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NOAA Technical Memorandum
NMFS - SEFC - 127

REPORT OF THE SOUTHEAST FISHERIES CENTER STOCK ASSESSMENT WORKSHOP
August 3-6, 1982

Joseph E. Powers

November 1983

U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Miami Laboratory
75 Virginia Beach Drive
Miami, Florida 33149

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William G. Gordon, Assistant Administrator of Fisheries

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INTRODUCTION

The first Southeast Fisheries Center (SEFC) Stock Assessment Workshop was convened at the SEFC's Miami Laboratory on August 3-6, 1982. The purpose of the Workshop was four-fold. The first objective was to develop written documentation on the present status of fishery stocks under the research purview of the SEFC. The report so developed represents existing knowledge and resulting management advice for use by regional Fishery Management Councils and other institutions and agencies.

The second purpose of the meeting was to provide a timely forum for critical review of the stock assessment research being done by the SEFC and other research groups 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 direct discussion of current stock assessments with the view toward improving their applicability and timeliness via further data collection and research efforts.

The final objective was to promote scientific interchange between stock assessment researchers working on the fishery resources of the Southeast. The Workshop provided the first 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 emphasis of the Stock Assessment Workshop was the biological status of the stocks and the effects of fishing effort and mortality on the production, recruitment and yield of the stocks. No attempt was made to incorporate economic analyses on the status of the fisheries and fishing industries. Analyses of fishery operations were only included as they relate to the quantification of fishing effort and the measurement of ensuing fishing mortality. Economic assessment awaits further data collection, analyses and future workshops.

It should be noted that the SEFC's stock assessments pertaining to bluefin tuna were not reviewed during the Workshop and thus are not included in this year's Workshop Report. Bluefin tuna analyses were reviewed by a separate group of experts which culminated in the presentation of the SEFC's analysis to the Standing Committee for Research and Statistics of the International Commission for the Conservation of Atlantic Tunas.

The Workshop was attended by more than fifty people representing individual laboratories within the Southeast Fisheries Center, the Northeast and Southwest Fisheries Centers, state agencies of the southeast United States and Territories, the three Fishery Management Councils within the region (South Atlantic, Gulf of Mexico and Caribbean) and various academic institutions. More than thirty stock assessment reports and documents were submitted to the Workshop by participants. These were reviewed during the Workshop by working groups covering: (1) Billfish, Swordfish and Sharks; (2) Groundfish and Coastal Pelagics; (3) Marine Mammals and Sea Turtles; (4) Menhaden and Coastal Herrings; (5) Reef Fish and Reef Resources; and (6) Shrimp. These groups represent an extremely diverse set of resources exhibiting a wide variety of biological, ecological and fishery characteristics. They demonstrate the complexity of stock assessment research and resource management in the southeast. The Workshop provided a succinct update and review of the status of these resources.

BILLFISH, SWORDFISH, AND SHARKS (BSS)

BLUE MARLIN

I. DESCRIPTION OF FISHERIES

The following history of the fisheries applies to white marlin, sailfish, and spearfish as well as to blue marlin.

I.1. History of the Fisheries
I.1.1. Commercial Longline Fishery

The commercial fishery for billfishes (excluding swordfish) in the Atlantic Ocean is conducted by the nations that maintain longline fleets. The fishing effort of these fleets is principally directed at tuna. However, billfishes occur in the same areas and depths as tunas and consequently, the incidental by-catch of billfishes is significant. The principal nations currently longlining in the Atlantic are Japan, Taiwan, Korea, Cuba, Venezuela, and to a lesser extent, Brazil, U.S.S.R., and Panama (SAW/82/BSS/2).

Prior to 1956, the only fisheries for billfishes in the Atlantic were the sport fishery and small subsistence fisheries throughout the Caribbean and off South America (Ueyanagi 1974). In 1956 the Japanese began longlining for yellowfin tuna in the waters north of Brazil. Within two years their operation expanded, in equatorial waters, to the African coast. A rapid expansion followed both to the north and south in pursuit of albacore, and by 1965 the fishery covered the area between latitude 45°S and 45°N. Japanese fishing effort declined after 1965 but an increase in the activity of the Cuban, Korean, Taiwanese, and Venezuelan longline fleets in the late 1960's more than made up the decrease in Japanese effort (Kikawa and Honma 1976). During the 1970's, the Japanese fleet increasingly targeted bluefin and bigeye tunas.

Longline catches of billfishes, as illustrated by the blue marlin and white marlin catches in the North Atlantic (Figs. BSS-1 and BSS-2, respectively), have declined appreciably since the mid-1960's. Blue marlin catches have decreased 90% from the peak level in 1963 to the 1979 level. Similarly, white marlin catches have declined 76% over the period 1965-79. Similar declines have probably occurred in sailfish and spearfish catches but the practice of reporting sailfish and spearfish in a single catch category - a practice employed by all longlining nations - makes the interpretation of trends more difficult.

Furthermore, the relative proportion of the catch taken by the individual longline nations has also changed markedly (Tables BSS-1 and BSS-2). Over the period 1963-65, the average annual Japanese catch of blue marlin (4174 MT) comprised 95% of the total longline catch of blue marlin and their white marlin catch (1608 MT) represented 90% of the total. By 1977-79 the Japanese percentages had decreased to 14% for blue marlin and to 20% for white marlin.

Although the fishing effort of the Atlantic longline fleet is principally tuna-directed, billfishes have been a valuable bycatch, commanding prices comparable with tunas on the world markets. Prices for the marlins at Japanese fish markets are typically lower than prices for bluefin and bigeye tunas but albacore, skipjack, and yellowfin do not command as high a price as the marlins (NMFS 1981).

I.1.2. Recreational Fishery

Sport fishing for billfishes is conducted in nearly all the warm ocean areas, primarily in the tropical and subtropical seas (de Sylva 1974). In the Atlantic, sport fisheries are concentrated from Massachusetts to North Carolina and about Bermuda, southeastern Florida, the northern Gulf of Mexico, the Bahamas, the larger islands of the Caribbean, Mexico (mainly Cozumel), Venezuela, from the Ivory Coast to Senegal in West Africa, and off Portugal and Spain. Landings from all these fisheries, other than the U.S. sport fishery (which includes Puerto Rico and the Virgin Islands), are not reported in the annual billfish landings statistics compiled by the International Commission for Conservation of Atlantic Tunas (SAW/82/BSS/2). Although significant sport fishing activity occurs seasonally in these areas, actual landings (excluding fish caught and released) are thought to be small relative to the commercial longline landings.

Sport fishing for billfishes has taken place since about 1900 in the United States. Angling for billfishes was the pastime of only the very wealthy during the early part of the century. Many of the devotees of big game fishing were recruited as a result of the writings of Ernest Hemingway, Zane Gray, and others. It was not until World War II, however, that significant increases in participation in the billfish fishery occurred along the Atlantic and Gulf coasts of the United States (de Sylva 1974b). The expansion of the fishery was largely the result of substantial improvements in the quality and design of offshore sport fishing vessels and equipment which greatly increased the probability of catching a billfish. Sport fishing for billfishes currently occurs off every state along the Atlantic and Gulf coasts from

Massachusetts southward, as well as off Puerto Rico and the Virgin Islands (Austin et al. 1976). U.S. fishermen also fish in foreign waters, particularly in the Bahamas, Venezuela, and Mexico.

The results of a mail and telephone survey indicated that between 17,000 and 22,000 recreational boats (both private and charter) participated in the U.S. billfish fishery during the period May 1977 to April 1978 and caught approximately 79,000 billfish (Hamm and Slater 1979). However, about 70% of the fish were released resulting in landings of about 22,000 fish (650 mt). More recent (1981) census type surveys in the Northern Gulf of Mexico and in Puerto Rico have estimated catches in these areas that are substantially smaller than the corresponding estimates from the 1977-78 survey. It is not known whether the differences are due to bias in the 1977-78 survey estimates, incomplete census in the 1981 surveys, or natural year-to-year fluctuations in the catch.

In contrast with the longline landings, which have been declining, the estimated annual U.S. recreational landings have been increasing with increased participation in the fishery (Figs. BSS-1 and BSS-2). Estimated landings have increased from approximately 400 MT in 1965 to 550 MT in 1970 to 650 MT in 1977 (SAW/82/BSS/2). In 1977 the U.S. recreational fishery took approximately 17% of the total Atlantic landings of billfishes, the remaining portion being taken by the commercial longline fishery.

I.2. Catch and Effort Trends

Blue marlin landings from the Total Atlantic increased rapidly from the inception of the fishery in 1956 to 1963, where they peaked at approximately 9000 MT. Landings then declined to a relatively stable level of about 3000 MT during 1967-75 (Table BSS-3). Landings from the Total Atlantic (Table BSS-3) show a continual decline over the period 1975-79 (3030 MT to 1347 MT) with an increase in 1980 to almost 1500 MT. The effective fishing intensity (in thousands of hooks per 5° area) for the entire longline fishery (FTOT in Table BSS-3), which is estimated as the quotient of total all-country catch and Japanese longline catch per unit fishing intensity, has decreased steadily from 1975-79 with a slight increase in 1980 to the 1978 level. Catches over 1976-80 are substantially less than those a decade earlier.

Landings trends in the North Atlantic (Table BSS-4) are similar to those of the Total Atlantic in the early years and also show a continual decline over the period 1975-79 (1924 MT to

812 MT) with an increase in 1980. The effective fishing intensity for the entire fishery (FTOT in Table BSS-4) has generally decreased from 1975-80. Catches from 1976-80 are substantially less than those a decade earlier.

Landings trends in the South Atlantic (Table BSS-5) are similar to those of the Total Atlantic in the early years and then show a general decline from the relatively recent high level in 1973 of 1565 MT to the 1979-80 level of 535 MT. Estimates of effective fishing intensity (FTOT in Table BSS-5) may not be reliable in recent years due to extremely low landings from the Japanese fleet which has been used to index CPUE over the historical time series. Thus recent trends in effort are uncertain.

II. STOCK STRUCTURE

The stock structure of blue marlin is uncertain. There are two working hypotheses: (1) that there is a single total Atlantic stock, and (2) that there are two stocks, one in the North Atlantic and one in the South Atlantic, separated at 5°N latitude (SAW/82/BSS/1).

III. STATUS OF STOCKS

III.1. Population Parameters

Growth and mortality parameters are generally lacking for blue marlin (SAW/82/BSS/1 and SAW/82/BSS/2). No new information was presented.

III.2. Catch Per Unit Effort Trends

CPUE indices have declined substantially from the early 1960's under both stock structure hypotheses (Fig. BSS-3).

III.3. Stock Assessment Analyses

III.3.1. Production Model Analyses

Production models were presented for Total Atlantic, North Atlantic, and South Atlantic stocks (SAW/82/BSS/3). Because of the problems in estimating effective effort for the South Atlantic in recent years and the relatively poor fit of the model, little information on the current status of the South Atlantic stock can be inferred. However, the Total Atlantic and North Atlantic models appear to fit the data well with r^2 ranging from 0.70 to 0.84 (Figs. BSS-4 and BSS-5, respectively). In both cases, the production model analysis indicates that blue marlin may have been overexploited during the early to mid-1970's, but fishing effort during recent years (1978-80) has been below the level needed to take Maximum Sustainable Yield (MSY). However, the Group felt that these results must be viewed with caution for two reasons. Although the method used for estimating effective effort adjusts for changing catchability that is due to temporal and spatial changes in fishing patterns, the Group felt that more subtle changes in the fishing patterns or techniques could cause this adjustment to be biased. However, no data on these more subtle changes are currently available. Secondly, the Japanese longline fishery has been used to index abundance for the entire fishery and the low level of Japanese catch in some recent years may cause this to be an unrepresentative sample. It was noted, however, that attempts to use data from other countries in conjunction with the Japanese data (via standardization) have not proved fruitful due to the poor quality or low coverage rate of the data from nations other than Japan.

III.3.2. Yield Per Recruit Analyses

No yield per recruit analyses have been done for blue marlin.

III.3.3. Recruitment Indices

No recruitment indices are available.

III.3.4. Other Fishery Indicators

An alternative method for assessing the status of stocks of blue marlin was proposed in SAW/82/BSS/7. The method employs average size and effort data to measure the relative condition of the population. Applying the method to the blue marlin data produced results that were consistent with production model results. However, these results should be viewed with some caution since the proposed model assumes the fishery is in equilibrium and no method of equilibrium approximation has been developed.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

Blue marlin, along with the other billfishes, is managed internationally by the International Commission for the Conservation of Atlantic Tunas (ICCAT). ICCAT has not recommended any management measures for blue marlin.

Within the U.S. FCZ, foreign fishing has been regulated by the U.S. Department of Commerce via a Preliminary Management Plan (PMP) since 1978. The PMP requires all foreign caught billfish in the U.S. FCZ to be released except for those retained for scientific purposes. The Group felt that given the uncertainties involved in the status of stocks of blue marlin, the fact that the PMP has been regulating only a small part of the blue marlin range (i.e., the U.S. FCZ) and only the Japanese fishery within the FCZ, and the short time that the PMP has been in effect, its effect cannot be measured at this time.

V. RECOMMENDATIONS

V.1. Data Needs

The Group recommended that (1) catch and effort statistics (in weight and number) from all countries be reported by 5° area and month; (2) length and sex data be collected on a regular basis; and (3) estimates of the total U.S. recreational catch be made annually and the historical estimates be examined for possible bias.

V.2. Research

The Group recommended that (1) age and growth studies be given high priority; (2) further research on the estimation of effective effort be undertaken, including an examination of available Japanese data on the type of bait used in their long-line fishery; (3) that further research be conducted on analytical techniques that use average length or similar parameters to assess the status of stocks, e.g., the method used in SAW/82/-BSS/7 and (4) research on stock structure determination be initiated - possible approaches were thought to be the examination of electrophoretic, mitochondria DNA, and X-ray fluorescence characteristics, and examination of otoliths. Tagging should also be continued.

V.3. Management

Declining CPUE indices, production model results, and average length data all provide evidence that the Total Atlantic or North Atlantic stock of blue marlin is at a population level where further increases in effort at the present time will not produce significant increases in yield. The Group recommended that the blue marlin fishery be closely monitored.

WHITE MARLIN

I. DESCRIPTION OF FISHERIES

I.1. History of Fisheries

The history of the fisheries in the blue marlin section applies to white marlin as well.

I.2. Catch and Effort Trends

Landings from the Total Atlantic (Table BSS-6) show a negative trend over the period 1972-80, decreasing from 2331 MT to 960 MT. The effective fishing intensity (in thousands of hooks per 5° area) for the entire fishery (FTOT in Table BSS-6) shows no significant trend since 1965.

Landings from the North Atlantic (Table BSS-7) show a negative trend over the period 1971-80, decreasing from 1535 MT to 522 MT. The effective fishing intensity for the entire fishery (FTOT in Table BSS-7) shows no significant trend since 1965.

Landings in the South Atlantic (Table BSS-8) show a decline over the period 1972-80, decreasing from 1133 MT to 438 MT. Estimates of effective fishing intensity (FTOT in Table BSS-8) may not be reliable during 1973-80 due to extremely low landings from the Japanese fleet which has been used to index CPUE over the historical time series. Thus recent trends in effort are uncertain.

II. STOCK STRUCTURE

As with blue marlin, the stock structure of white marlin is uncertain. There are two working hypotheses: (1) that there is a single total Atlantic stock, and (2) that there are two stocks; one in the North Atlantic and in the South Atlantic, separated by 5°N latitude (SAW/82/BSS/1).

