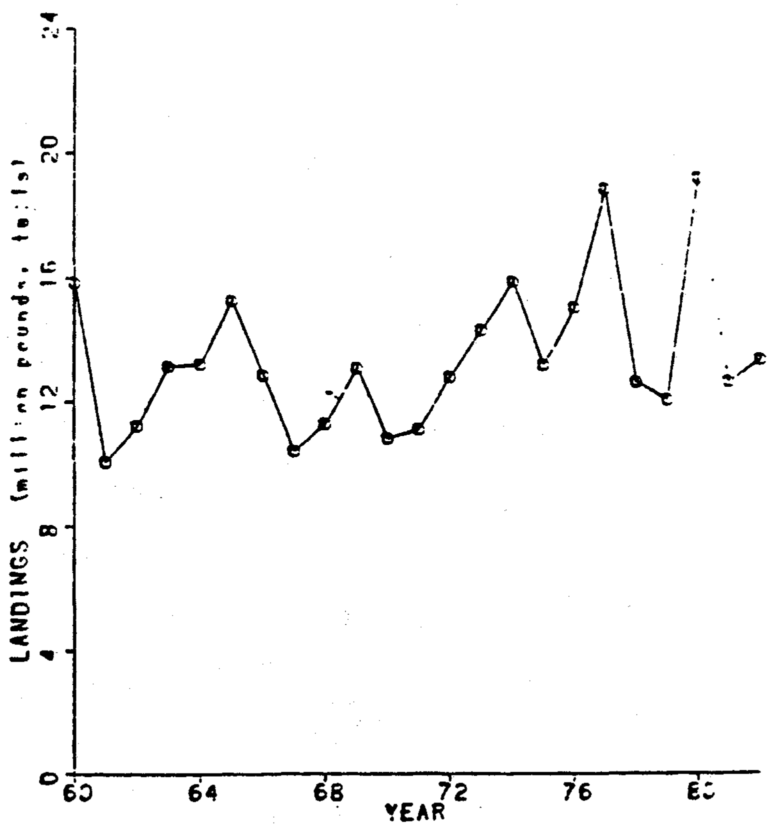


Figure SHR-5. Reported annual landings of pink shrimp from the U.S. Gulf of Mexico.

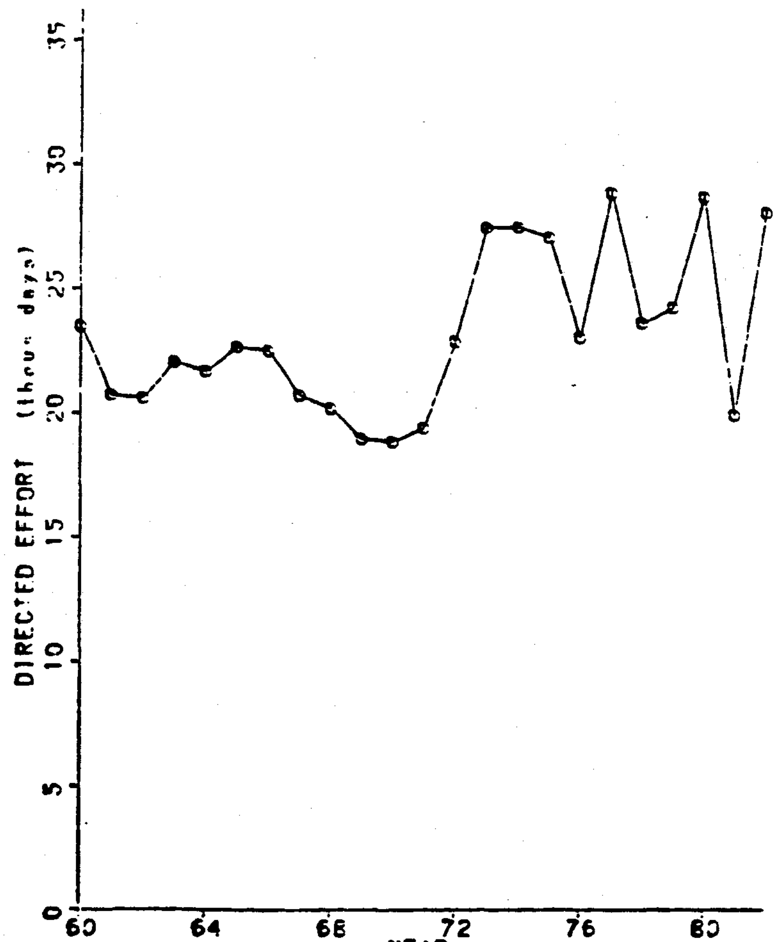


Figure SHR-6. Estimated annual directed effort for pink shrimp in the U.S. Gulf of Mexico.

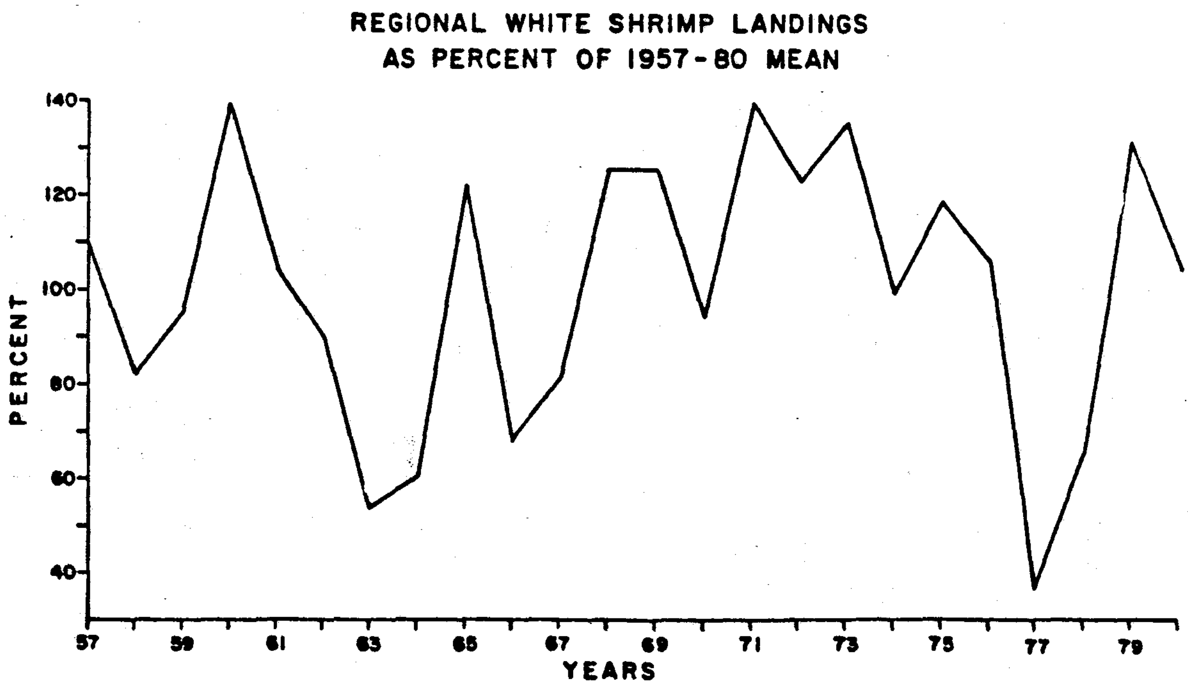


Figure SHR-7. South Atlantic Bight white shrimp landings shown as percent of the 1957-1980 mean.

Figure SHR-8. Estimated annual average catch per unit effort for Gulf brown shrimp.

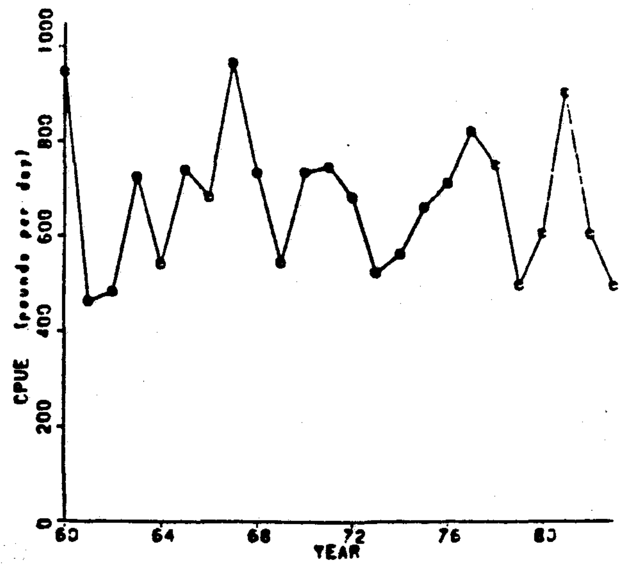


Figure SHR-9. Estimated annual average catch per unit effort for Gulf white shrimp.

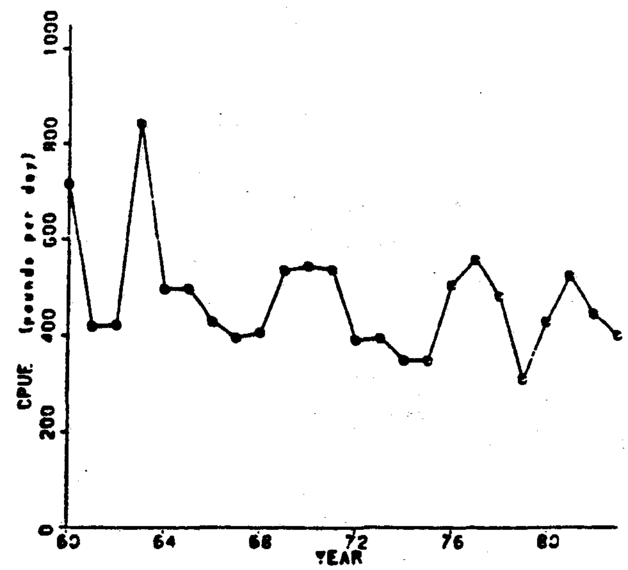


Figure SHR-10. Estimated annual average catch per unit effort for Gulf pink shrimp.