III. STATUS OF STOCKS

III.1. Population Parameters

Growth and mortality rates have been estimated for white marlin using mark-recapture data. However, due to the generally poor estimates of size at release and the lack of other data needed for validation, little confidence can be placed in these estimates (SAW/82/BSS/2). No new information was presented in the working papers, but it was noted that a tagged white marlin that was released in 1970 was recently recaptured. This extends the known life span of a white marlin to at least twelve years.

III.2. Catch Per Unit Effort Trends

CPUE indices for the Total Atlantic and South Atlantic have declined substantially (with some fluctuation) from the early 1960's (Fig. BSS-6). A decline (with fluctuation) is also apparent in the North Atlantic, although the rate of decline is more moderate than in the Total or South Atlantic. Data from the period 1977-80 for the Total and North and data from 1973-80 in the South are less reliable than earlier data because Japanese catch, which is used to estimate the CPUE index, comprised a relatively small portion of the total catch during these periods.

III.3. Stock Assessment Analyses

III.3.1. Production Model Analysis

Production model analysis was presented for Total Atlantic, North Atlantic, and South Atlantic stocks (SAW/82/BSS/3). The model does not fit the data well (r^2 generally less than 0.18) and the caveats associated with blue marlin production model results are also appropriate for white marlin. It was concluded that the white marlin production models provide little useful information on the status of stocks.

III.3.2. Yield Per Recruit Analysis

No yield per recruit analysis has been done for white marlin.

III.3.3. Recruitment Indices

No recruitment indices are available.

III.3.4. Other Fishery Indicators

The average length analysis (SAW/82/BSS/7) discussed in the blue marlin section was also applied to white marlin. However, a relationship between average length and effort was not apparent in the white marlin data and no useful information on the status of stocks was obtained.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

The discussion in the blue marlin section applies here as well.

V. RECOMMENDATIONS

The data, research, and management recommendations in the blue marlin section apply here as well.

SAILFISH/SPEARFISH

Sailfish and spearfish have generally been considered as a species group in stock assessment work because their catch statistics have been reported in one aggregate group for all of the longline fisheries since the 1950's. No new analyses of the status of stocks of sailfish/spearfish were presented and it was felt that previous analyses, e.g. Conser (1980), may no longer be appropriate after the extensive data base modification in 1981 (SAW/82/BSS/2). Furthermore, the Group felt that future analyses may not be fruitful until the historical catches of the two species can be separated. In this regard, it was recommended that the importance of separating the historical data be stressed to all longlining nations through ICCAT. In particular it was noted that sailfish and spearfish catches have been separated in the logbooks of Japanese research vessels and this data may be useful in separating the historical commercial landings.

It was noted that CPUE data from sailfish tournaments off southeast Florida over the past 30-40 years have been stable. This may imply that the stock is also stable. It was further noted that growth parameters have recently been estimated for sailfish (Hedgepeth and Jolley 1982) and that significant advances in our understanding of the status of stocks of sailfish can be achieved (e.g., through VPA) provided that the sailfish/spearfish catches can be separated.

The description of the fisheries, effect of current management, and recommendations discussed in the blue marlin section are appropriate for sailfish/spearfish as well.

SWORDFISH

I. DESCRIPTION OF FISHERIES

I.1. History of Fisheries

The various Atlantic fisheries on swordfish are predominantly commercial. The United States and Canada have directed fisheries using harpoons and longlines (which catch other billfishes, sharks and pelagics) between the Caribbean and Grand Banks. There is a rather small U.S. recreational (rod and reel) catch. Spain, Brazil, and Italy have directed swordfish fisheries that account for a considerable percentage of total Atlantic landings. There are substantial bycatches from the Japanese and other tuna longliners throughout the Atlantic Ocean. There has been a rapid expansion of the U.S. longline swordfish fishery in the southeast U.S. since 1975 (SAW/82/BSS/4).

In late 1970-early 1971 the U.S. and Canadian swordfish fisheries were severely impacted by U.S. Food and Drug Administration (FDA) regulations prohibiting the sale of swordfish with a tissue content of mercury in excess of 0.5 ppm (essentially all marketable fish). The fishery nearly ceased, but later continued as some fishermen reported their catches as occurring within state waters (three-mile limit) and sold their catches only for local consumption, thus remaining technically immune from FDA regulations. Some catches were reported, but apparently many operations were conducted in secrecy and significant quantities of swordfish were landed unreported.

I.2. Catch Trends

The Atlantic-wide reported landings of swordfish (including the Mediterranean) increased to approximately 12,000 MT during the period 1957-63 (Table BSS-9). The landings fluctuated during 1963-79 between 12,000 and 18,700 MT, reaching a high in 1980 of 20,400 MT. BSS Fig. 7 shows the wide distribution of swordfish throughout the Atlantic (1956-68). The Japanese annual landings have fluctuated widely from less than 500 MT per year during 1957-62 to 750 MT - 3,175 MT during 1963-80 (Table BSS-9). The percentage of total catch represented by the Japanese fleet varied from 2% to 22% but has averaged only 9% over 1971-80. SAW/82/BSS/5 presents the annual Japanese longline catch (in numbers of fish) Atlantic-wide and for several sub-areas of the total Atlantic.

The percentage of the total reported U.S. east coast landings taken in the Florida Straits increased from 24% in 1979 to 42% in 1980 (Berkeley and Irby, 1982).

I.3. Effort Trends

Even though most of the swordfish catch in the Atlantic are from directed fisheries, there are no available complete effort statistics. Table BSS-9 presents the annual effective fishing intensity for the Japanese longline fleet. SAW/82/BSS/5 also presents the annual Japanese longline effective effort Atlantic-wide and for several sub-areas of the Total Atlantic.

II. STOCK STRUCTURE

CPUE from the Japanese longline fishery show three distinct seasonal concentrations of swordfish (SAW/82/BSS/1). One concentration was noted to be in, or just outside the Mediterranean during September-December. A second concentration appeared off the northeast U.S. coast during July-October. This was supported by substantial U.S. and Canadian catches in the same area. A third concentration was located in the South Atlantic off Argentina during April-October. Based on these distinct temporal and spatial distributions, SAW/82/BSS/1 suggested that three populations of swordfish exist in the Atlantic Ocean. That report went on to note that although distinct seasonal concentrations were recorded, swordfish were taken in almost all areas of the Atlantic, and there did not appear to be any clear-cut dividing lines between the well-defined concentrations. This suggested considerable interchange was possible.

Sex ratios were found to vary considerably among fishing areas with the males to females ratio in the Canadian longline fishery being 1:3.0 and in the Straits of Florida 1.7:1. Also, SAW/82/BSS/4 found that sex ratios change with age, with females comprising virtually the entire catch after age 8.

Tag recovery data provide evidence of movement between the Gulf of Mexico and the Straits of Florida and between the Straits of Florida and Georges Bank/Scotian Shelf (SAW/82/BSS/2).

Concentrations of larvae have been found in the Straits of Messina in the Mediterranean from April through September, in the Caribbean and Florida Straits throughout the year (SAW/82/BSS/1) and off the eastern tip of Brazil (SAW/82/BSS/1).

Various stock structure hypotheses have been suggested but there is no general consensus as to which hypothesis might be most reasonable. It was recommended that various stock structure hypotheses be examined in conjunction with all stock assessment work on swordfish and that sensitivity analyses should also be conducted.

III. STATUS OF STOCKS

III.1. Population Parameters

Parameter estimates of the von Bertalanffy growth equation, derived using length-frequency data from the Canadian fishery to age the catch, were presented in SAW/82/BSS/1 as L = 365 cm and K = 0.23. SAW/82/BSS/4 presented the parameter estimates by sex for swordfish from the Straits of Florida fishery using back-calculated lengths at age based on anal fin spine analysis; finding for males: L = 217 cm, K = 0.19, t_0 = -2.04, and for females: L = 340 cm, K = 0.09, t_0 = -2.59. This work showed that slower growth in males is apparent by age 3. SAW/82/BSS/2 noted that size frequency data for the Brazilian longline fishery suggested that size modes could be detected passing through the fishery which were compatible to the sizes at age proposed in SAW/82/BSS/4.

SAW/82/BSS/8 estimated population parameters for both sexes by fitting the Gompertz growth equation to the mean back-calculated lengths at age from SAW/82/ BSS/4. The results, which the authors consider preliminary, indicated a greater precision in the estimated growth parameters (and other parameters derived from the age structure) can be achieved using the Gompertz model rather than the von Bertalanffy growth model.

Mortality estimates for swordfish in the western North Atlantic ranged from Z = 0.12 to Z = 0.65 for the harpoon fishery (SAW/82/BSS/1); and M was estimated to be in the range of 0.21 - 0.43. In SAW/82/BSS/4 several methods were used to estimate Z. The results using the Beverton and Holt method were Z = 0.36 for males and 0.26 for females; using the Robson and Chapman method yielded esti-mates with 95% confidence limits of Z = 0.44 ± 0.07 for males and 0.33 ± 0.06 for females. The natural mortality was estimated to be M = 0.26 (males) and 0.14 (females) using the empirical equation derived by Pauly (1980). Using the Gompertz growth parameters to estimate Z, in a manner analagous to the way the von Bertalanffy parameters are used, SAW/82/BSS/8 estimated Z = 0.33 (males) and 0.22 (females).

III.2. Catch Per Unit Effort Trends

The CPUE for swordfish Atlantic-wide and in several sub-areas of the Atlantic for the incidental Japanese longline catch are presented in SAW/82/BSS/5. The catch (in number) per ten thousand effective hooks Atlantic-wide and for the North Atlantic areas has remained, on the average, relatively constant since 1963 at roughly 6 fish per 10,000 effective hooks. Other sub-areas indicate either no distinct trend or an increasing trend, with the exception of the Northwest Atlantic which has shown a steady decrease over the period 1977 to present (1980). The latest data available for the Straits of Florida directed swordfish longline fishery (Berkeley and Irby 1982) show that the estimated CPUE (in number of fish per 100 hooks) decreased from 4.26 in 1979 to 3.03 in 1980.

III.3. Stock Assessment Analyses

III.3.1. Production Model Analysis

Production model analysis has not been attempted on swordfish data due to the limitations in the total annual landings data and the catch and effort data base.

III.3.2. Yield Per Recruit Analysis (YPR)

In SAW/82/BSS/4 a YPR analysis was presented on the data from the Straits of Florida. Results based on an estimated mean length at entry into the Florida longline fishery of 119 cm (both sexes) indicate that the present rate of exploitation is at a level that would maximize YPR for females (Fig. BSS-8). A considerable increase in F on males would result in an increase in YPR, but it is not possible to fish differentially on sexes.

III.3.3. Recruitment Indices

No recruitment indices have been presented for swordfish.

IV. EFFECTS OF CURRENT MANAGEMENT PROCEDURES

Swordfish, along with other billfishes, are managed internationally by ICCAT. ICCAT has not recommended any management measures for swordfish.

A Preliminary Management Plan (PMP), that has been in effect since 1978, requires all swordfish (as well as other billfishes and sharks) caught by foreign fishermen within the U.S. FCZ to be released (dead or alive). The effects of the PMP have not been analyzed to date. A fishery management plan (FMP) is currently under development which will attempt to regulate harvest to achieve maximum yield per recruit of females. This will be done by variable season closures.

V. RECOMMENDATIONS

V.1. Data Needs

With the historical data base revised and updated following the Miami Workshop in 1981, emphasis must be placed on the reporting of catches and effort (whenever possible) of both the directed and bycatch swordfish fisheries. To achieve a more definitive understanding of the status of stocks of swordfish, it will be necessary to employ virtual population analysis or similar methods and this can only be accomplished when total catch is known. Data should be reported by area in order to facilitate stock structure analysis. Size frequency data, by sex, are necessary to monitor the age composition of the catch for assessment purposes. Though SAW/82/BSS/4 analyzed the anal fin spines from over 400 fish in their ageing work, continued sampling for biological data from swordfish throughout the Atlantic is necessary. The proposed sample design for the collection of catch data from the U.S. commercial fishery (SAW/82/BSS/8) emphasizes the need to obtain a representative sample of size, sex and age over the study area.

V.2. Research

As outlined in SAW/82/BSS/2, a study of stock structure can include a number of measures that might be coordinated by the ICCAT Secretariat. These could include morphometric measurements with a description of standard lengths and conversion factors used, recording of natural tags, tagging studies, protein analyses for genetic variation and biochemical analysis of contaminants and trace elements. These are in addition to the basic biological research as noted above. Alternative procedures for the estimation of population parameters should be investigated (e.g., the use of the Gompertz model versus the von Bertalanffy as presented in SAW/82/BSS/8). Due to the high cost of sampling at sea, there is also a need to develop a simple method to sex the catch at the dock (e.g., biochemical assay).

V.3. Management

It is the conclusion of the Working Group that the swordfish fishery should be closely monitored. This is based on the Florida fishery operating near the maximum YPR for females as of the latest fishery data (1980) and on personal observations and recent reports of declining catch rates.

SHARKS

I. DESCRIPTION OF FISHERIES

Pelagic sharks (defined here as all sharks except dogfish) are distributed throughout the world's oceans. In many areas, sharks have been harvested either by directed fisheries or more commonly as inadvertent bycatch in fisheries directed towards other species. SAW/82/BSS/6 presents various sources of pelagic shark catches (all sharks except dogfish) in the Northwest and Western Central Atlantic Ocean and Gulf of Mexico. Complete and accurate statistics are not available, and in some cases have only been intermittently estimated, due to the fact that the majority of the catches are incidental or are a bycatch. The sources of pelagic shark catches considered include reported commercial catches in the U.S. FCZ, estimates of the directed U.S. recreational catch, estimates of bycatch by U.S. and Canadian swordfish longliners, estimates of bycatch by the Japanese tuna longliners, estimates of bycatch by the foreign squid trawl fishery in the Northwest Atlantic, and estimates of bycatch by the U.S. shrimp trawl fishery and groundfish fisheries in the Gulf of Mexico.

It has been demonstrated in several shark fisheries that sharks are very vulnerable to fishing, exhibiting slow recovery from exploitation, having very low reproductive potential that decreases as the population decreases. Therefore, though many of the catch estimates must be considered only as first-order approximation, they are worthwhile in terms of analyzing trends and possibly serve as indicators of excessive fishing pressure and potential over-exploitation.

Commercial fisheries are comprised of both directed and incidental landings (Tables BSS-10 and BSS-11). Directed fisheries in the Northwest Atlantic (FAO Area 21) were conducted by the Faroe Islands and Norway for porbeagle during the early 1960's. In recent years small directed longline fisheries have developed sporadically along the East Coast of the United States. In the Western Central Atlantic and Gulf of Mexico, Cuba, Mexico (FAO Area 31), and Venezuela accounted for an average of 80% of the total catch during 1965-78 (SAW/82/BSS/6). The estimated incidental catches from the Japanese tuna longliners (Table BSS-11) are discussed below.

Estimates of the recreational catch of sharks must be interpreted with caution due to varying methodologies in sampling and survey design over the years. The total estimated U.S. recreational catch of sharks (excluding dogfish) in the Atlantic and Gulf (Table BSS-10) has been on the order of 9,000 MT yearly for 1970-78. This approximates the reported commercial catches of the Western Central Atlantic and Gulf of Mexico (Table BSS-10: FAO Area 31).

The estimated catches of sharks from the swordfish longline fisheries of the U.S. and Canada account for several thousand MT annually from 1974-78 (SAW/82/BSS/6). Most sharks that are caught by the U.S. swordfish longline fishery are released, with a substantial number alive when released. Many of these estimates are constructed from very crude estimates of swordfish landings.

The foreign squid trawl bycatch of sharks has been estimated to be under 300 MT annually (1965-78). The estimated Japanese tuna longline bycatch of sharks within the U.S. FCZ (SAW/82/BSS/-6) has ranged from approximately 200 MT to 4000 MT over the years 1962-78 (with most catches less than 2000 MT). Since 1978, all sharks have been required to be released from Japanese longliners fishing within the U.S. FCZ, with a substantial number alive when released.

There is apparently a significant bycatch of sharks in the Gulf of Mexico from the U.S. shrimp trawl fishery which has been estimated to exceed 2200 MT annually (Gulf of Mexico Fishery Management Council 1979). A small annual bycatch from the Gulf groundfish fishery has been estimated to be roughly 100 MT (Gulf of Mexico Fishery Management Council 1979).

II. STOCK STRUCTURE

There is no definitive information on stock structure.

III. STATUS OF STOCKS

Due to the uncertainty of catch data, multiple species, at least several dozen combined in the catch estimates, and general lack of fishing effort data for sharks, no attempt was made in SAW/82/BSS/6 to generate MSY estimates based on analysis of catch and effort data. At the request of Fishery Management Councils, MSY estimates for pelagic sharks were generated using production model analysis. It is important to note that the mathematical models used to estimate MSY for most teleost fishes, such as the Schaefer production model, are not as applicable to elasmobranch species. Further, combining species violates the assumptions of production models. Therefore, MSY estimates are not presented in this report.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

A Preliminary Management Plan (PMP) that has been in effect since 1978 requires all sharks (as well as billfishes) caught by foreign fishermen within the U.S. FCZ to be released (dead or alive). Any effect of this regulation has not been measured at this time.

V. RECOMMENDATIONS

V.1. Data Needs

Catch estimates are based on various assumptions and are generally imprecise. Emphasis should be placed on encouraging all nations, through international organizations such as NAFO, ICCAT and FAO, fishing in the Western Atlantic Ocean to report catch, effort, size and sex by species, for all fisheries.

V.2. Research

Due to the lack of basic knowledge of most species of pelagic sharks, the Group recommended that research emphasize ageing and recruitment studies. In order to assess the population dynamics of the stocks, appropriate models should be investigated and developed. Tagging should be continued to help ascertain migration patterns, growth rates, and stock structure.

V.3. Management

Due to their unique biological characteristics, shark populations are very vulnerable to over-exploitation. It is recommended that management measures be implemented to obtain the data needed to monitor the fishery (see Data Needs section) so that problems can be recognized if they should develop.

Table BSS-1. A comparison of blue marlin landings in the North Atlantic Ocean between the period of peak removals (1963-65) and recent years (1977-79). Data are from ICCAT (1981).

COUNTRY	1963-65 Average Catch (MT)	%	1977-79 Average Catch (MT)	%
Japan	4174	92	90[1]	10
Taiwan	12	< 1	65	7
Korea	2	< 1	186	20
Cuba	132	3	158	17
Venezuela	70	2	101	11
Other Longline	1	< 1	48	5
Total Longline	4391	97[3]	648	69[3]
U.S.A.	151[2]	3	295[2]	31
Total Recreational	151	3	295	31
GRAND TOTAL	4542	100	943	100

[1]For 1978 and 1979, the number of fish caught in the U.S. FCZ is estimated from U.S. observer data. Only fish classified as "dead" when released are included.

[2]Only includes fish that are boated. All fish that are caught and released are assumed to survive.

[3]Percentages may not add to total due to rounding.

Source: Conser (1982)

Table BSS-2. A comparison of white marlin landings in the North Atlantic Ocean between the period of peak removals (1964-66) and recent years (1977-79). Data are from ICCAT (1981).

COUNTRY	1964-66 Average Catch (MT)	%	1977-79 Average Catch (MT)	%
Japan	1608	86	77[1]	16
Taiwan	12	1	62	13
Korea	18	1	40	8
Cuba	77	4	59	12
Venezuela	78	4	139	28
Other Longline	0	0	10	2
Total Longline	1793	96	387	78[3]
U.S.A.	74[2]	4	109[2]	22
Total Recreational	74	4	109	22
GRAND TOTAL	1867	100	496	100

[1]For 1978 and 1979, the number of fish caught in the U.S. FCZ is estimated from U.S. observer data. Only fish classified as "dead" when released are included.

[2]Only includes fish that are boated. All fish that are caught and released are assumed to survive.

[3]Percentages may not add to total due to rounding.

Source: Conser (1982)

Table BSS-3. Blue marlin landings (MT), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN) and entire fleet (FTOT), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the total Atlantic Ocean, 1957-1980.

YEAR	JAPAN	U.S.	USSR	CHTAI	CUBA	KOREA	VENEZ	ARGN	BRZL	PAN	BR-KO	BR-JP	GRNA	TOTAL	FJPN	FTOT	UJPN	%JPN
1957	764	0	0	0	0	0	0	0	0	0	0	0	0	764	27.0	27.0	28.30	1.00
1958	772	0	0	0	0	0	0	0	0	0	0	0	0	772	58.6	59.0	13.17	1.00
1959	841	0	0	0	0	0	0	0	0	0	0	0	0	841	132.0	132.0	6.37	1.00
1960	2712	103	0	0	0	0	0	0	0	0	0	0	0	2815	167.3	174.0	16.21	0.96
1961	3768	116	0	0	0	0	152	0	41	0	0	0	0	4077	163.7	177.0	23.02	0.92
1962	7044	115	0	20	0	0	99	0	24	0	0	0	0	7302	503.1	522.0	14.00	0.96
1963	8600	128	0	48	145	0	101	0	12	0	0	0	0	9034	654.7	688.0	13.14	0.95
1964	7590	161	1	13	154	2	74	0	12	0	0	0	0	8007	866.7	914.0	8.76	0.95
1965	5751	163	4	4	176	7	36	0	12	0	0	0	0	6153	709.2	759.0	8.11	0.93
1966	3370	149	6	69	118	93	35	0	12	0	0	0	0	3852	416.2	476.0	8.10	0.87
1967	1073	197	16	291	444	145	62	0	6	0	0	0	0	2234	192.6	401.0	5.57	0.48
1968	946	168	15	722	280	186	96	0	15	0	0	0	0	2428	156.3	401.0	6.05	0.39
1969	960	207	16	1364	165	312	43	0	18	0	0	0	0	3085	194.5	625.0	4.94	0.31
1970	1005	204	14	929	149	488	30	0	39	0	0	0	0	2858	194.2	552.0	5.18	0.35
1971	1395	179	17	762	166	479	178	0	21	0	0	0	0	3197	383.2	878.0	3.64	0.44
1972	420	191	43	928	89	466	188	0	26	22	0	0	0	2373	135.1	763.0	3.11	0.18
1973	346	209	62	692	298	989	124	0	8	452	0	0	0	3180	90.9	835.0	3.81	0.11
1974	284	234	9	552	686	834	83	0	16	134	0	0	0	2832	74.7	745.0	3.80	0.10
1975	608	241	18	527	789	658	82	0	12	95	0	0	0	3030	194.2	968.0	3.13	0.20
1976	264	265	1	409	409	566	78	0	33	154	10	0	0	2189	111.3	923.0	2.37	0.12
1977	135	295	10	171	320	663	79	0	52	190	29	113	?	2057	57.9	882.0	2.33	0.07
1978	114	295	5	258	210	325	93	0	14	74	0	24	?	1412	28.5	353.0	4.00	0.08
1979	164	295	44	190	336	145	132	0	25	13	0	3	0	1347	39.1	321.0	4.19	0.12
1980	336	295	0	289	336	137	79	0	12	0	0	8	0	1492	79.3	352.0	4.24	0.23

CHTAI = China-Taiwan
ARGN = Argentina
BRZL = Brazil
PAN = Panama
BR-KO = Brazil-Korea
BR-JP = Brazil-Japan
GRNA = Granada

Source: SAW/82/BSS/3

Table BSS-4. Blue marlin landings (MT), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN) and entire fleet (FTOT), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the North Atlantic Ocean, 1957-1980.

YEAR	JAPAN	U.S.	USSR	CHTAI	CUBA	KOREA	VENEZ	ARGN	BRZL	PAN	BR-KO	BR-JP	GRNA	TOTAL	FJPN	FTOT	UJPN	%JPN
1957	91	0	0	0	0	0	0	0	0	0	0	0	0	91	5.1	5.0	17.84	1.00
1958	240	0	0	0	0	0	0	0	0	0	0	0	0	240	48.0	48.0	5.00	1.00
1959	231	0	0	0	0	0	0	0	0	0	0	0	0	231	76.9	77.0	3.00	1.00
1960	581	103	0	0	0	0	0	0	0	0	0	0	0	684	78.9	93.0	7.36	0.85
1961	379	116	0	0	0	0	152	0	0	0	0	0	0	647	42.8	73.0	8.86	0.59
1962	3223	115	0	0	0	0	99	0	0	0	0	0	0	3446	310.9	332.0	10.37	0.94
1963	4759	128	0	27	123	0	101	0	0	0	0	0	0	5138	539.9	583.0	8.81	0.93
1964	4434	161	0	8	128	1	74	0	0	0	0	0	0	4806	825.0	894.0	5.37	0.92
1965	3330	163	1	2	144	4	36	0	0	0	0	0	0	3680	639.9	707.0	5.20	0.90
1966	1677	149	1	34	91	46	35	0	0	0	0	0	0	2033	331.5	402.0	5.06	0.82
1967	485	197	3	131	223	66	62	0	0	0	0	0	0	1167	139.1	335.0	3.49	0.42
1968	474	168	3	337	167	93	96	0	0	0	0	0	0	1338	133.9	378.0	3.54	0.35
1969	658	207	3	348	122	214	43	0	0	0	0	0	0	1595	203.3	493.0	3.24	0.41
1970	758	204	2	369	108	368	30	0	0	0	0	0	0	1839	231.9	563.0	3.27	0.41
1971	1223	179	3	158	149	221	178	0	0	0	0	0	0	2111	537.5	928.0	2.28	0.58
1972	335	191	7	300	67	215	188	0	0	10	0	0	0	1313	177.7	696.0	1.89	0.26
1973	229	209	10	155	223	457	124	0	0	208	0	0	0	1615	108.7	767.0	2.11	0.14
1974	267	234	1	183	516	385	83	0	0	62	0	0	0	1731	110.6	717.0	2.41	0.15
1975	551	241	3	105	594	304	82	0	0	44	0	0	0	1924	280.3	979.0	1.97	0.29
1976	260	265	0	169	250	174	78	0	0	47	0	0	0	1243	169.1	808.0	1.54	0.21
1977	118	295	1	64	220	307	79	0	0	87	0	0	?	1171	82.5	819.0	1.43	0.10
1978	99	295	1	81	97	185	93	0	0	42	0	0	?	893	38.9	351.0	2.54	0.11
1979	98	295	7	51	156	67	132	0	0	6	0	0	0	812	39.8	330.0	2.46	0.12
1980	223	295	0	160	156	45	79	0	0	0	0	0	0	958	70.3	302.0	3.17	0.23

CHTAI = China-Taiwan
ARGN = Argentina
BRZL = Brazil
PAN = Panama
BR-KO = Brazil-Korea
BR-JP = Brazil-Japan
GRNA = Granada

Source: SAW/82/BSS/3

Table BSS-5. Blue marlin landings (MT), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN) and entire fleet (FTOT), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the South Atlantic Ocean, 1957-1980.

YEAR	JAPAN	U.S.	USSR	CHTAI	CUBA	KOREA	VENEZ	ARGN	BRZL	PAN	BR-KO	BR-JP	GRNA	TOTAL	FJPN	FTOT	UJPN	%JPN
1957	673	0	0	0	0	0	0	0	0	0	0	0	0	673	67.4	67.0	9.99	1.00
1958	532	0	0	0	0	0	0	0	0	0	0	0	0	532	78.2	78.0	6.80	1.00
1959	610	0	0	0	0	0	0	0	0	0	0	0	0	610	233.7	234.0	2.61	1.00
1960	2131	0	0	0	0	0	0	0	0	0	0	0	0	2131	330.3	330.0	6.45	1.00
1961	3389	0	0	0	0	0	0	0	41	0	0	0	0	3430	386.5	391.0	8.77	0.99
1962	3821	0	0	11	0	0	0	0	24	0	0	0	0	3856	857.4	865.0	4.46	0.99
1963	3841	0	0	21	22	0	0	0	12	0	0	0	0	3896	866.3	879.0	4.43	0.99
1964	3156	0	1	5	26	1	0	0	12	0	0	0	0	3201	943.8	957.0	3.34	0.99
1965	2421	0	3	2	32	3	0	0	12	0	0	0	0	2473	837.2	855.0	2.89	0.98
1966	1693	0	5	35	27	47	0	0	12	0	0	0	0	1819	572.5	615.0	2.96	0.93
1967	588	0	13	160	221	79	0	0	6	0	0	0	0	1067	291.3	529.0	2.02	0.55
1968	472	0	12	385	113	93	0	0	15	0	0	0	0	1090	197.6	456.0	2.39	0.43
1969	302	0	13	1016	43	98	0	0	18	0	0	0	0	1490	178.2	879.0	1.69	0.20
1970	247	0	12	560	41	120	0	0	39	0	0	0	0	1019	124.7	514.0	1.98	0.24
1971	172	0	14	604	17	258	0	0	21	0	0	0	0	1086	98.9	624.0	1.74	0.16
1972	85	0	36	628	22	251	0	0	26	12	0	0	0	1060	56.7	707.0	1.50	0.08
1973	117	0	52	537	75	532	0	0	8	244	0	0	0	1565	58.1	777.0	2.01	0.07
1974	17	0	8	369	170	449	0	0	16	72	0	0	0	1101	8.7	563.0	1.95	0.02
1975	57	0	15	422	195	354	0	0	12	51	0	0	0	1106	35.6	691.0	1.60	0.05
1976	4	0	1	240	159	392	0	0	33	107	10	0	0	946	4.8	1135.0	0.83	0.00
1977	17	0	9	107	100	356	0	0	52	103	29	113	?	886	12.5	329.0	1.36	0.02
1978	15	0	4	177	113	140	0	0	14	32	0	24	?	519	9.5	329.0	1.58	0.03
1979	66	0	37	139	180	78	0	0	25	7	0	3	0	535	37.6	305.0	1.76	0.12
1980	113	0	0	129	180	92	0	0	12	0	0	8	0	534	95.9	453.0	1.18	0.21

CHTAI = China-Taiwan
ARGN = Argentina
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PAN = Panama
BR-KO = Brazil-Korea
BR-JP = Brazil-Japan
GRNA = Granada

Source: SAW/82/BSS/3

Table BSS-6. White marlin landings (MT), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN) and entire fleet (FTOT), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the Total Atlantic Ocean, 1957-1980.