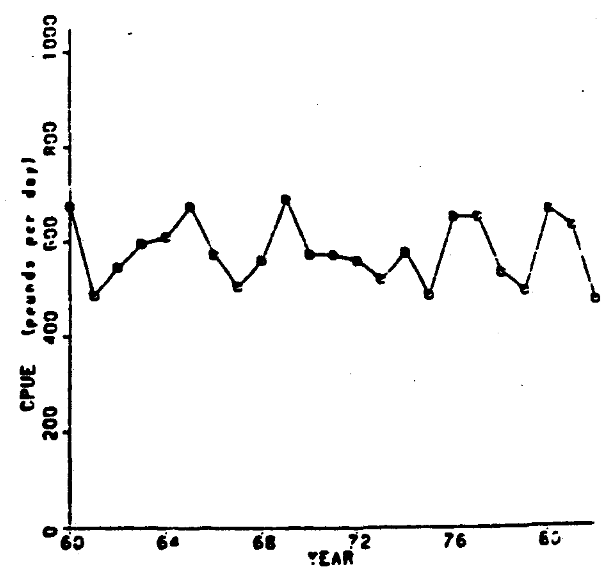


Figure SHR-11. Estimated realized yield per recruit vs. year class for Gulf brown shrimp.

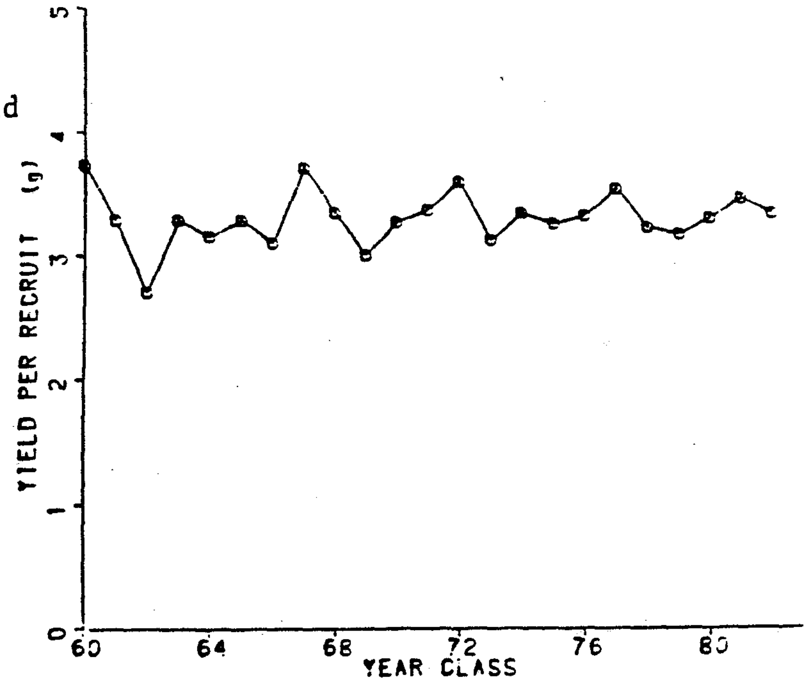


Figure SHR-12. Estimated realized yield per recruit vs. year class for Gulf white shrimp.

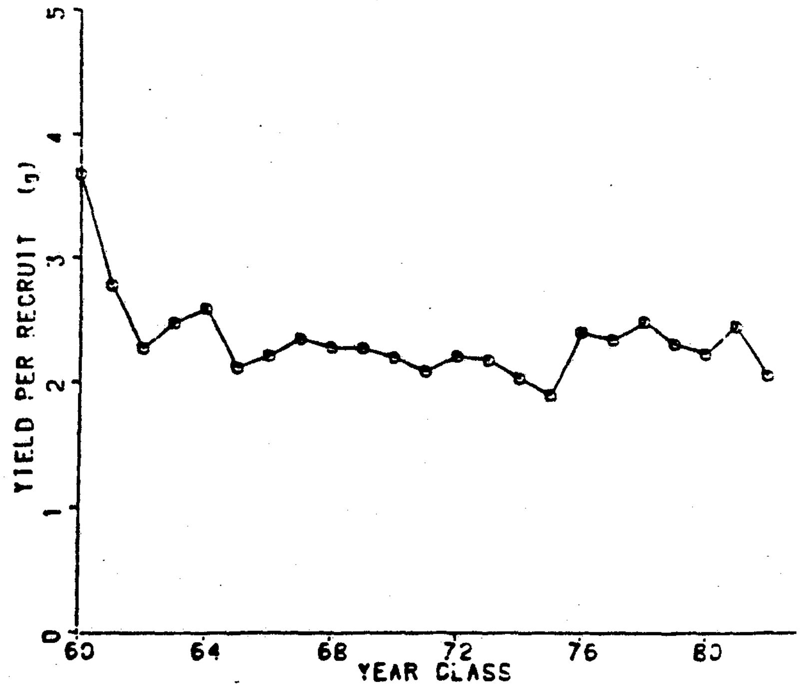


Figure SHR-13. Estimated realized yield per recruit vs. year class for Gulf pink shrimp.

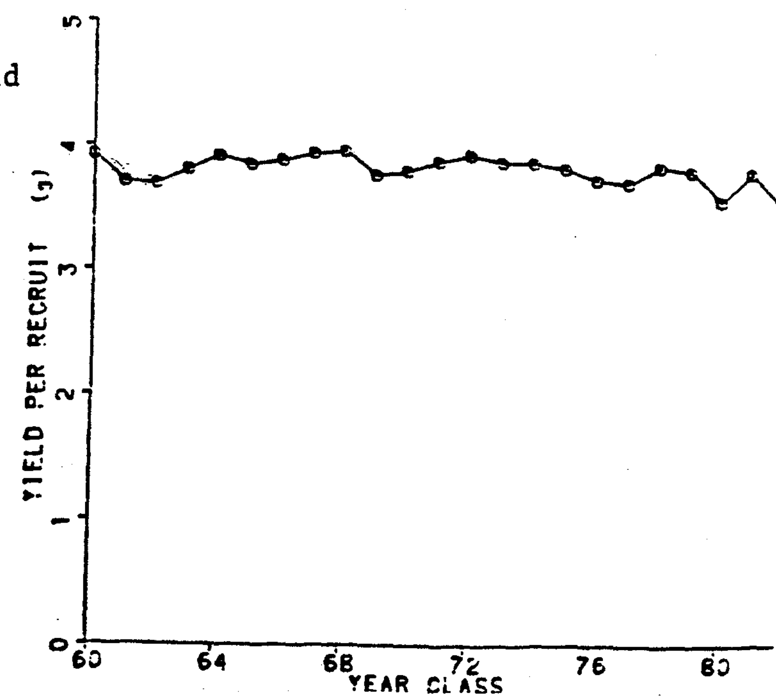


Figure SHR-14. Estimated annual recruitment for Gulf brown shrimp.

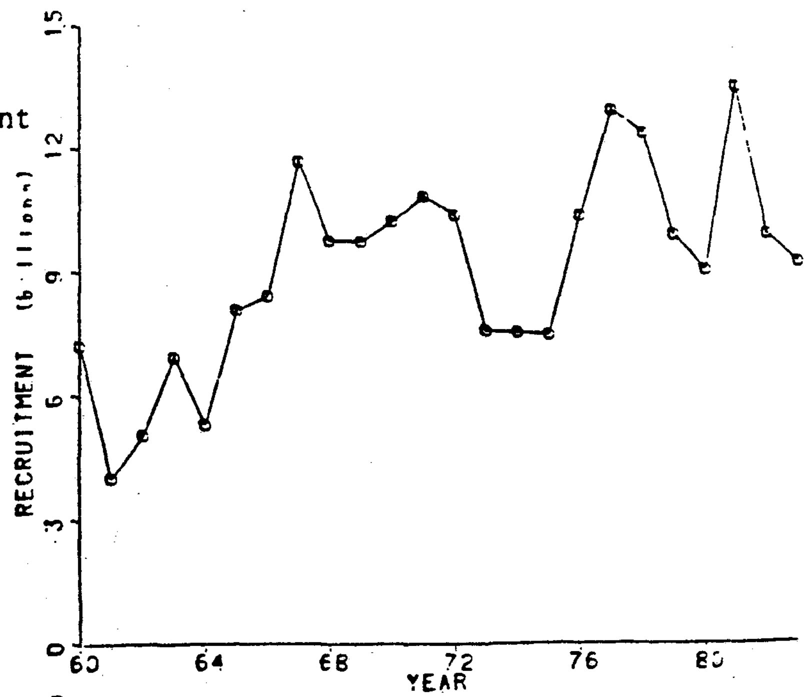


Figure SHR-15. Estimated annual recruitment for Gulf white shrimp.