YEAR	JAPAN	U.S.	USSR	CHTAI	CUBA	KOREA	VENEZ	ARGN	BRZL	PAN	BR-KO	BR-JP	GRNA	TOTAL	FJPN	FTOT	UJPN	%JPN
1957	160	0	0	0	0	0	0	0	0	0	0	0	0	160	9.2	9.0	17.39	1.00
1958	161	0	0	0	0	0	0	0	0	0	0	0	0	161	30.3	30.0	5.31	1.00
1959	112	0	0	0	0	0	0	0	0	0	0	0	0	112	115.4	115.0	0.97	1.00
1960	253	60	0	0	0	0	0	0	0	0	0	0	0	313	111.8	138.0	2.26	0.81
1961	692	60	0	0	0	0	11	0	60	0	0	0	0	823	93.8	112.0	7.38	0.84
1962	1915	74	0	6	0	0	30	0	34	0	0	0	0	2059	392.1	422.0	4.88	0.93
1963	2418	64	0	14	44	0	55	0	17	0	0	0	0	2612	394.6	426.0	6.13	0.93
1964	3595	70	0	6	62	3	78	0	17	0	0	0	0	3731	963.3	1028.0	3.63	0.94
1965	4631	76	2	4	102	8	63	0	17	0	0	0	0	4903	652.4	691.0	7.10	0.94
1966	3002	76	2	61	141	109	93	0	17	0	0	0	0	3501	461.8	539.0	6.50	0.86
1967	668	81	7	181	194	169	104	3	9	0	0	0	0	1416	189.6	402.0	3.52	0.47
1968	1088	87	7	385	118	209	107	14	21	0	0	0	0	2036	214.6	402.0	5.07	0.53
1969	843	76	7	568	65	381	268	0	24	0	0	0	0	2232	158.2	419.0	5.33	0.38
1970	703	104	4	566	69	570	15	0	54	0	0	0	0	2085	223.6	663.0	3.14	0.34
1971	980	95	7	438	49	560	82	20	15	0	0	0	0	2246	242.9	557.0	4.03	0.44
1972	440	99	16	713	40	545	258	100	94	26	0	0	0	2331	132.1	700.0	3.33	0.19
1973	355	104	24	532	133	271	170	57	10	123	0	0	0	1779	84.5	423.0	4.20	0.20
1974	390	108	3	527	304	229	114	0	36	36	0	0	0	1747	74.3	333.0	5.25	0.22
1975	418	107	7	339	349	180	113	0	31	26	0	0	0	1570	142.7	536.0	2.93	0.27
1976	543	109	0	519	106	284	107	2	56	76	8	0	0	1810	110.8	369.0	4.90	0.30
1977	106	109	3	163	124	182	108	2	15	51	19	76	?	958	57.1	516.0	1.86	0.11
1978	129	109	2	276	170	38	127	0	22	9	0	120	?	1002	38.8	301.0	3.32	0.13
1979	110	109	16	217	273	40	181	0	21	3	0	93	0	1063	35.3	341.0	3.12	0.10
1980	125	109	0	250	273	37	110	0	35	0	0	21	0	960	77.5	595.0	1.61	0.13

CHTAI = China-Taiwan
ARGN = Argentina
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BR-JP = Brazil-Japan
GRNA = Granada

Source: SAW/82/BSS/3

Table BSS-7. White marlin landings (MT), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN) and entire fleet (FTOT), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the North Atlantic Ocean, 1957-1980.

YEAR	JAPAN	U.S.	USSR	CHTAI	CUBA	KOREA	VENEZ	ARGN	BRZL	PAN	BR-KO	BR-JP	GRNA	TOTAL	FJPN	FTOT	UJPN	%JPN
1957	25	0	0	0	0	0	0	0	0	0	0	0	0	25	3.3	3.0	7.58	1.00
1958	62	0	0	0	0	0	0	0	0	0	0	0	0	62	41.0	41.0	1.51	1.00
1959	16	0	0	0	0	0	0	0	0	0	0	0	0	16	95.4	95.0	0.17	1.00
1960	25	60	0	0	0	0	0	0	0	0	0	0	0	85	45.8	156.0	0.55	0.29
1961	30	60	0	0	0	0	11	0	0	0	0	0	0	101	22.8	77.0	1.32	0.30
1962	271	74	0	1	0	0	30	0	0	0	0	0	0	376	173.1	240.0	1.57	0.72
1963	754	64	0	4	35	0	55	0	0	0	0	0	0	912	357.2	432.0	2.11	0.83
1964	1493	70	0	3	45	1	78	0	0	0	0	0	0	1690	884.7	1001.0	1.69	0.88
1965	1913	76	0	2	69	1	63	0	0	0	0	0	0	2124	527.5	586.0	3.63	0.90
1966	1417	76	0	32	118	51	93	0	0	0	0	0	0	1787	419.9	530.0	3.37	0.79
1967	174	81	1	47	127	44	104	0	0	0	0	0	0	578	131.3	436.0	1.33	0.30
1968	273	87	1	58	103	52	107	0	0	0	0	0	0	681	122.4	305.0	2.23	0.40
1969	451	76	1	132	58	204	268	0	0	0	0	0	0	1190	144.2	380.0	3.13	0.38
1970	419	104	0	97	61	340	15	0	0	0	0	0	0	1036	212.8	526.0	1.97	0.40
1971	915	95	1	178	45	219	82	0	0	0	0	0	0	1535	399.9	671.0	2.29	0.60
1972	339	99	1	244	34	213	258	0	0	10	0	0	0	1198	180.4	638.0	1.88	0.28
1973	328	104	2	120	112	106	170	0	0	48	0	0	0	990	133.8	404.0	2.45	0.33
1974	381	108	0	248	256	90	114	0	0	14	0	0	0	1211	127.4	405.0	2.99	0.31
1975	404	107	1	84	294	71	113	0	0	10	0	0	0	1084	236.1	633.0	1.71	0.37
1976	540	109	0	142	68	64	107	0	0	17	0	0	0	1047	191.6	371.0	2.82	0.52
1977	80	109	0	44	67	71	108	0	0	20	0	0	?	499	92.8	579.0	0.86	0.16
1978	115	109	0	79	43	33	127	0	0	8	0	0	?	514	61.2	274.0	1.88	0.22
1979	95	109	1	62	68	16	181	0	0	1	0	0	0	533	53.2	298.0	1.79	0.18
1980	118	109	0	105	68	12	110	0	0	0	0	0	0	522	120.7	534.0	0.98	0.23

CHTAI = China-Taiwan
ARGN = Argentina
BRZL = Brazil
PAN = Panama
BR-KO = Brazil-Korea
BR-JP = Brazil-Japan
GRNA = Granada

Source: SAW/82/BSS/3

Table BSS-8. White marlin landings (MT), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN) and entire fleet (FTOT), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the South Atlantic Ocean, 1957-1980.

YEAR	JAPAN	U.S.	USSR	CHTAI	CUBA	KOREA	VENEZ	ARGN	BRZL	PAN	BR-KO	BR-JP	GRNA	TOTAL	FJPN	FTOT	UJPN	%JPN
1957	135	0	0	0	0	0	0	0	0	0	0	0	0	135	17.1	17.0	7.89	1.00
1958	99	0	0	0	0	0	0	0	0	0	0	0	0	99	16.0	16.0	6.19	1.00
1959	96	0	0	0	0	0	0	0	0	0	0	0	0	96	142.2	142.0	0.68	1.00
1960	228	0	0	0	0	0	0	0	0	0	0	0	0	228	200.7	201.0	1.14	1.00
1961	662	0	0	0	0	0	0	0	60	0	0	0	0	722	189.0	206.0	3.50	0.92
1962	1644	0	0	5	0	0	0	0	34	0	0	0	0	1683	686.3	703.0	2.40	0.98
1963	1664	0	0	10	9	0	0	0	17	0	0	0	0	1700	444.8	454.0	3.74	0.98
1964	2002	0	0	3	17	2	0	0	17	0	0	0	0	2041	1068.9	1090.0	1.87	0.98
1965	2718	0	2	2	33	7	0	0	17	0	0	0	0	2779	820.2	839.0	3.31	0.98
1966	1585	0	2	29	23	58	0	0	17	0	0	0	0	1714	518.1	560.0	3.06	0.92
1967	494	0	6	134	67	125	0	3	9	0	0	0	0	838	267.9	454.0	1.84	0.59
1968	815	0	6	327	15	157	0	14	21	0	0	0	0	1355	338.4	563.0	2.41	0.60
1969	392	0	6	436	7	177	0	0	24	0	0	0	0	1042	177.0	470.0	2.21	0.38
1970	284	0	4	469	8	230	0	0	54	0	0	0	0	1049	238.0	879.0	1.19	0.27
1971	65	0	6	260	4	341	0	20	15	0	0	0	0	711	31.9	349.0	2.04	0.09
1972	101	0	15	469	6	332	0	100	94	16	0	0	0	1133	67.2	754.0	1.50	0.09
1973	27	0	22	412	21	165	0	57	10	75	0	0	0	789	18.1	529.0	1.49	0.03
1974	9	0	3	279	48	139	0	0	36	22	0	0	0	536	2.9	173.0	3.10	0.02
1975	14	0	6	255	55	109	0	0	31	16	0	0	0	486	17.2	597.0	0.81	0.03
1976	3	0	0	377	38	220	0	2	56	59	8	0	0	763	2.2	560.0	1.36	0.00
1977	26	0	3	119	57	111	0	2	15	31	19	76	?	459	9.0	159.0	2.89	0.06
1978	14	0	2	197	127	5	0	0	22	1	0	120	?	488	8.7	303.0	1.61	0.03
1979	15	0	15	155	205	24	0	0	21	2	0	93	0	530	11.2	396.0	1.34	0.03
1980	7	0	0	145	205	25	0	0	35	0	0	21	0	438	19.5	1220.0	0.36	0.02

CHTAI = China-Taiwan
ARGN = Argentina
BRZL = Brazil
PAN = Panama
BR-KO = Brazil-Korea
BR-JP = Brazil-Japan
GRNA = Granada

Source: SAW/82/BSS/3

Table BSS-9. Swordfish landings (metric tons), effective fishing intensity (thousands of hooks per 5-degree area) for Japanese fleet (FJPN), index of abundance (UJPN), and ratio of Japanese to total catch (%JPN) in the Total Atlantic Ocean.

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
ALGER																2	100	196	500	368	370	320	521	
ARGN				281	111	196	400	508	400	200	79	259	500	400	63	100	48	10	10	111	132	4		
BRZL					440	251	125	125	125	125	62	100	181	162	113	108	137	348	318	372	342	143	214	1125
CANA	3102	3219	4014	2328	1913	2092	7482	7099	4674	4433	4794	4393	4257	4800					21	15	113	2314	2970	1885
CHTAI						1	6	3	2	110	204	490	855	1219	825	750	1092	821	928	935	708	607	1254	643
CUBA					300	400	188	235	335	297	895	634	267	282	234	141	469	1081	528	600	700	600	400	600
FRAN																								5
ITALY											1900	1400	2000	1800	2900	3700	2800	3330	3002	3346	3345	4031	3375	3699
JAPAN	134	135	99	98	319	427	1136	1988	2870	1958	754	1121	2273	3175	1578	1807	998	1369	1500	809	792	971	1100	2195
KOREA								2	6	81	125	101	392	422	415	404	976	715	451	1147	1240	1333	606	683
LIBYA									200	200	300	500			100									
MALTA														100	200	200	200	171	191	156	199	121	135	198
MAROC					100	200	100	400	324	253	204	240	270	231	360	273	201	211	133	198	151	183	207	136
NORWY										300	300	200	600	400	200									
POLAN																	100					6		1
PORTU								9	6	15	11	12	11	8	11	21	37	92	58	32	38	17	29	15
S AFR																							28	31
SPAIN	1000	1246	1100	722	1700	2300	1000	1800	1200	3999	3390	4551	4602	4060	4484	4510	4938	3593	3836	2905	3976	4342	3382	4990
TUNIS																		5		5				
TURKY				100	100	100	200	100	100	300	98		119	88	76	76		6		7	34	20	44	13
USA	366	710	690	458	408	424	1250	1384	1227	614	474	274	170	287	35	246	406	1125	1700	1429	912	3039	3405	3535
GHANA																								110
PAN																19	445	114	65	310	50	159	52	
VENEZ						8	13	12	8	11	21	18	100	23	52	27	23	24	52	43	15	46	67	40
MEXI																2	4	3				2		
USSR								4	44	64	180	176	100	200	200	230	214	140	263	157	121	184	80	175
BULGA																					3			
CPRUS																			5	72	118	91	108	79
RUMAN																						1		
BR-KO																				22	41			
BR-JP																					9	129	144	289
IREL																				1				
TOTAL	4602	5310	5903	3987	5391	6399	11900	13669	12954	12960	13791	14469	16697	17657	11846	12616	13188	13354	13561	13040	13409	18663	18121	20447
FJPN	16.0	36.9	79.2	120.1	156.2	282.9	289.9	395.6	549.4	273.6	174.9	179.0	489.2	490.3	356.2	370.2	208.3	263.0	372.2	210.1	145.4	176.2	224.9	362.3
UJPN	8.38	3.66	1.25	0.83	2.04	1.51	3.92	5.03	5.22	7.16	4.31	6.26	4.65	6.48	4.43	4.88	4.79	5.20	4.03	3.85	5.45	5.51	4.89	6.06
%JPN	0.03	0.03	0.02	0.03	0.06	0.07	0.10	0.15	0.22	0.15	0.05	0.08	0.14	0.18	0.13	0.14	0.08	0.10	0.11	0.06	0.06	0.05	0.06	0.11

UJPN = JAPAN/FJPN; %JPN = JAPAN/TOTAL; CHTAI = CHINA-TAIWAN; BR-KO = BRAZIL-KOREA; BR-JP = BRAZIL-JAPAN

Source: SAW/82/BSS/5

Table BSS-10. Total international reported and estimated pelagic shark catch (tons) in the western North Atlantic (FAO Areas 21 and 31) during 1965-78, including the amount taken from within the U.S. FCZ.

	REPORTED COMMERCIAL		ESTIMATED						
Year	FAO Area 21	FAO Area 31	U.S. Recreational	Swordfish Bycatch	Squid Bycatch	Tuna Bycatch	Other[1]	TOTAL	U.S. FCZ
1965	5534	4800	2623	4061	1	1740	2383	21142	13967
1966	2473	5400	4068	2825	2	1472	2383	18623	12258
1967	831	5200	5516	3147	4	270	2383	17351	12008
1968	1117	5400	6962	3593	24	189	2383	19668	13557
1969	1428	5700	8409	3471	41	147	2383	21579	14729
1970	934	6000	9854	3049	90	948	2383	23258	17054
1971	770	6700	9294	4	101	4028	2383	23280	16053
1972	451	7900	8732	76	228	1892	2383	21662	13847
1973	307	10500	8170	506	265	2266	2383	24397	14240
1974	163	10900	7608	1523	255	1216	2383	24048	13808
1975	231	11400	7818	3174	240	1075	2383	26321	15823
1976	389	10600	8465	3807	223	2180	2383	28047	18290
1977	454	13700	9112	2543	194	1140	2383	29526	15622
1978	522	10600	9759	4851	128	2492	2383	30735	20140

[1]Bycatch in shrimp trawl, groundfish, snapper-grouper, and other miscellaneous fisheries in the Gulf of Mexico.

Source: Anderson. 1980. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 80-18

Table BSS-11. Japanese reported shark catch (tons), reported longline effort (all pelagics), and calculated shark catch per unit effort for FAO Area 31, and international catch and effort (international catch divided by Japanese CPUE for Area 31) for the western North Atlantic (FAO Areas 21 and 31), 1965-1977.

	FAO AREA 31			FAO AREAS 21 and 31	
Year	Japanese Catch	Japanese Effort[1]	Japanese CPUE[2]	International Catch	International Effort[3]
1965	800	20,879,615	3.83	21,142	5,520
1966	700	11,503,228	6.09	18,623	3,058
1967	200	5,804,609	3.45	17,351	5,029
1968	100	5,004,961	2.00	19,668	9,834
1969	200	5,157,624	3.88	21,579	5,562
1970	200	8,540,876	2.34	23,258	9,939
1971	200	11,889,891	1.68	23,280	13,857
1972	100	3,297,972	3.03	21,662	7,149
1973	100	2,070,674	4.83	24,397	5,051
1974	74	2,674,822	2.77	24,048	8,682
1975	147	5,464,756	2.69	26,321	9,785
1976	76	5,706,423	1.33	28,047	21,088
1977	24	4,990,038	0.48	29,526	61,512

[1]Number of longline hooks fished
[2]Catch per 100,000 hooks
[3]Expressed as Japanese hook equivalents (10^5)

Source: Anderson. 1980. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 80-18

Figure BSS-1. Blue marlin landings from the North Atlantic Ocean, 1960-79. LONGLINE represents the total catch of all longlining nations. RECREATIONAL represents the United States recreational boated catch, i.e. released fish are not included. IN U.S. FCZ represents the estimated catch taken within the area that is now the United States FCZ. The difference between IN U.S. FCZ and RECREATIONAL represents the Japanese catch within the United States FCZ. For 1978 and 1979, Japanese catches in the United States FCZ are estimated from U.S. observer data and only fish classified as "dead" when released are included. Other data are from ICCAT (1981).
Source: Conser (1982)

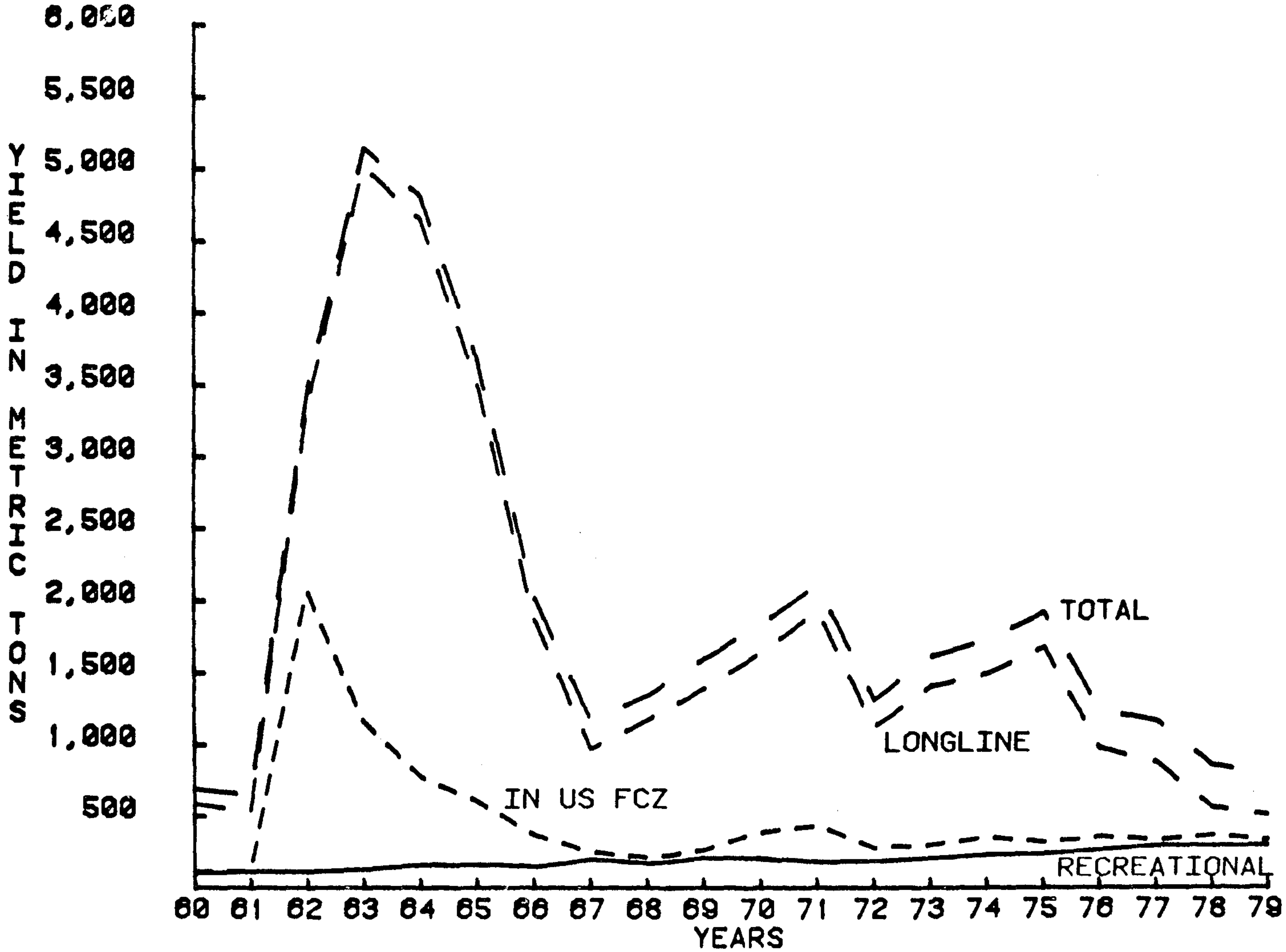


Figure BSS-2. White marlin landings from the North Atlantic Ocean, 1960-79. LONGLINE represents the total catch of all longlining nations. RECREATIONAL represents the United States recreational boated catch, i.e. released fish are not included. IN U.S. FCZ represents the estimated catch taken within the area that is now the United States FCZ. The difference between IN U.S. FCZ and RECREATIONAL represents the Japanese catch within the United States FCZ. For 1978 and 1979, Japanese catches in the United States FCZ are estimated from U.S. observer data and only fish classified as "dead" when released are included. Other data are from ICCAT (1981). Source: Conser (1982)

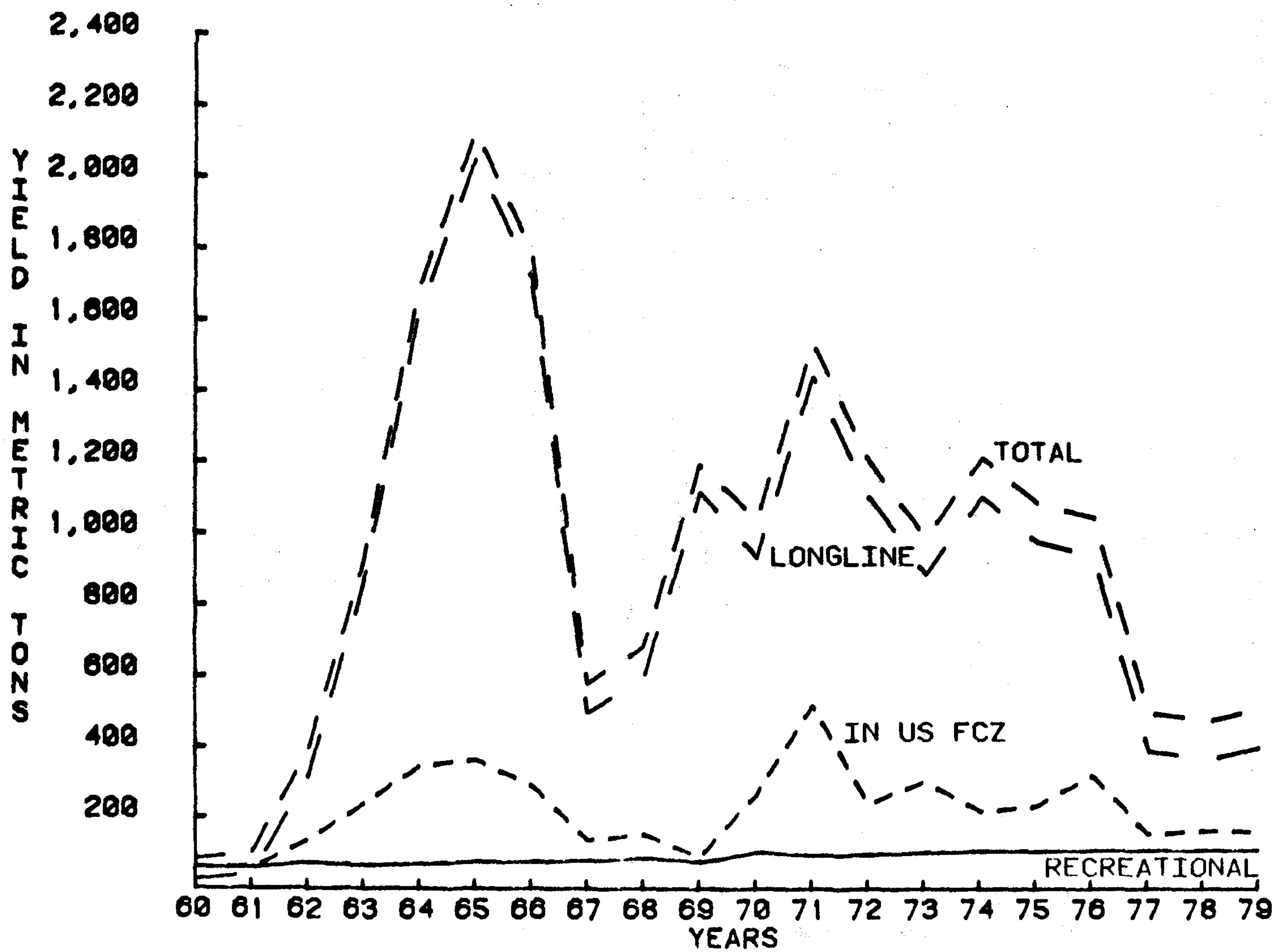


Figure BSS-3. Catch per unit of effective effort for blue marlin in the Atlantic Ocean, 1958-80. All data are from the Japanese longline fishery. Source: SAW/82/BSS/3.

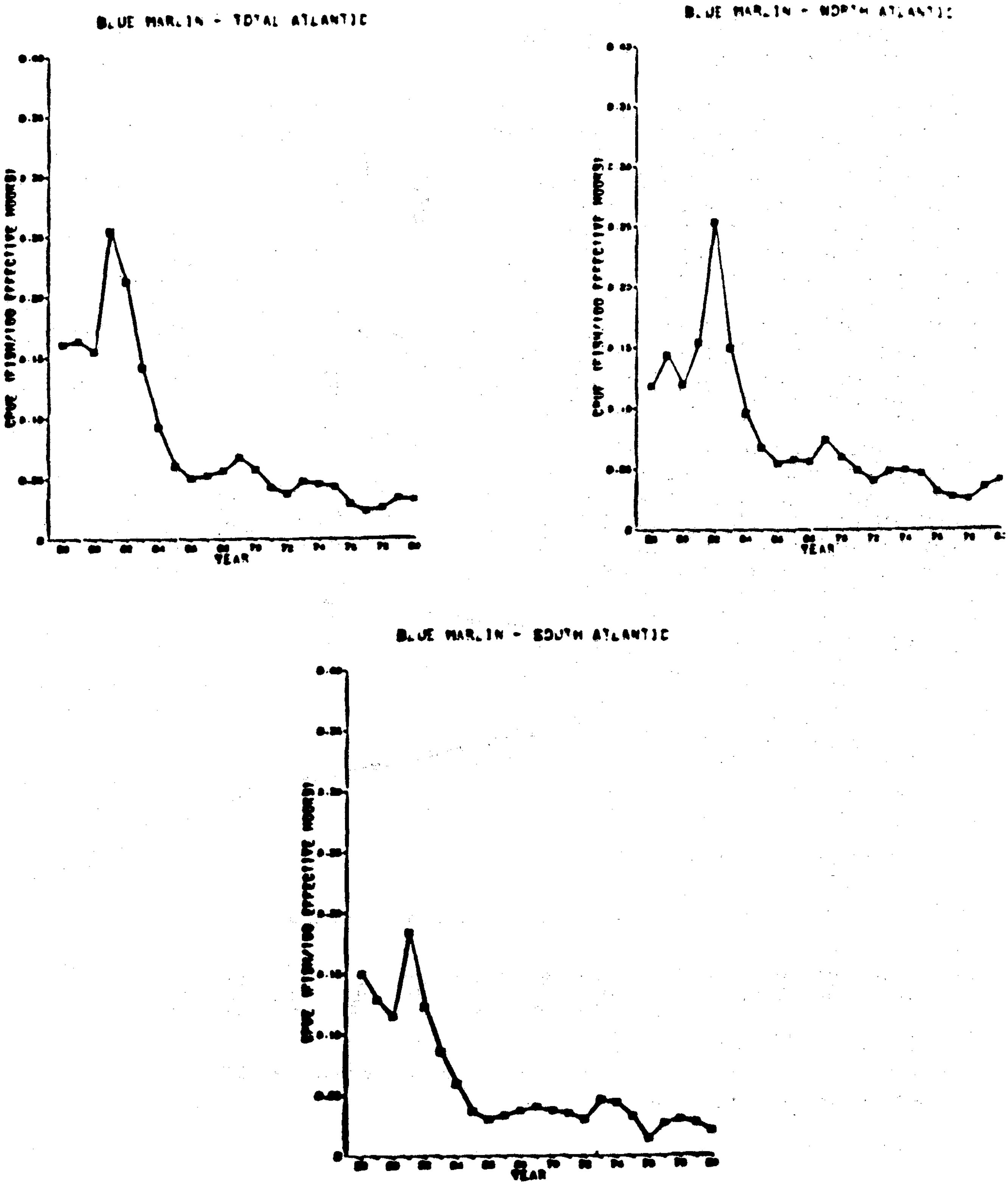


Figure BSS-4. Equilibrium yield curves and unobserved data for blue marlin under a Total Atlantic stock structure hypothesis, with the assumption of five significant year-classes in the catch, and for various values of M. Note: the production model is fitted to the index of abundance and a weighted average of total effective fishing intensity for 1957-80. See text for further details. Source: SAW/82/BSS/3.

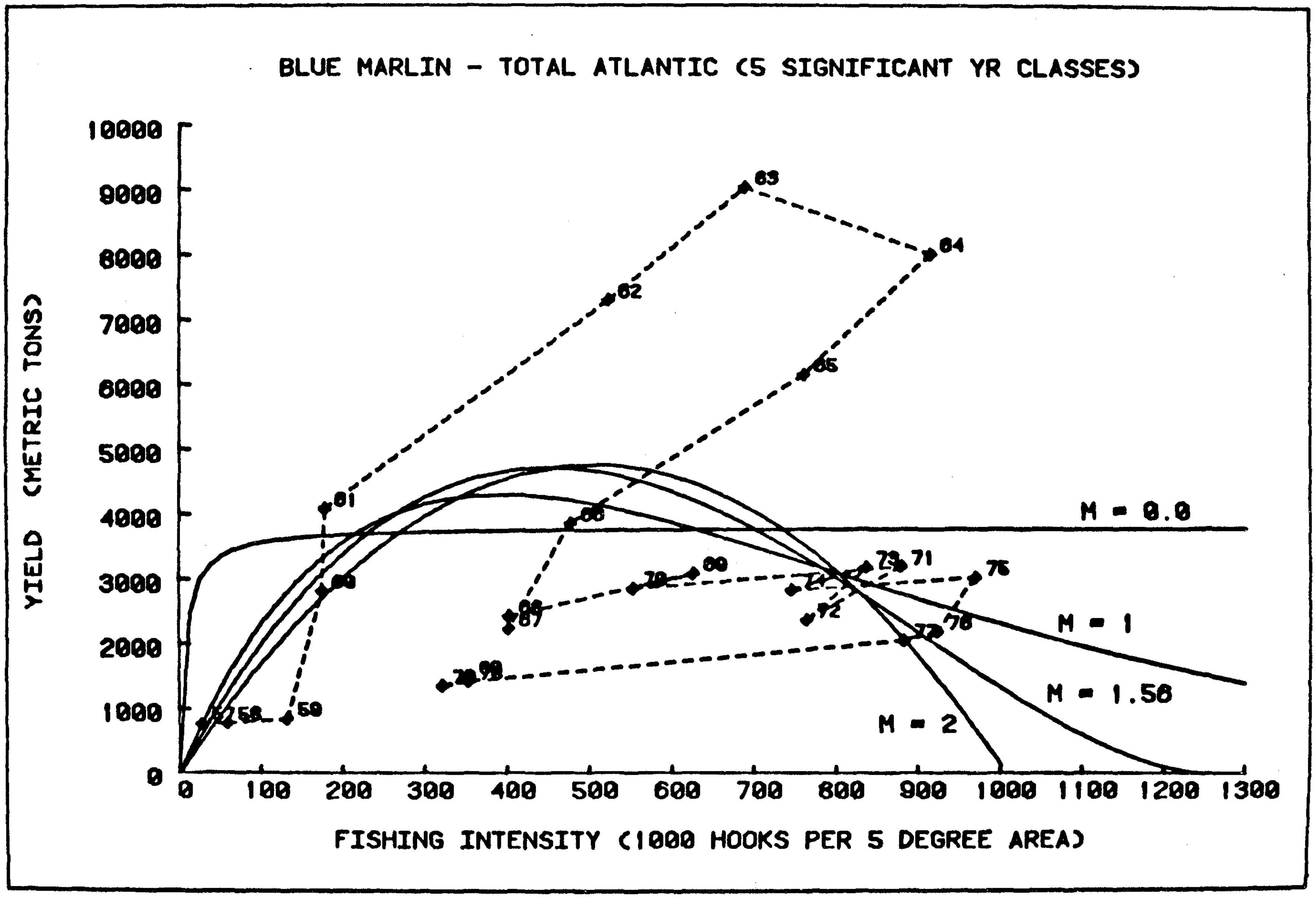


Figure BSS-5. Equilibrium yield curves and unobserved data for blue marlin under a North Atlantic stock structure hypothesis, with the assumption of five significant year-classes in the catch, and for various values of M. Note: the production model is fitted to the index of abundance and a weighted average of total effective fishing intensity for 1957-80. See text for further details. Source: SAW/82/BSS/3.