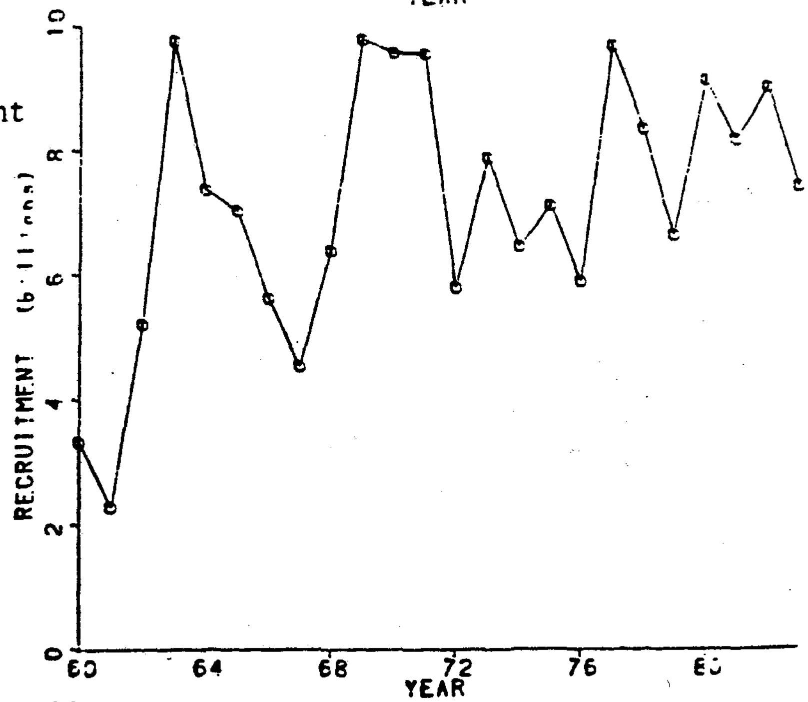
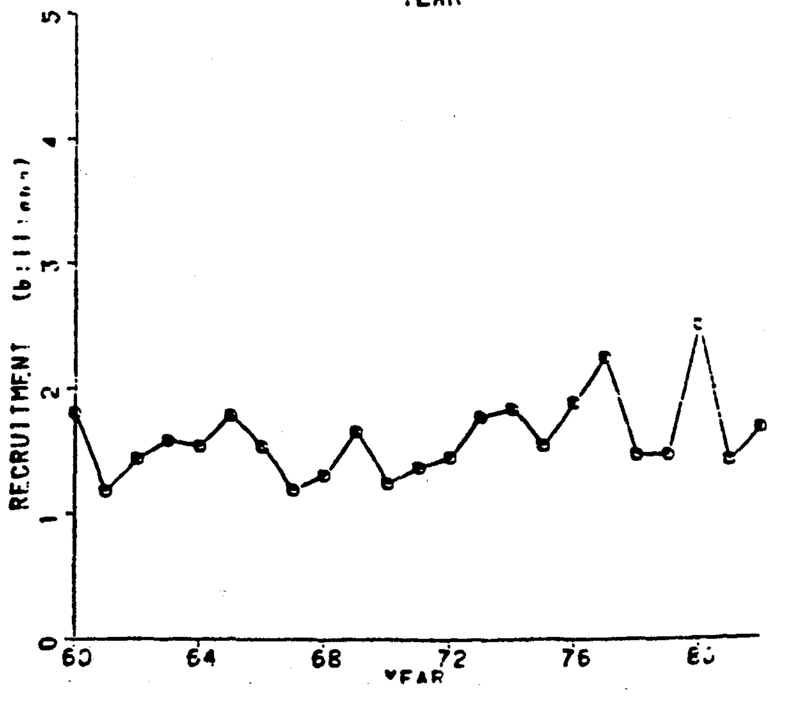


Figure SHR-16. Estimated annual recruitment for Gulf pink shrimp.



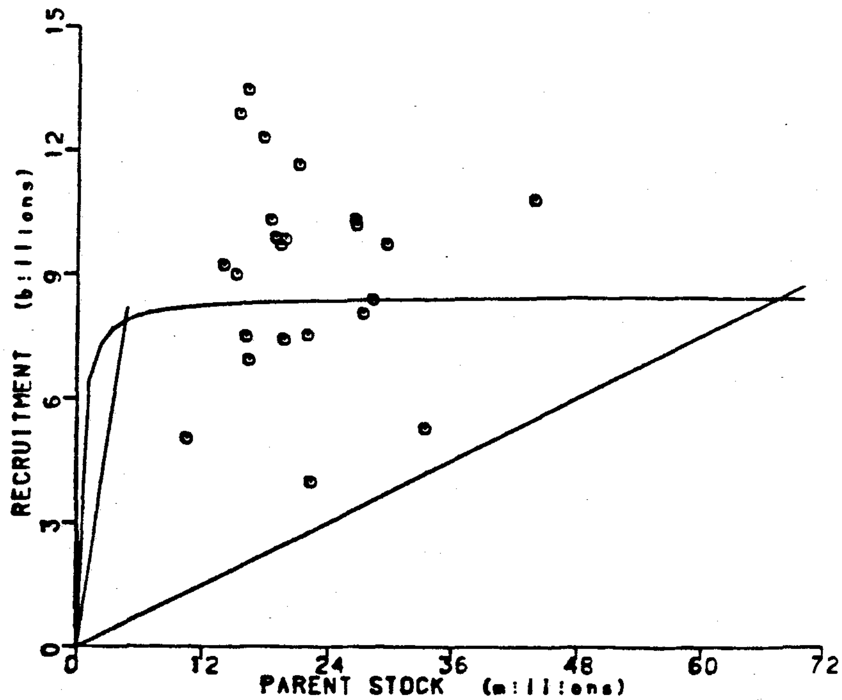


Figure SHR-17. Gulf brown shrimp stock/recruitment relationships, between annual recruitemnt and December parent stock size. A: replacement line with no fishing, B: replacement line at MSR.

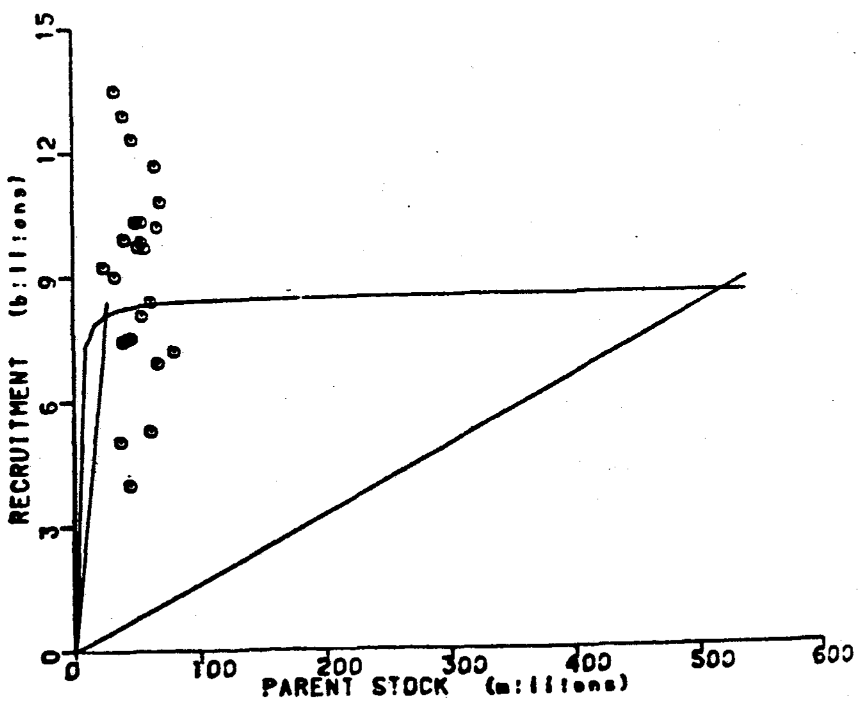


Figure SHR-18. Gulf brown shrimp stock/recruitment relationship, between annual recruitment and March parent stock size. A: replacement line with no fishing, B: replacement line at MSR.

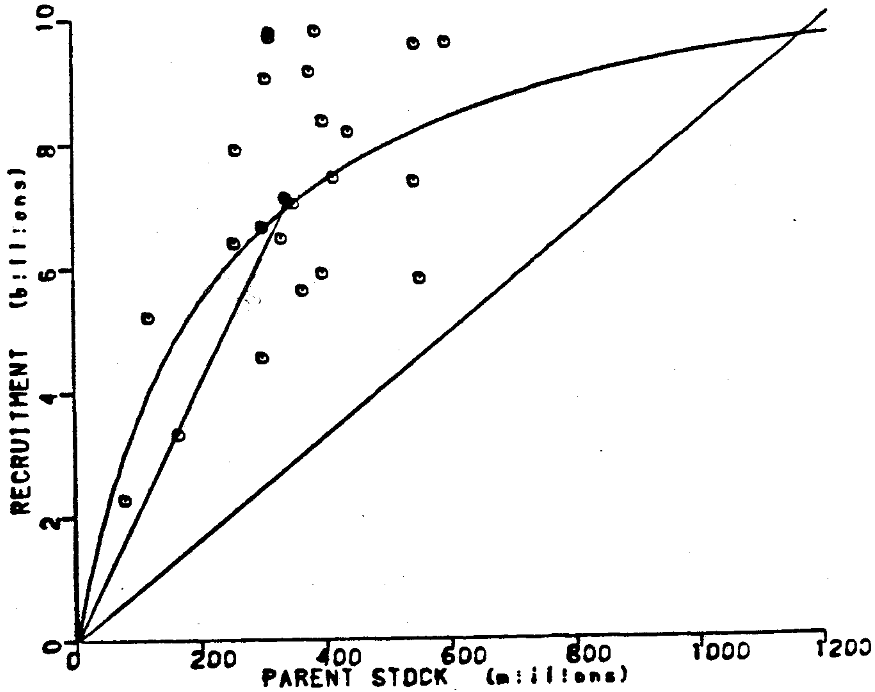


Figure SHR-19. Gulf white shrimp stock/recruitment relationship between annual recruitment and April parent stock size. A: replacement line with no fishing, B: replacement line at MSR.

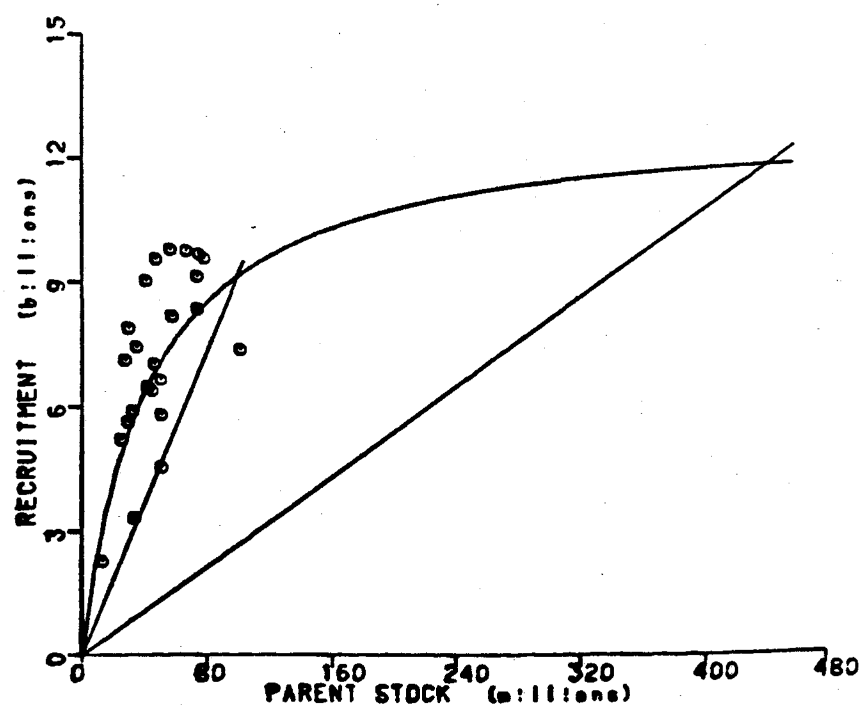


Figure SHR-20. Gulf white shrimp stock/recruitment relationship between annual recruitment and August parent stock size. A: replacement line with no fishing, B: replacement line at MSR.