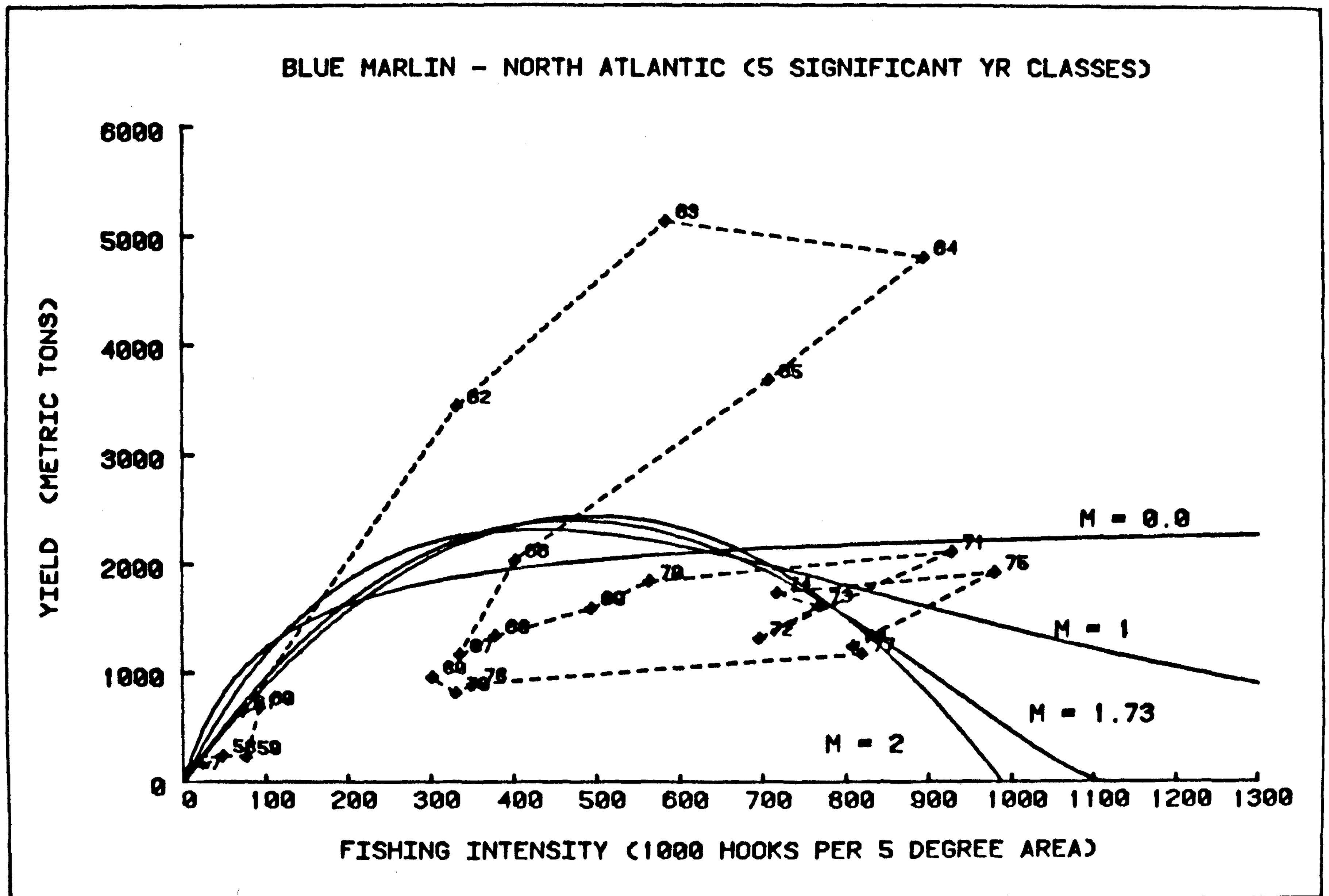


Figure BSS-6. Catch per unit of effective effort for white marlin in the Atlantic Ocean, 1958-80. All data are from the Japanese longline fishery. Source: SAW/82/BSS/3.

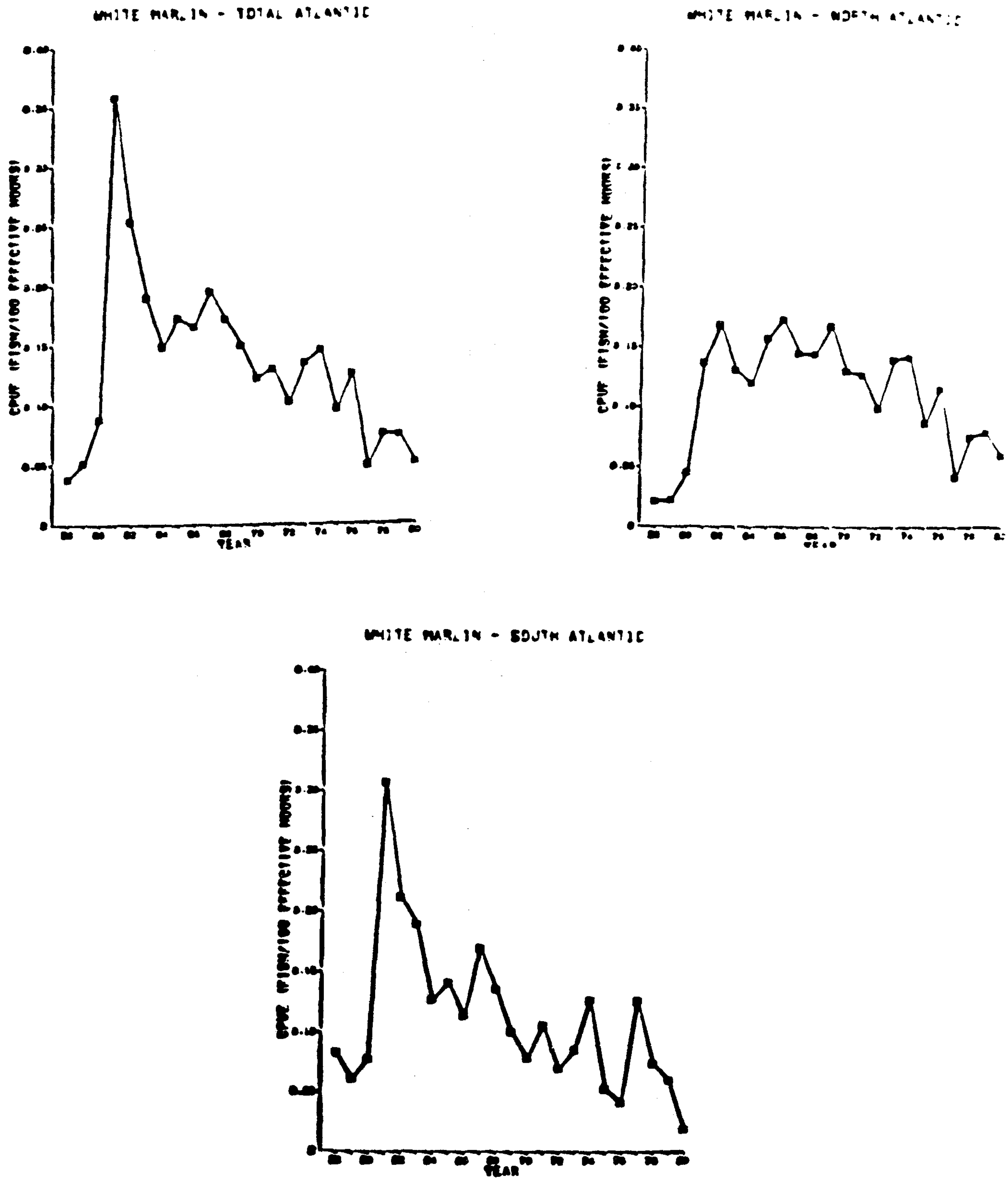


Figure BSS-7. Distribution of catches of swordfish (per 10,000 hooks) in the four quarters of the year, 1956-68. Source: Wise, J.P. and C.W. Davis. 1973. Seasonal distributions of tunas and billfishes in the Atlantic. NOAA Technical Report NMFS SSRF-662. 24 pp.

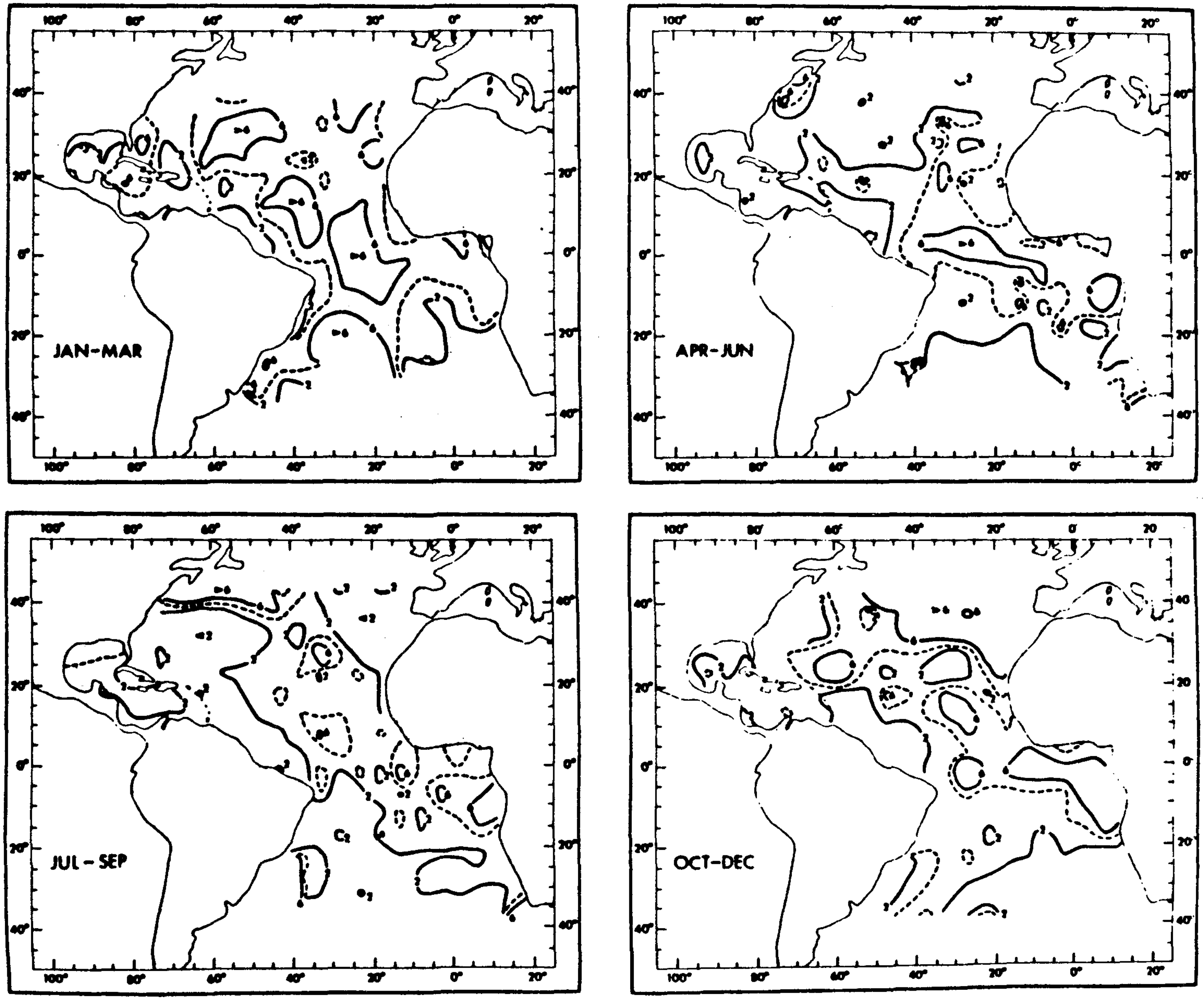
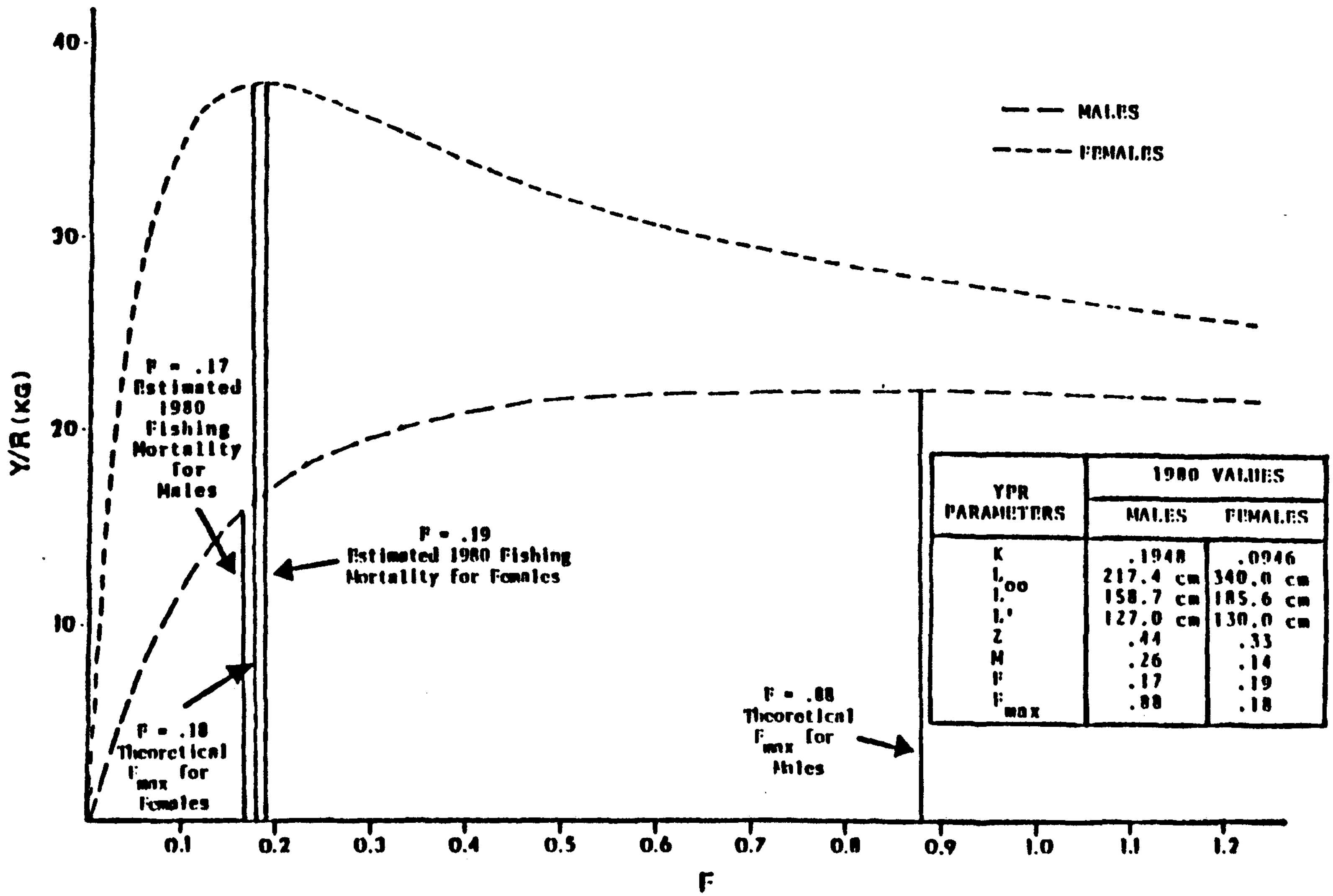


Figure BSS-8. Yield curves for Florida swordfish. Yield per recruit (YPR) is given in relation to the instantaneous fishing mortality rate (F) for males and females. The various fishing mortality rates are estimated using F = Z - M, where Z is estimated using Robson and Chapman (1961) and M is from Pauly's (1980) empirical relationship Source: modified from SAW/82/BSS/4.



YPR PARAMETERS	1980 VALUES	
	MALES	FEMALES
K	.1948	.0946
L_{∞}	217.4 cm	340.0 cm
$\bar{L}$	158.7 cm	185.6 cm
L'	127.0 cm	130.0 cm
Z	.44	.33
M	.26	.14
F	.17	.19
F_{max}	.88	.18

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 (Randall 1968). King mackerel is not a target species of commercial or recreational fisheries in waters north of North Carolina. Annual landings over one million pounds of king mackerel have been reported fairly consistently by Brazil, Mexico, the United States, and Venezuela between 1970 and 1980 (ICCAT 1981).

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 and occurs 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 (Costa and Paiva 1968).

King mackerel in Brazil are fished artisanally with troll lines and gill nets. Surface gears are also used to catch them in Venezuela (ICCAT 1981). The Mexican king mackerel fishery is artisanal.

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 (Beaumariage 1973; Austin *et al*. 1978; Manooch 1979). 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 (Harris 1974). 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 (Pete Eldridge, National Marine Fisheries Service, Charleston, South Carolina, personal communication). Other incidental catches of king mackerel have occurred with shrimp trawls, possibly as a result of the fish feeding on discards since two tag returns of adult king mackerel have occurred from shrimp trawls fishing off South Carolina (Williams, personal communication). A small bycatch of king mackerel also occurs in the Florida gill net fishery for Spanish mackerel. In a survey that covered over 150,000 mackerels from landings totalling 1.1 million pounds, Fable and Trent (1981) estimated found that approximately 0.08% of the total catch was king mackerel.

Recently there has been some expansion in the United States commercial fishery, probably because of a 250% increase in exvessel price from 1976 to 1982. This expansion has occurred through exploitation of new areas (North Carolina with trolling and anchor gill nets), South Carolina, and Louisiana) and through utilization of new gear, such as drift gill nets off the east coast of Central Florida. Limited purse seining is expected to be added to the fishery off the east and west coast of Florida in the 1982-1983 season.

I.2. Catch Trends

Examination of catch trends of the U.S. commercial fisheries indicates that catches have fluctuated around an average of 6.88 million pounds between 1970 and 1981, with a peak in 1974 of 10.5 million pounds. Following 1974, commercial catch levels have remained relatively stable in states along the Atlantic and Gulf coasts, with the exception of North and South Carolina (Table GCP-1). Landings on the east and west coasts of Florida, which account for generally 90% of the total landings of king mackerel in the U.S., have fluctuated around an average of 3.4 and 2.8 million pounds, respectively, between 1975 and 1981. Landings in North Carolina have increased by 700% from 1975 to 1981, with 0.7 million pounds being landed in 1981. Landings in South Carolina have also increased dramatically since 1975, though at present they constitute a small proportion of the total catch. Information available to the working group indicates that landings in these two states are likely to increase. Commercial landings were available for Florida in the first six months of 1982. The total landed (4.29 million pounds) is comparable to previous years and suggests landings in 1982 will not be appreciably lower than those of recent years.

Landings of king mackerel reported by other countries are shown in Table GCP-2. Landings of king mackerel in Brazil appear to have tripled between 1979 and 1980, being relatively low and stable over the previous four years. Venezuelan landings appear to have declined slightly between 1975 and 1980. The recent status of Mexican landings of king mackerel is not well-known. Figures published by ICCAT apparently contain a large percentage of Spanish mackerel, as figures obtained independently by G. Nakamura from Mexican scientists estimated a much lower catch of king mackerel than those indicated by ICCAT (Table GCP-2).

Sizes of king mackerel landed vary in relation to area and method of capture. The sizes landed within an area by a single method also vary because sizes of king mackerel are distributed heterogeneously in time and space. Schooling tendencies may contribute to these patterns; king mackerel are generally thought to school by age or size group. SAW/82/GCP/3 found that average sizes of fish caught by recreational fishermen were smallest in south and northwest Florida, intermediate in Texas and the Carolinas and largest in Louisiana. They also found that within areas, sizes changed significantly between some months. In south Florida, a greater range of sizes was landed by recreational fishing gear than by gill nets or commercial hook and line gear. However, drift gill nets were found to capture larger king mackerel than (runaround) gill nets or commercial hook and line gear. The perception of the population size distributions of king mackerel, therefore, is partly a function of capture patterns (methods, seasons, area) and schooling behavior and, thus, may not reflect the actual population size distribution. The expansion of fisheries into areas resulting in more frequent catches of large fish may revise current appraisals of average maximum sizes of king mackerel.

II. STOCK STRUCTURE

There appear to be two or more distinct populations of king mackerel in the southeast region of the United States according to tagging data (SAW/82/GCP/8) and the known distribution of larvae (Powles, unpubl; Wollam 1970; Dwinnell and Futch 1973; Burns 1981). One is a south Atlantic population which moves between the Carolinas and south Florida and appears to spawn in the summer from south Florida to the Carolinas. A Gulf of Mexico population moves between the northern and northwestern Gulf areas and both coasts of south Florida. More Gulf populations may exist, especially since there is a considerable king mackerel fishery off the Mexican coast, but there are only a few tag returns from Mexico. Hence we have a very limited knowledge of how these fish interact with the fish exploited from Texas to Florida.

The Atlantic coast population is distributed and apparently spawns from North Carolina to Miami during the warm months. By fall, the bulk of this group seems to be distributed toward the northern part of the range. In winter, the smaller fish are probably forced south along the inshore areas whereas the large fish probably simply move offshore. Some small fish may appear off the south Florida coast by late winter, their abundance there being determined by the severity of the winter (SAW/82/GCP/8).

The Gulf of Mexico population(s) is distributed during the warm months along the north and northwestern Gulf coasts. By winter, a large fraction of this group moves into southeast Florida where they stay from late November to mid-March. Fish from as far as Texas make this migration. Some large fish remain in the northern Gulf during winter (SAW/82/GCP/8; Sutherland and Fable 1980).

Groups of extremely large individuals, principally females, have been repeatedly observed off Louisiana, North Carolina, and Cape Canaveral. Recent otolith work suggests that the Louisiana group is made up of faster growing fish than those which are captured by fisheries in south Florida (Johnson *et al.*, unpubl.); however, this is not necessarily indicative of separate stocks. Large king mackerel ($>$ 20 pounds) occur in Louisiana year-round (Fischer 1980). The distribution of pre-recruit king mackerel is not well known.

The relationship between the king mackerel occurring in Puerto Rico and the Virgin Islands to the Gulf of Mexico and Atlantic populations is not known. Schooling small fish (5-10 pounds in weight) seasonally migrate through this Caribbean region from April to November. The local perception is that the fish only move from east to west. Non-schooling king mackerel, which are larger than the schooling fish, occur year-round there but are apparently not very abundant, as evidenced by low catch rates (J. Dammann, Caribbean Fishery Management Council, Hato Rey, Puerto Rico, personal communication).

III. STATUS OF THE STOCK
III.1. Population Parameters
III.1.1. Mortality Rates

Estimates of mortality rates have been derived from tagging data (SAW/82/GCP/8), catch curve analysis (Beaumariage 1973; Johnson et al., unpubl.) and relationships between growth curve parameters and natural mortality rates (SAW/82/GCP/1). SAW/82/-GCP/8 preliminarily estimated a natural mortality rate (M) of 0.36 from ratios of total mortality rates and estimates of fishing mortality rates (F). SAW/82/GCP/1 calculated natural mortality rates for male and female king mackerel, respectively, using growth curve parameters estimated by Beaumariage (1973), Johnson et al. (unpubl.), Nomura and Rodrigues (1967) and Ximenez et al. (1978). Average male mortality rates (M) calculated from a variety of equations for each growth curve ranged from 0.445 to 0.618. Those similarly computed for females ranged from 0.328 to 0.445. Mortality rates calculated for males and females in each growth case were higher for males than for females.

SAW/82/GCP/8 estimated total mortality rates from recaptures of fish tagged in various locations and years and concluded that total mortality rates of the so-called winter stock (Gulf stock) in southeast Florida were higher than the fish that support the spring-summer fishery, which belong to the Atlantic stock. These differences were attributed to differences in fishing pressure. Total mortality of the group of fish tagged at Key West and Naples appears to vary from year to year, with highest rates during years such as 1977, when large numbers of fish were caught off Naples and No Man's Land near Key West. The Z's they observed and considered legitimate ranged from 0.12 to 1.71, and averaged 0.583 with a standard deviation of 0.378, based on the Heinke method. Those calculated using the Everhart et al. (1975) method ranged from .56 to .89, averaging 0.718 with a standard deviation of 0.135. Hence, these average estimates, although they represent various fisheries and mixes of males and females, suggest that the average fishing mortality incurred by females in the Gulf of Mexico and/or south Atlantic ranges from .390 to .138 while that of males caught in the same areas ranges up to 0.209, based on average natural mortality rate estimates by SAW/82/GCP/1.

Total mortality rates estimated by Johnson et al. (unpubl.), using various methods employing aged catches, ranged from 0.39 to 0.54. Examination of these values in relation to average natural mortality rates estimated by SAW/82/GCP/1 for U.S. caught males and females, respectively, suggests that the averaged M values were too high or the estimated Z's were too low, since the maximum F's of 0.210 for females and 0.039 for males result.

III.1.2. Growth Estimates

Presently available growth curves indicate that females grow faster and/or to larger sizes than males. This difference is supported by samples of catches of large fish in which females invariably predominate (SAW/82/GCP/3; Fischer 1980). Recent calculations suggesting that natural mortality rates also differ between males and females, being less for females (SAW/82/GCP/1), further suggest that sex ratio may vary considerably in favor of females with increasing size/age.

Growth curves for king mackerel caught in the northern Gulf of Mexico and/or south Atlantic have been estimated by Beaumariage (1973) and Johnson et al. (unpubl.) using hardpart age estimation and SAW/82/GCP/8 using mark-recapture data. Nomura and Rodrigues (1967) and Ximenes et al. (1978) have estimated growth curves based on hardpart ageing for king mackerel caught in Brazilian waters. All authors have estimated growth in terms of the von Bertalanffy growth equation (Table GCP-3). SAW/82/GCP/8 attempted to reconcile differences in size at age estimated by Beaumariage (1973) and Nomura and Rodrigues (1967) with their observations and concluded re-analysis of these authors' data was necessary.

Johnson et al. (unpubl.) suggested that one source of variation between their fits and those of Beaumariage (1973) and Nomura and Rodrigues (1967) was the source of length estimates. Beaumariage (1973) used observed lengths, Nomura and Rodrigues (1967) used both observed lengths and back-calculated lengths. At present, there is no consensus of opinion regarding which available growth curves for male and female king mackerel are likely to be the most accurate. At present ageing of king mackerel by otoliths has not been validated. This contributes to the uncertainty in the determination of growth curves.

While the presently available growth curves differ in their estimates of average maximum lengths and growth rates of males and females, they do agree in suggesting that females attain larger sizes than males and grow faster than males at some or all ages.

III.2. Catch Per Unit Effort Trends

At present, the working group feels that the available data for commercial and recreational king mackerel fisheries is not sufficient to permit definitive statements concerning the status of the stock, since nominal effort data by which commercial catch trends could be gauged are not available. However, the increase in the number of boats participating in the U.S. fishery suggests that effort may be increasing and CPUE may be declining. Sample data pertaining to the commercial king mackerel hook and line fishery on the southeast coast of Florida show a decline in catch per boat from 1969 to 1976 (Fisheries Management Plan for Coastal Pelagics: FMP). Trends in catch per vessel estimated for the roller-rig gill net fleet also indicate declines during this span of years (FMP). However, comparable data extending to 1981/1982 are not available.

Because the NMFS review of the national recreational fishery survey data for 1979 and 1980 has not been completed, the working group was unable to evaluate recreational landings and associated effort for south Atlantic and Gulf of Mexico areas. These data are important in evaluating total catch, since the recreational catch is significant. However, limited catch and effort data pertaining to the recreational fishery in northwest Florida indicate lower than average CPUE levels occurred during 1981 and 1982. In the St. Petersburg-Tampa area of Florida, a strong perception exists among recreational fishermen that there has been a large decline in catch and CPUE. This seems to be supported by commercial landings data, which show a decline since 1975 in the same area. However, it should be noted that the weather may influence the spatial distribution of king mackerel and thus their availability at different locations along the coast and their vulnerability to different gear. An analysis by Fable et al. (1981) of charter boats fishing for king mackerel in northwest Florida showed high spring catch rates were associated with warm winters, while low catch rates followed cold winters.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

The Fishery Management Plan for Coastal Pelagics (FMP), which includes king mackerel, is scheduled for implementation in the fall of 1982[1]. Hence, the effect of current management procedures which are discussed are those that relate to State regulations.

At present, several states regulate the minimum size of king mackerel that can be taken and/or impose restrictions on the type of gear that may be fished to which this species can be vulnerable. Florida and South Carolina both prohibit the taking or

[1]The FMP was implemented on February 4, 1983.

possession and sale of king mackerel less than 12 inches in length; while Florida applies this restriction to both recreational and commercial fisheries, whereas only the commercial fishery is regulated thusly in South Carolina. Texas applies its 14 inch minimum size regulation similarly to South Carolina. Other states along the southeast Atlantic and Gulf of Mexico do not restrict the size of king mackerel that can be taken commercially or recreationally.

Gear restrictions in Florida include minimum mesh sizes for gill nets and prohibitions regarding the use of purse seines. Almost all states' waters within the range of king mackerel have minimum size regulations for seines and nets. Prohibited commercial gears in other states include purse seines and gill nets for king and Spanish mackerel in North Carolina and gill nets in Georgia. North Carolina imposes a daily landing limit of 2,000 pounds of king and/or Spanish mackerel (in aggregate) per boat. The North Carolina Marine Fisheries Commission is presently considering increasing the daily landing limit to 5,000 pounds per boat in view of an expressed need by commercial fishermen to be able to land more than 2,000 pounds from a multiple day fishing trip (M. Street, personal communication).