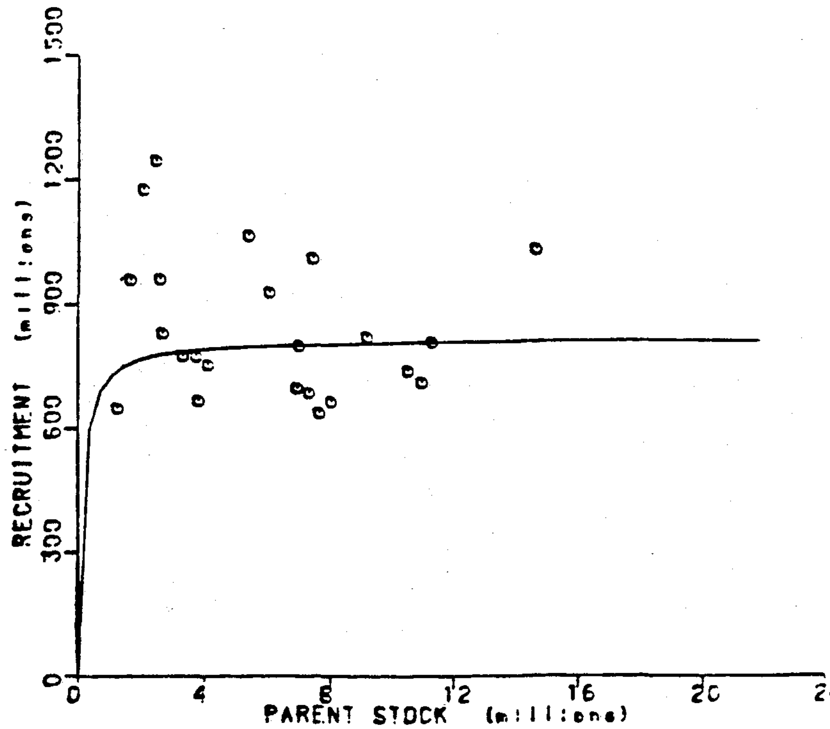


Figure SHR-21. Gulf pink shrimp stock/recruitment relationship between January through June recruitment and February parent stock size.

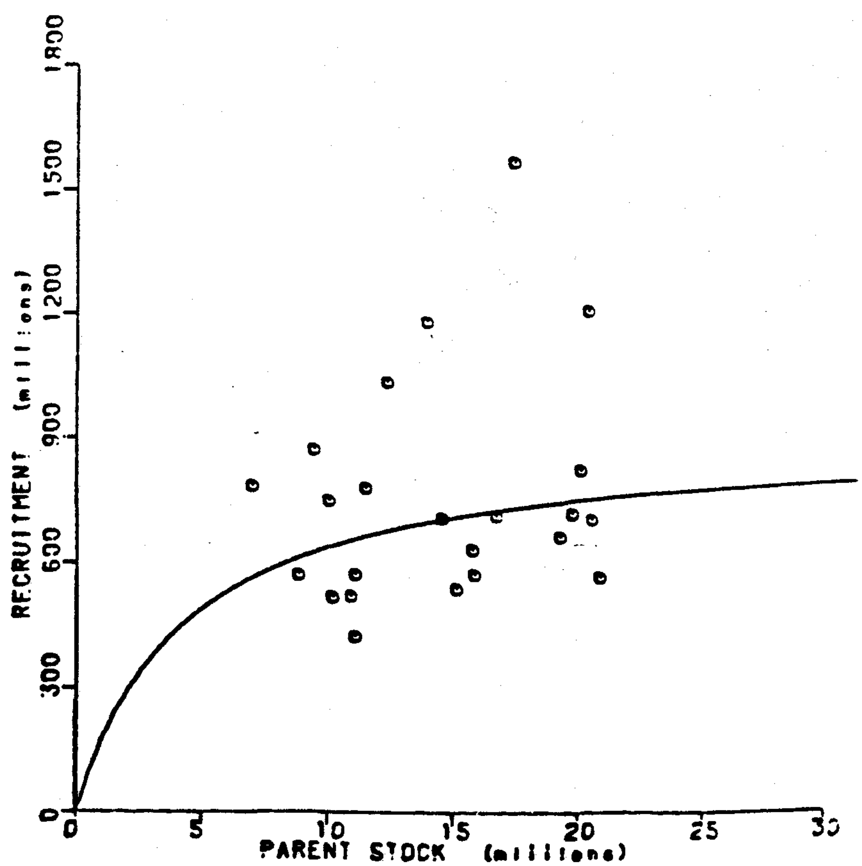


Figure SHR-22. Gulf pink shrimp stock/recruitment relationship between July through December recruitment and August parent stock size.

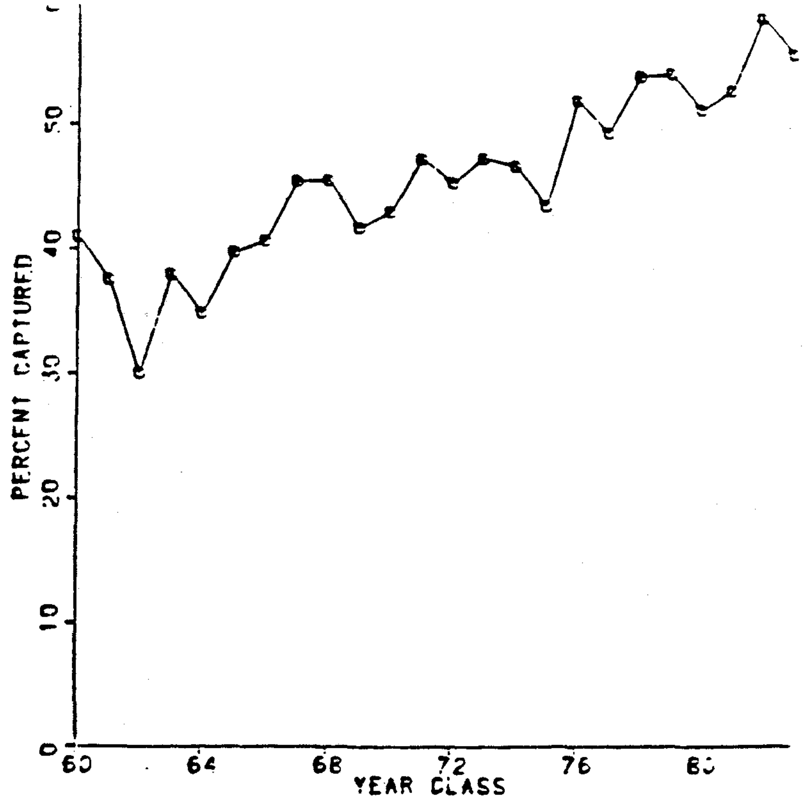


Figure SHR-23. Percentage of Gulf brown shrimp recruits captured by the fishery from each year class.

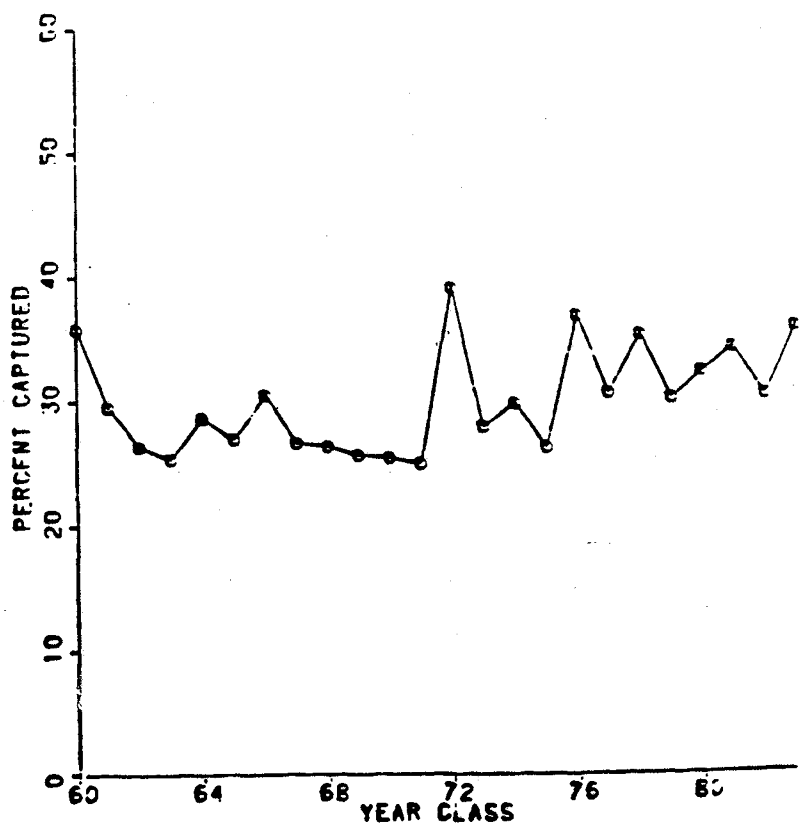


Figure SHR-24. Percentage of Gulf white shrimp recruits captured by the fishery from each year class.

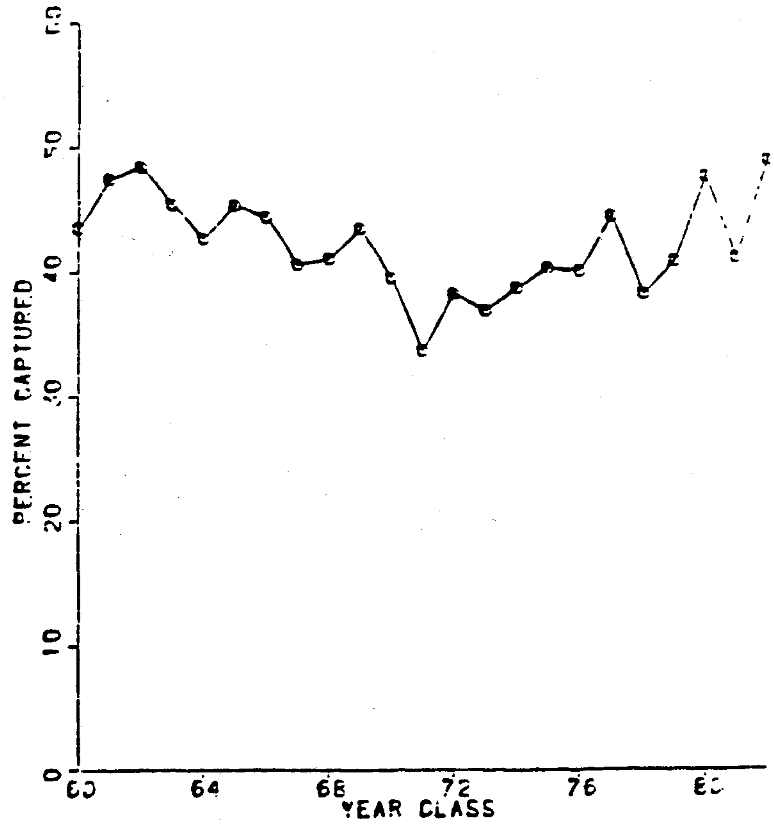


Figure SHR-25. Percentage of Gulf pink shrimp recruits captured by the fishery from each year class.

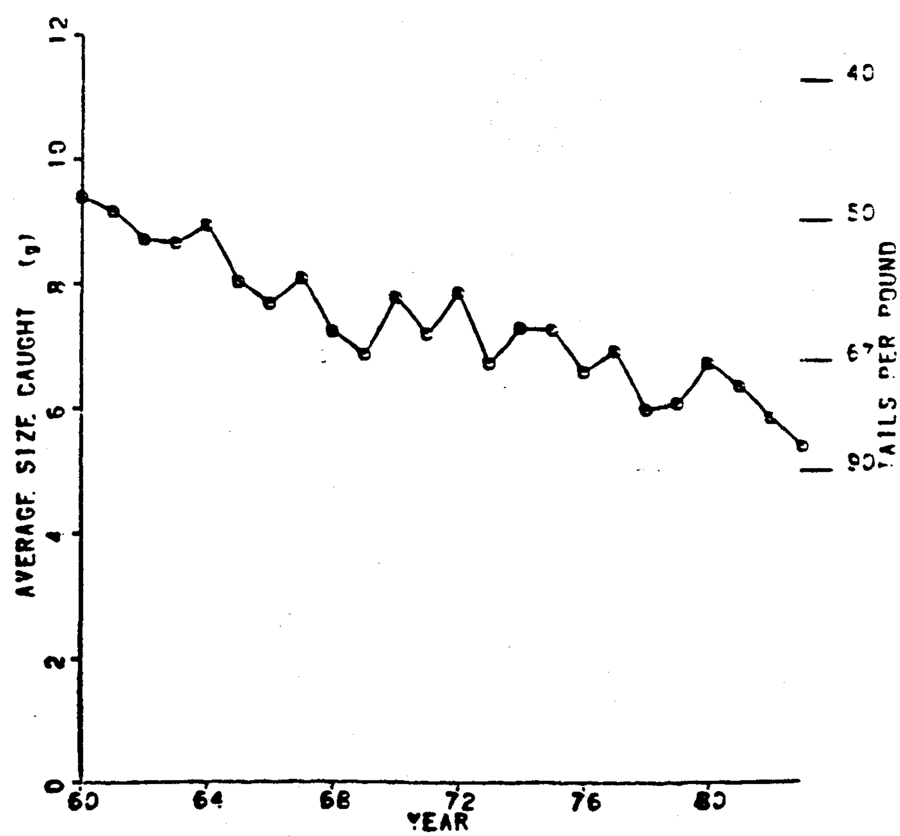


Figure SHR-26. Annual average size of Gulf brown shrimp landed.

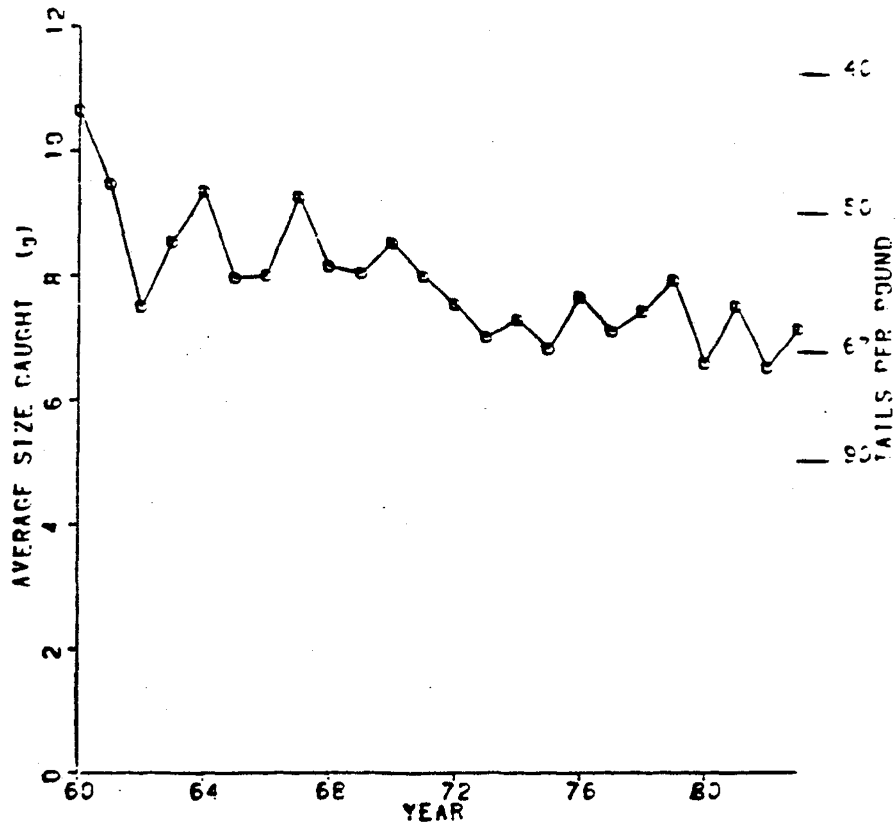


Figure SHR-27. Annual average size of Gulf white shrimp landed.

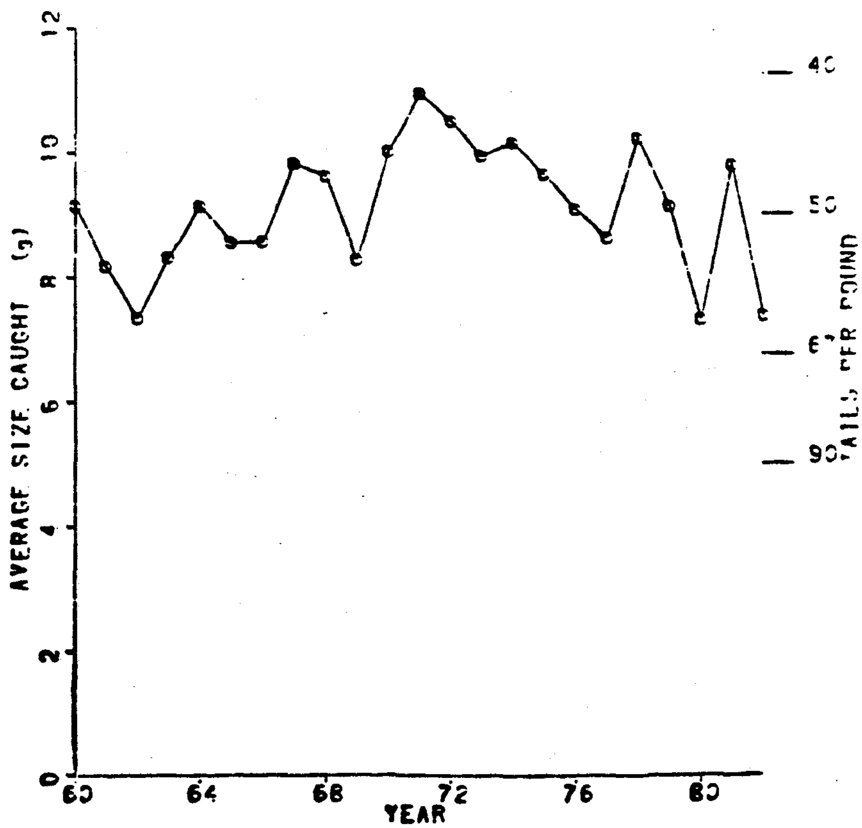


Figure SHR-28. Annual average size of Gulf pink shrimp landed.

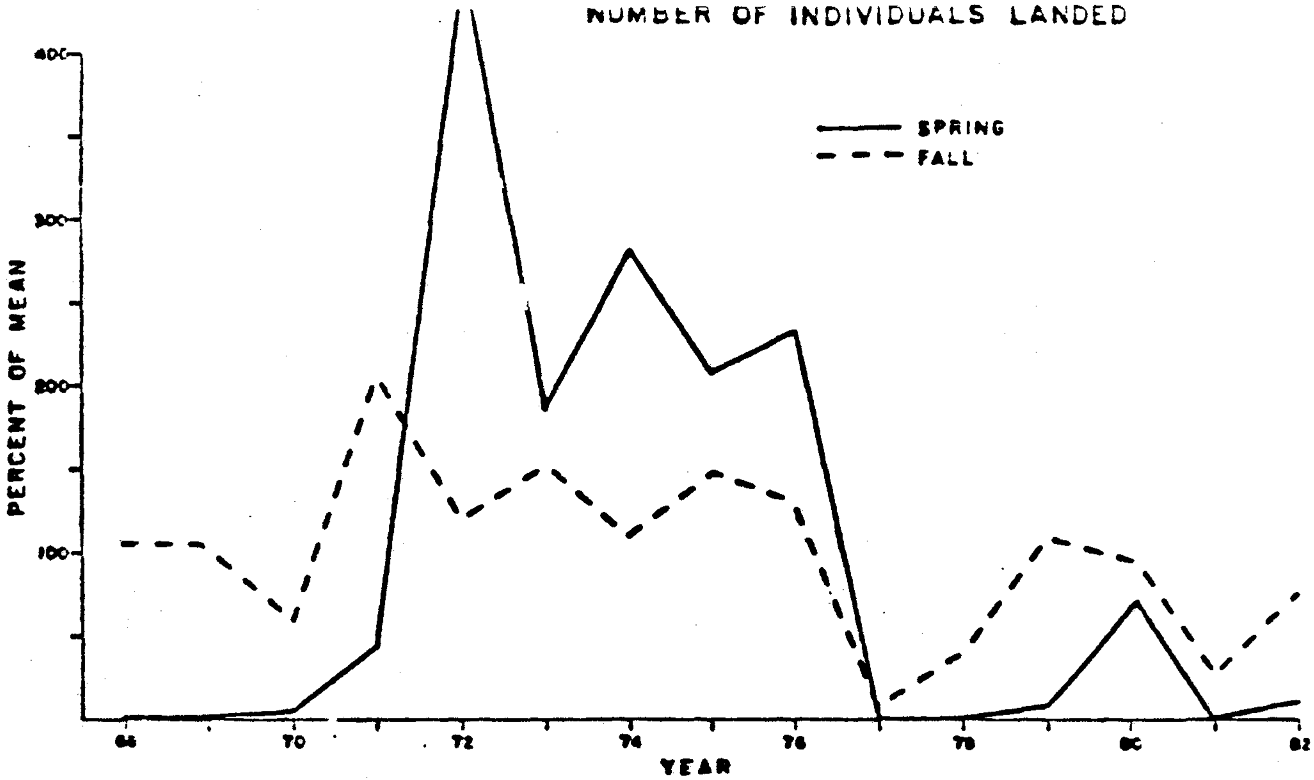


Figure SHR-29. South Carolina's white shrimp landings shown as 1968-1982 means of spring landed and fall landed shrimp.

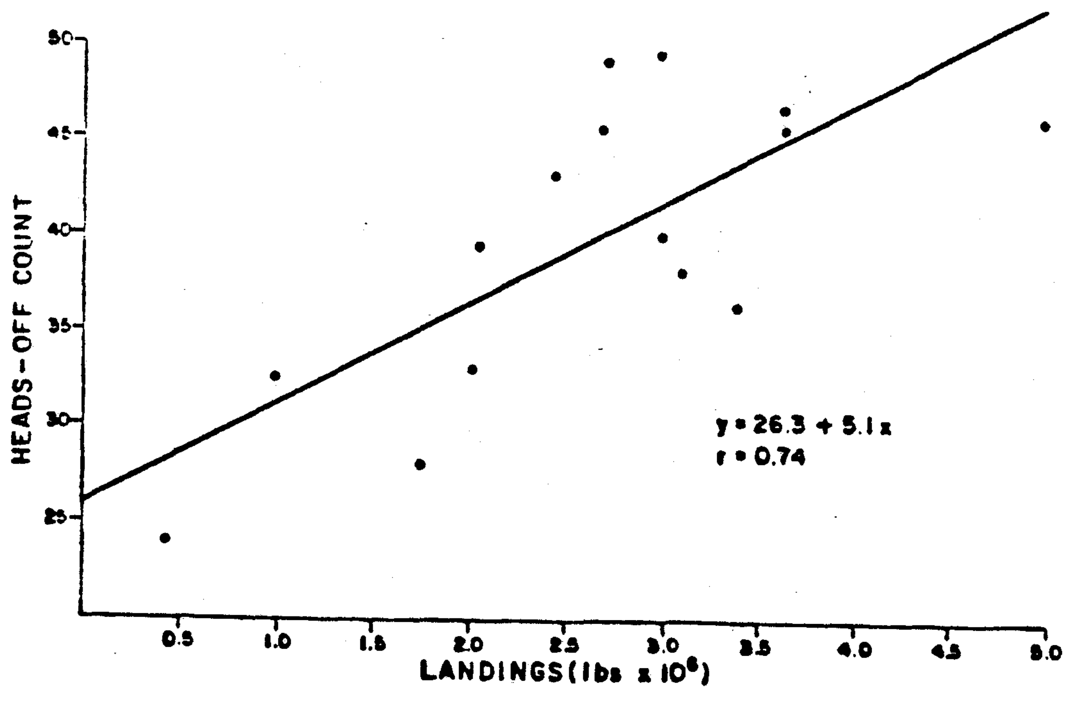


Figure SHR-30. Regression of fall landings (pounds) and fall average count (heads-off) for white shrimp in South Carolina, 1968-1982.

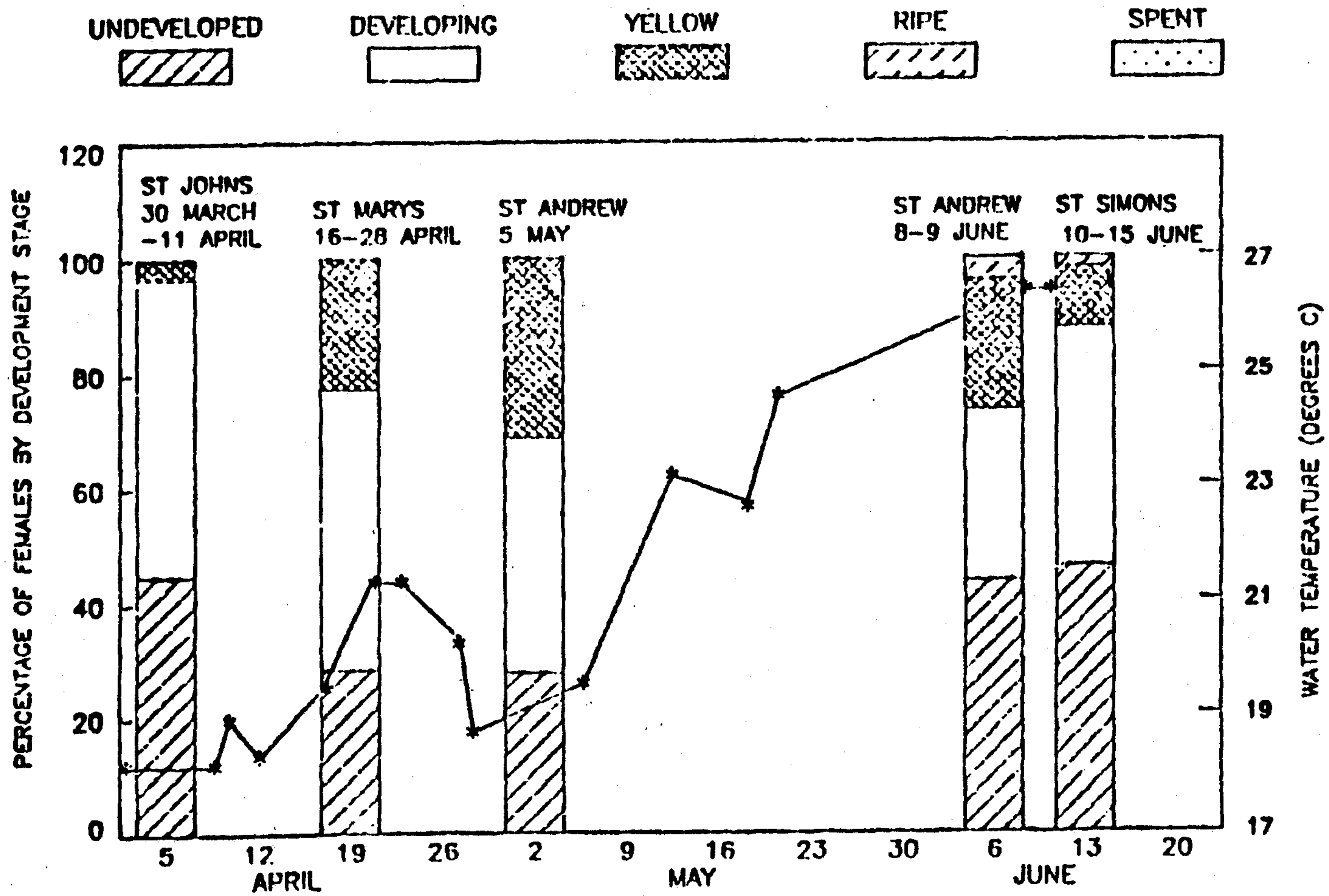


Figure SHR-31. Correlation between mean water temperature and ovarian maturation observed in tagged white shrimp released in southeastern Georgia and northeastern Florida from 30 March - 15 June 1982.

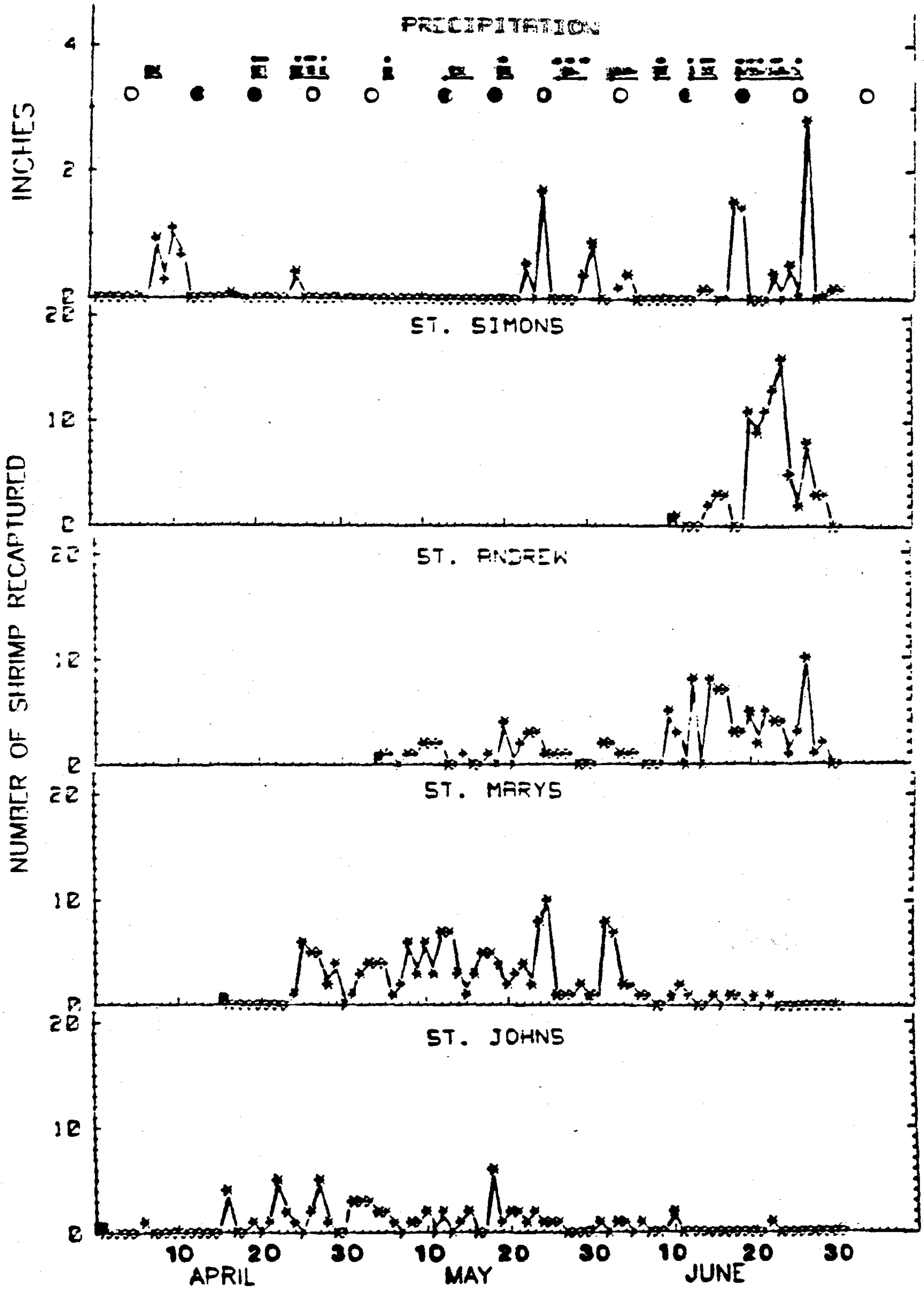


Figure SHR-32. Results from Atlantic interjurisdictional tagging experiments. Correlation between environmental influences of lunar phase, wind, and precipitation and number of tagged white shrimp recovered daily from 1 April through 30 June 1982. NOTE: R - initial date of release events; ● - new moon; ◐ - first lunar quarter; ○ - full moon; ◑ - last lunar quarter; * indicates winds from which recorded speeds exceeded 15 mph; ** - 20 mph; *** - 30 mph.

GENERAL RESEARCH RECOMMENDATIONS

In the report of the first Stock Assessment Workshop (SAW/82) four general themes of research and data collection were recommended as critical for improving the accuracy, precision and usefulness of the assessments. These categories were: stock identification, statistical data collection, recruitment indices and multi-stock assessment. The following is a discussion of the progress that has been made and recommendations for further research required to make significiant improvements in the assessments.

(1) Stock Identification - The definition of unit stock remains a critical assumption in many assessments. In several cases the precision of the estimates of present status are not affected; however, the management strategy which might be implemented is extremely sensitive to the stock identification assumption. Research has been initiated since the last Workshop to address this problem in several species including king mackerel (SAW/84/GCP/15) and marine mammals and turtles (SAW/84/MMT11, 13, 14, 15 and 17). Several additional methods of determining stock identification were suggested in the research recommendations of the Working Groups. However, research must still be done to address this key management issue. Specifically, the various methods (electrophoresis, high pressure liquid chromatography, trace element constituencies, morphometric analysis and others) must be compared so that the efficacy of the methods for each species can be evaluated. Second, sampling programs should be efficiently designed to assure that geographical region, size of fish, sex and season are appropriately weighted in the stock identification. Finally, studies of the distribution and movement of larvae from spawning to settling will be valuable in guiding stock identification research, particularly for species which are less migratory in the post-larval stages such as lobster and reef fish.

(2) Statistical Data - The need for time series of effort data, complete catch statistics and size/sex statistics were stressed in SAW/82. These data are needed to perform the more sophisticated analyses of virtual population assessment (VPA). Since 1982 size frequency information was been collected on a more regular basis. In addition, previously collected data for several stocks have been collated so that the history of sizes and catches could be estimated. Thus, VPA's were able to be performed with vermilion snapper (SAW/84/RFR/2), pink, white, and brown shrimp of the Gulf of Mexico (SAW/84/SHR/2), Atlantic and Gulf menhaden (SAW/84/MCH/1). However, several other critical analyses were severely hampered by the lack of available

catch and effort data (king mackerel, sea turtles, reef fish, lobsters). Therefore, the need for these data must be reemphaized. In particular, the need is for size and sex frequency data by fishery to use in estimating catch-at-size and, thus, catch-at-age. Special emphasis should be placed on estimating recreational catch in those fisheries where it is a large component of the total catch (for example, mackerels, lobsters, reef fish).

(3) Recruitment Indices - Past estimates of recruitment are generated by the VPA method. However, current or future predictions of recruitment levels shold be included in the stock assessment advice. In most cases, we are severely hampered by lack of data and relevant biological research to do that. Several documents in this Workshop attempted to evaluate the potential for determining current recruitment levels (SAW/84/GCP/9; SAW/84/SHR/3). In addition research recommendations of several of the Working Groups suggested examination of alternative data sources, such as ichthoplankton survey data for mackerel, shrimp bycatch rates for mackerel, menhaden and reef fish. All potential methods for estimating current recruitment and forecasting future levels should be explored. Variation in recruitment caused by the interaction of oceanographic variability, fishing patterns and spawning stock size should be examined to develop statistically precise and accurate forecasting models.

(4) Multi-Stock Assessment - Little progress has been made in developing models and management criteria for multi-stock fisheries and, thus, recommendations for data needs to evaluate multiple-stock affects. Resources where progress in this area is needed are reef fishes in the US Virgin Islands and Puerto Rico, where the fisheries take many species, where data are often aggregated over species and where criteria are needed to manage species aggregations. Similar problems exist with groundfish in the Gulf of Mexico, where the largest proportion of the catch is likely to be discarded. Additionally, development of coastal herring fisheries may affect catches of coastal pelagics. Research on these and other multiple stock questions need to be initiated and continued.

A fifth area of research is recommended here, although it was not mentioned directly in SAW/82. This area is data and research for providing aging estimates of the catch for use in VPA's. Improvements are needed 1) to provide sufficiently disaggregated samples of ages by time and area; 2) annual age-length keys to convert catch-at-size to catch-at-length; and 3) development of appropriate statistical techniques for estimating age from length samples. Samples by time and area are needed to account for geographical and seasonal differences in growth and for the within year time birth. Annual age-length keys are needed because a constant key causes bias in recruitment estimates. Better statistical methods are needed to discriminate between ages with large variation in size, as is seen in older ages of some species when growth rates are low (turtles, mammals, oceanic pelagics, some coastal pelagics and some reef fish). These areas of research are critical to many assessments.

These recommended research problems will not be solved by short-term programs. A continuous long-term committment to these priorities are needed before substantial improvements in the utility of our stock assessment can be made.

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APPENDIX 1

Second Southeast Fisheries Center
Stock Assessment Workshop
Chairman: Dr. Joseph E. Powers, Chief, Fishery Analysis Division, Miami Laboratory, Southeast Fisheries Center

Meeting Schedule

Groundfish and Coastal Pelagics
June 4 (9:00 AM) - June 6 (12 Noon)
Rapporteurs: Drs. Joan Browder, Pete Eldridge, and Joseph Powers, Fishery Analysis Division, Miami Laboratory

Marine Mammals and Turtles
June 4 (1:00 PM) - June 6 (4:30 PM)
Rapporteurs: Drs. Gerald Scott and Nancy Thompson, Fishery Analysis Division, Miami Laboratory

Menhaden and Coastal Herrings
June 5 (9:00 AM) - June 7 (12 Noon)
Rapporteur: Dr. Douglas Vaughan, Beaufort Laboratory

Reef Fish and Reef Resources
June 5 (1:00 PM) - June 7 (4:30 PM)
Rapporteur: Mr. Scott Bannerot, Fishery Analysis Division, Miami Laboratory

Shrimp
June 6 (9:00 AM) - June 8 (12 Noon)
Rapporteur: Dr. Scott Nichols, Fishery Analysis Division, Miami Laboratory

Special Seminar on Fisheries Research in Coastal Marshes
June 4 (2:30 p.m.)

Timing and vertical distribution of immigration and emmigration of fish, shrimp, and crabs from coastal canal systems associataed with tidal marshes in the Sabine National Wildlife Refuge (B. Rogers, Louisiana State University).

A comparison of total export of fish, shrimp, and crabs from a weired and non-weired marsh pond in the Cameron-Creole watershed (E. Knutsen, Louisiana State University).

Conclusions about the life-history of spotted sea trout from four studies across the Louisiana Coast (B. Rogers, Louisiana State University).

Special Seminar on Assessment Techniques
June 7 (10:00 a.m.)

Risk analysis in the Georges Bank haddock fishery - a pragmatic approach (B. Brown, SEFC).

Density-dependent changes in length at age and sex ratio of tilefish from bottom longline data (S. Turner, Rutgers University).

Use of surveys for marine mammal stock assessment (R. Holt, Southwest Fisheries Center).

A simulation study of bias in parameter estimates of surplus production models (R. Conser, Fishery Analysis Division, SEFC)

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APPENDIX 3

Southeast Fisheries Center
STOCK ASSESSMENT WORKSHOP

LIST OF DOCUMENTS

Groundfish and Coastal Pelagics

SAW/84/GCP/1 Powers, J. and P. Eldridge. A preliminary assessment of king mackerel resources of the southeast United States.

SAW/84/GCP/2 Powers, J. and P. Eldridge. Assessment of Gulf of Mexico and South Atlantic king mackerel.

SAW/84/GCP/3 Eldridge, P. and J. Powers. Effect of potential bag limits on recreational catch of king mackerel.

SAW/84/GCP/4 Williams, R. and M. Godcharles. King mackerel tagging and stock assessment.

SAW/84/GCP/5 Trent, L., P. Eldridge and E. Anthony. Commercial and recreational fisheries statistics for king mackerel in the southeast United States.

SAW/84/GCP/6 Trent, L., G. Bane, W. Fable, A. Trimble, S. Ellsworth, and C. Boulet. Lengths and sex ratios of king mackerel from the recreational and commercial hook and line fisheries in Louisiana and management groups hypothesized from these data.

SAW/84/GCP/7 Eldridge, P.and J. Powers. Commercial and recreational fisheries statistics for Spanish mackerel in the southeast United States.

SAW/84/GCP/8 Browder, J. A. An analysis of trends in offshore Atlantic croaker biomass (from the OREGON II Resource Survey) in relation to shrimping effort in the Mississippi Delta area.

SAW/84/GCP/9 Browder, J. A. Standardized estimates of annual abundance and biomass Atlantic croaker in seven Louisiana bay systems, using the estuarine resource survey data base of the Louisiana Department of Wildlife and Fisheries.

SAW/84/GCP/10 Sutter, F. Trends in abundance and biomass of Atlantic croaker in Mississippi Sound.

SAW/84/GCP/11 Epperly, S. Trends in North Carolina commercial king mackerel fishery.

SAW/84/GCP/12 Muller, R. G. Discussion of surplus yield models for king and Spanish mackerel in Florida.

SAW/84/GCP/13 Fable, W., L. Trent and G. Bane. Lengths, tag numbers, and recovery data for king mackerel tagged in Louisiana during 1983.

SAW/84/GCP/14 Brusher, H. and B. Palko. Evaluation of the catch and effort data from the 1983 charter boat survey.

SAW/84/GCP/15 Portier, R. and G. W. Bane. Racial studies of Gulf of Mexico mackerels.

Marine Mammals and Turtles

SAW/84/MMT/1 Frazer, N. B. A model for assessing mean age-specific fecundity in sea turtle populations.

SAW/84/MMT/2 Frazer, N. B. and L. M. Ehrhart. Preliminary growth models for green, *Chelonia mydas*, and loggerhead, *Caretta caretta*, turtles in the wild.

SAW/84/MMT/3 Frazer, N. B. and J. I. Richardson. Variation in reproductive characteristics of loggerhead turtles, *Caretta caretta*, nesting at Little Cumberland Island, GA, USA.

SAW/84/MMT/4 Murphy, T. M. and S. R. Hopkins. Aerial and ground surveys of marine turtle nesting beaches in the southeast region, U.S.

SAW/84/MMT/5 Shoop, C. R. and C. Ruckdeschel. Southeast turtle survey (SETS): nesting surveys.

SAW/84/MMT/6 Thompson, N. B. Abundance of female *Caretta caretta* (loggerhead turtles) nesting along the southeast U.S. coast: 1982 nesting season.

SAW/84/MMT/7 Thompson, N. B. Progress report on estimating density and abundance of marine turtles: results of first year pelagic surveys in the southeast U.S.

SAW/84/MMT/8 Thompson, T. J. and C. R. Shoop. Southeast turtle survey (SETS): pelagic surveys.

SAW/84/MMT/9 Frazer, N. B. and F. J. Schwartz. 1984. Growth curves for captive loggerhead turtles, *Caretta caretta* in North Carolina, U.S.A.

SAW/84/MMT/10 Odell, D. K. and E. D. Asper. Indian River herd biodynamics.

SAW/84/MMT/11 Duffield, D. A. *Tursiops truncatus* genetics studies: Indian River 1980-1981.

SAW/84/MMT/12 Solangi, M. A. and G. E. Dukes. Atlantic bottlenose dolphin, *Tursiops truncatus*, herd studies in the Mississippi Sound, USA.

SAW/84/MMT/13 Toom, P. M. Serum protein and hemoglobin electrophoretic profiles in Tursiops from the northern Gulf.

SAW/84/MMT/14 Middlebrooks, B. Microbiological profiles of the Atlantic bottlenose dolphins, Tursiops truncatus, from the Mississippi Sound.

SAW/84/MMT/15 Odell, D. K. and A. Schneyer. Age estimation and hormone analysis for bottlenose dolphins, Tursiops truncatus, from Mississippi.

SAW/84/MMT/16 Scott, G. Management oriented research on Tursiops truncatus at the Southeast Fisheries Center.

SAW/84/MMT/17 Reynolds, J. Identification and evaluation of possible differences in hardiness of bottlenosed dolphins from different coastal areas of the southeastern United States.

SAW/84/MMT/18 Not received.

SAW/84/MMT/19 Schroeder, B. A. A review of the status of the leatherback turtle (Dermochelys coriacea) in the western Atlantic.

SAW/84/MMT/20 Hersh, S. L. and D. K. Odell. Bottlenose dolphin mortality patterns in the Indian/Banana River System of Florida.

Menhaden and Coastal Herrings

SAW/84/MCH/1 Ahrenholz, D. W. Stock assessment report for Atlantic menhaden.

SAW/84/MCH/2 Chester, A. J. and J. R. Waters. Two-stage sampling for age distribution in the Atlantic menhaden fishery with comments on optimal survey design.

SAW/84/MCH/3 Christmas, J. Y., D. J. Etzold, and L. B. Simpson. The menhaden fishery of the Gulf of Mexico United States: a regional management plan.

SAW/84/MCH/4 Houde, E. D., C. Grall, and S. A. Berkeley. Population parameter estimates for three shoaling pelagic fishes in the eastern Gulf of Mexico.

SAW/84/MCH/5 Reish, R. L., R. B. Deriso, D. Ruppert, and R. J. Carroll. An investigation of the population dynamics of Atlantic menhaden (Brevoortia tyrannus).

SAW/84/MCH/6 Ruppert, D., R. L. Reish, R. B. Deriso, and R. J. Carroll. A stochastic population model for managing the Atlantic menhaden (Brevoortia tyrannus) fishery and assessing managerial risk.

SAW/84/MCH/7 Vaughan, D. S. An approach for assessing the reliability of stock asessment of Atlantic menhaden.

Reef Fish and Reef Resources

SAW/84/RFR/1 Waters, J. Dynamic yield per recruit analysis for establishing minimum size limits in the South Atlantic snapper-grouper fishery.

SAW/84/RFR/2 Mahmoudi, B., J. Powers and G. Huntsman. Assessment of vermilion snapper resources of the South Atlantic Bight.

SAW/84/RFR/3 Morales-Santana, I. Results of the size frequency survey for snappers and groupers conducted by the Caribbean Fishery Management Council in Puerto Rico and the U.S. Virgin Islands, July-September, 1983.

SAW/84/RFR/4 Powers, J. and S. Bannerot. Assessment of south Florida spiny lobster resources.

SAW/84/RFR/5 Huntsman, G. R., C. S. Manooch and B. Grimes. Yield per recruit of some reef fishes of the U.S. South Atlantic Bight.

SAW/84/RFR/6 Witzig, J. and G. Huntsman. Mortality rates of South Atlantic reef fishes as determined from samples from the headboat fishery.

SAW/84/RFR/7 Mason, D. and C. Manooch. Age and growth of mutton snapper collected along the east coast of Florida.

SAW/84/RFR/8 Matheson, R., G. Huntsman, and C. Manooch. Age, growth, foods and reproduction of the scamp, Mycteroperca phenax, collected off North Carolina and South Carolina.

SAW/84/RFR/9 Matheson, R. and G. Huntsman. Growth, mortality, and yield per recruit models for speckled hind and snowy grouper from the U.S. South Atlantic Bight.

SAW/84/RFR/10 Slater, B. and J. Powers. Commercial and recreational fishery statistics for snapper and grouper of the southeast and Gulf of Mexico coasts of the United States.

SAW/84/RFR/11 Waters, J. Review of the reef fish fisheries in the South Atlantic, 1982.

SAW/84/RFR/12 Lebron, A. L. and M. Brandon. Spiny lobster size frequency survey U.S. Virgin Islands 1981/82.

SAW/84/RFR/13 Calderon, J. R., J. A. Collazo-Battistini and F. Torres. Spiny lobster size frequency survey.

SAW/84/RFR/14 Phares, P. Review of the Florida stone crab fishery, 1962-82.

SAW/84/RFR/15 Huntsman, G. Summary of headboat catches of South Atlantic reef fishes from the South Atlantic Bight, southeast Florida, Florida Keys and the Dry Tortugas by species.

SAW/84/RFR/16 Waters, J. Review of the snapper-grouper fisheries in the Gulf of Mexico, 1982.

Shrimp

SAW/84/SHR/1 Whitaker, J. D. Effects of severe winters on white shrimp stocks in the Atlantic Ocean off the southeastern United States.

SAW/84/SHR/2 Nichols, S. Updated assessments of brown, pink, and white shrimp in the U.S. Gulf of Mexico.

SAW/84/SHR/3 Nichols, S. and N. J. Cummings. Investigation of commercial catch per effort data for indexing brown shrimp recruitment.

SAW/84/SHR/4 Shipman, S. Preliminary results of interjurisdictional mark-recapture experiments with *Penaeus setiferus* in the South Atlantic.

SAW/84/SHR/5 Clark, S. Assessment methods for northern shrimp stocks.