The intended effect of the minimum size limits and mesh regulations is to minimize the mortality of small fish. Other regulations in effect serve to minimize user conflict. The effect of the North Carolina quota has been to prevent roller rigs from entering the fishery there (D. DeVries, personal communication). The effect of these regulations on the status of the stocks has not been measured.

V. RECOMMENDATIONS

V.1. Data Needs

Better and more complete fishing effort, catch, and size composition data from both commercial and recreational fisheries are needed. Further, these data need to be reported in a more timely way. This timeliness relates both to obtaining the raw data from the fishery and to data processing.

In the commercial king mackerel fishery no information is currently available that reflects nominal fishing effort, only numbers of operating units are known and these are not usually separable to specific areal fisheries. Further, the units are not recorded to have been fished within a particular time period or in any appreciable frequency. Thus, effort data by location, time, gear type, and the species sought are needed.

In the recreational fishery, not even sampling plans exist to provide real time catch and effort data. The data presently being obtained are not available until one to two years after collection. For example, we are presently awaiting the revised estimates of the 1979 and 1980 landings.

Additional information needs related to both recreational and commercial fisheries include estimates of the numbers of recreationally caught fish that are sold and data on the size composition of the catches. Under our present systems of collecting landing data, the fish that are caught by recreational fishermen which are sold are represented in both commercial and recreational landing statistics and will be counted against the commercial as well as the recreational quota as articulated in the Fishery Management Plan. Because the ex-vessel price per pound of king mackerel has increased markedly in the last few years, the contribution of recreationally caught fish to the commercial landing statistics may be increasing and may be obscuring landing trends of the full time commercial fishing sector.

Size-frequency samples of landings by sex, gear and area are needed to provide information on comparative features of the fisheries with respect to recruitment ages and levels, and total mortality patterns. At present, the available data for commercial fisheries are generated only during known peak times of landings. With respect to the recreational fishery, size-frequency samples are available for some years and areas, but no effort to collect these statistics is currently being expended.

V.2. Research

The working group identified five areas for future research effort concerning king mackerel populations. These were stock identification, age and growth characteristics, mortality rates, recruitment phenomena, and stock assessment.

V.2.1. Stock Identification

Tagging studies have indicated the existence of at least two stocks of king mackerel in the southeastern waters of the United States. These observations point to the need to further delineate these populations. One approach which may be fruitful is electrophoretic studies of the genetic variation and differentiation of these recognized groups. Such delineation would significantly contribute to an understanding of the fisheries, their component stocks and the dynamics of these entities.

Further tagging studies are also needed to help determine the distribution of king mackerel stocks. The effort in this research, however, should be expended in geographical areas not formerly studied or for which fragmentary data exists. These areas are North Carolina, South Carolina, Louisiana, Texas, Mexico and the Caribbean. In these studies, effort should be expended to tag all available sizes of fish so that suspected differential migration patterns of large and small fish can be better understood.

V.2.2. Age and Growth

The several growth curves which have been fit to male and female king mackerel differ in their estimates of growth rate and average maximum size attained. A detailed examination of the data on which these curves were based, for U.S. caught fish especially, is recommended so that some of the differences may be resolved. Resolutions of growth patterns for both male and female king mackerel is an important prerequisite to the assessment of king mackerel stocks.

The working group also feels that validation of age estimates through the utilization of tetracycline marking techniques would provide useful information.

V.2.3. Mortality

Natural mortality rates within populations, based on analyses utilizing growth curve parameters, appear to be high when compared to the present estimates of total mortality, since exploitation rates based on these comparisons appear to be too low. More detailed examination of the presently available data is recommended so that factors contributing to the variation in these estimates can be explored.

Investigation of the sensitivity of analytical procedures to differences in mortality rates is also recommended.

V.2.4. Recruitment

Several aspects of recruitment were identified as research concerns. These aspects include a detailed examination of the available information on commercial and recreational landings in order to determine size/age recruitment patterns, recruitment levels and variation in these features among gears and over years.

Also the delineation of spawning and nursery areas could possibly be enhanced through the examination of existing collections of ichthyoplankton from survey work. In this regard, MARMAP surveys in South Carolina may be useful. Also, samples from SEAMAP ichthyoplankton cruises in the Gulf of Mexico might be profitably examined for the presence of king mackerel larvae.

V.3. Management

The analysis of the status of king mackerel stock(s) contained in the Coastal Migratory Pelagic FMP was prepared in 1978. Substantial new pertinent information is, or soon will be available as detailed above. Re-analysis of the status of the stock(s) based on this new information may yield conclusions which are substantially different from those generated by the existing analysis. Division of the population into two stocks may be particularly significant in this regard.

The Gulf and South Atlantic Fishery Management Councils should consider the management implications of a re-assessment of the condition of the king mackerel stock(s) as soon as possible after the re-assessment becomes available. Separate management of the two stocks may need to be considered, provided the new assessment demonstrates that such an approach is valid.

GROUNDFISH

As defined for this Workshop, groundfish are sciaenid species that occur abundantly in the FCZ and other fish species that have similar life-history characteristics or share the offshore habitat of these sciaenids. Most of this group of fishes are estuarine dependent but spawn offshore. The Workshop definition is consistent with the fishery management plan recently prepared for groundfish in the Gulf of Mexico (GMFMC 1980a). Table GCP-4 lists the species specifically covered by the Draft FMP. The Groundfish Working Group concentrated on Atlantic croaker (*Micropogonias undulatus*), which makes up the major portion of the biomass of this group and is the most important species in commercial and recreational fisheries. Primary attention of the Groundfish Working Group was given to the Gulf of Mexico because of the existence of the Draft FMP for that area. However, many of the same species or their conspecifics or congeners are the basis of important local fisheries in the South Atlantic, and there is some interest in developing state-federal cooperation in research on these species in this area. Two papers concerning North Carolina groundfish fisheries were submitted to the Workshop (SAW/82/GCP/5 and SAW/82/GCP/7). North Carolina fisheries are somewhat representative of the southeast coast as a whole because most of the landings of these species on the southeast coast come from North Carolina.

I. DESCRIPTION OF FISHERY

I.1. Gulf of Mexico

Groundfish support both commercial and recreational fisheries in the Gulf of Mexico. In addition, there is a large bycatch of groundfish by the shrimp fishery, most of which is discarded.

I.1.1. Commercial Fisheries

In the Gulf of Mexico, groundfish species harvested by directed fisheries or as the bycatch of shrimp vessels have been marketed as fresh food fish, frozen animal food, fish meal, canned petfood, minced fish, and surimi, a fish paste used in making a sausage sold to domestic oriental markets (SAW/82/GCP/4). Only the petfood, surimi, and fresh food fish industries are currently active in the Gulf.

Double-rigged steel trawlers 23 to 44 meters in length land fish specifically for the petfood industry. Shrimp vessels equipped with heavy-duty rigging harvest fish for fresh fish markets on a regular basis. Other shrimp vessels with no special rigging sometimes sell their larger fish. Only the larger individuals can be marketed fresh, and the preferred species is croaker.

Commercial groundfish fisheries are concentrated in the north-central Gulf of Mexico. The petfood canneries are located in Mississippi, the surimi plant is located in Alabama, and Alabama is the major producer of fresh croaker. A small gillnet fishery for croaker and other sciaenids exists in Pensacola, Florida (GMFMC 1980). Eleven vessels are currently operating in the petfood fleet (H. Hague, National Marine Fisheries Service, Pascagoula, Mississippi, personal communication). Gutherz et al. (1975) reported 12 shrimp vessels equipped with heavy-duty rigging in 1973. Griffin and Warren (1978) reported that at least 160 shrimp vessels out of Bayou La Batre sometimes landed croaker in 1978.

Landings of combined species for the petfood industry from 1952 through 1977 are shown in Figure GCP-1. (Landings since 1977 could not be plotted on the graph due to rules governing confidentiality of data.) Petfood landings fluctuated around about 45,000 metric tons from 1967 through 1976 and reached a high of approximately 47,700 in 1974, but have been below 34,000 mt every year since then.

Croaker food fish landings for Alabama, Mississippi, and Louisiana are given in Table GCP-5. On the average, 89 percent of the croaker landings of these three states that go to the fresh fish market come from Alabama. Landings of the three states reached a high of 6,365 mt in 1973 and fell to a low of 1,339 mt in 1978. They climbed to 4,320 mt in 1979 and exceeded 5,000 mt in 1980 and 1981 (Table GCP-5). Fish supplied to the surimi plant in Bayou La Batre, Alabama, are included in these landings. Average prices of food croaker vary greatly from year to year and may be influenced by prices outside the Gulf. Effort in this fishery probably also varies considerably due to the involvement of shrimp vessels. Some of the croaker goes to markets for fresh fish in the southeast (Austin et al. 1978).

I.1.2. Recreational Fishery

Croaker is an important recreational species in inshore and offshore waters of the Gulf of Mexico. One reason for its popularity inshore is that croaker can be caught from bridges, piers, and jetties, as well as from boats. Offshore, croaker is becoming an increasingly important target of charter vessels fishing off oil rigs, where individuals several pounds in weight can be found. The 1970 recreational catch of croaker was estimated as 62,790 mt (Table GCP-6). Estimates for 1979 and 1980 are not yet available. Spot and sand and silver sea-trouts are also caught recreationally in the Gulf of Mexico. Two other highly sought after sciaenids in the Gulf of Mexico are spotted seatrout (Cynoscion nebulosus) and red drum (Sciaenops ocellata).

I.1.3. Discards

The discards of shrimp fisheries amounted to approximately 83 percent of the average annual catch of groundfish in the area of the Gulf of Mexico from Perdido Bay, Florida, to Point Au Fer, Louisiana (87.5-91.5°NW), from 1973 through 1976 (GMFMC 1980). The fish/shrimp ratio can vary considerably, as can the proportion of fish that is croaker. The ratio, by weight, of fish to shrimp in the catch of shrimp trawls averaged 5.6 to 1 in Texas and 14.5 to 1 in Louisiana in the multi-year survey (Pellegrin 1982). In the Perdido Bay-Point Au Fer area, the fish-shrimp ratio was more than twice as great for vessels catching brown shrimp, which trawl at night, than for vessels catching white shrimp, which trawl during the daytime (GMFMC 1980b). In that area, the fish-shrimp ratio was 3.26 times higher offshore than in inshore waters (GMFMC 1980b). Croaker account for 53 percent of the offshore discards and 27 percent of the discards in inside waters (GMFMC 1980b). Croaker caught inshore were smaller; the average weight of croaker discards caught offshore is 2.9 larger than that caught inshore. The number of croaker killed in shrimp trawls was approximately three times as great inshore as offshore (GMFMC 1980b).

I.2. North Carolina

I.2.1. Commercial Fisheries

In North Carolina, groundfish marketed as food fish are taken by several fisheries, including long-haul seine and pound-net fisheries in Pamlico Sound (SAW/82/GCP/5 and SAW/82/GCP/7) and winter fish trawl and sinking gillnet fisheries in nearshore Atlantic waters. Croaker, spot, and weakfish are the target species of the long-haul seine, sinking gillnet, and winter trawl fisheries. Landings of croaker in North Carolina rose steadily through the 1970's to a peak of 9,526 mt in 1980 (Table 2). Landings dropped sharply in 1981 to about 4,990 mt and have remained depressed in 1982. The greatest drop occurred in the offshore winter trawl fishery. Landings of weakfish in North Carolina have also risen steadily in the last decade to a high of 9,208 mt in 1980, although they dropped to 7,666 mt in 1981. About 70 percent of this species was taken in the offshore winter trawl fishery. Spot landings have varied from 1,588 mt to 3,311 mt from 1978 to 1981 (North Carolina Tar Heel Coast, March, 1982).

Most of the fresh fish harvested in North Carolina goes to east coast markets. Croaker, the favored species, has traditionally been a more important food fish on the east coast than in the Gulf of Mexico (Austin et al. 1978).

I.2.2. Discards

Large amounts of groundfish too small to sell as food fish are taken by the long-haul seine, pound net, fish trawl, and, particularly, the estuarine shrimp fisheries. Most of the small fish taken by the long haul, pound net, and fish trawl fisheries is thought to be frozen for crab pot bait, while that taken by the shrimp fishery is almost all discarded (D. DeVries, North Carolina Department of Natural Resources and Community Development, personal communication). The ratio of fish discards to shrimp is approximately 5.4 to 1 (Wolff 1972). The magnitude of this discard is probably quite variable because it is directly related to the amount of effort in the shrimp fishery, which varies depending upon the abundance of shrimp.

II. STOCK STRUCTURE

II.1. Gulf of Mexico

The groundfish group is made up of two assemblages of fish that overlap in range (Chittenden and McEachran 1976). The first, which includes the sciaenids, occurs nearer to shore and is made up primarily of estuarine-dependent species. The second extends farther offshore and contains few, if any, estuarine-dependent species. Many of the species in these assemblages reach their greatest biomass in the north-central Gulf, near the Mississippi Delta (GMFMC 1980b). The total biomass of fish susceptible to bottom trawls is greatest in the north-central Gulf (87.5-91.5°NW) (GMFMC 1980b). Roithmayr (1965a) found 170 species in the landings of the petfood industry, but six species predominate in the biomass of the north-central Gulf region: croaker, spot, sand seatrout, silver seatrout, cutlassfish, and sea catfish.

There is no evidence for more than one population of each species in the Gulf of Mexico, and recent work by M. Chittenden (Texas A & M, personal communication) suggests that, for at least some species, the north-central Gulf may be a major spawning area for fish in the western Gulf, with permanent spawning migrations eastward by fish maturing as they approach age I and eggs transported westward and shoreward by currents that prevail during seasons of peak spawning. Fish older than approximately age I are infrequent in Texas, and relatively more abundant in the north-central Gulf (M. Chittenden, Texas A & M, College Station, personal communication).

Table GCP-7 from SAW/82/GCP/4 ranks fish species according to biomass in regions of the Gulf of Mexico. Atlantic croaker is the dominant species in terms of biomass in both the northwestern and the north-central Gulf. Approximately 50 percent of the trawlable fish biomass in the north-central Gulf is croaker (GMFMC 1980).

II.2. South Atlantic

Population dynamics of these fishes along the southeast Atlantic coast are not clear. However, the available information on many species or genera, such as croaker and sand seatrout and weakfish, suggests similar population dynamics in the Gulf and southeast Atlantic (White and Chittenden 1977, Shlossman and Chittenden 1981). Many species or genera whose ranges traverse the Cape Hatteras area show zoogeographic variation there. Carolinian Province forms show shorter life spans, higher mortality rates, and more rapid turnover of biomass than their conspecifics or congeners in the Mid-Atlantic Bight. There is some evidence for zoogeographic variation in the Atlantic in croaker (White and Chittenden 1977), weakfish (Shlossman and Chittenden 1981), scup (Geoghegan and Chittenden 1982), and butterfish (Murphy and Chittenden, in prep.).

III. STATUS OF STOCKS

With regard to status of stocks, the Working Group concentrated its attention on groundfish in the Gulf of Mexico.

III.1. Population Parameters

Age and growth were discussed by the Working Group only as pertaining to Atlantic croaker. Mortality was discussed for the groundfish group as a whole as well as for croaker specifically.

III.1.1. Mortality Rates

Chittenden (1976) assumed a Z of 3.0 for croaker, based on reported age estimates and data from the northwestern Gulf. As Chittenden (personal communication) has pointed out, this mortality rate may be too high if croaker migrate from the northwestern to the north-central Gulf as they approach age I, as is suggested by his work with several other species.

Klima (1976) estimated an aggregate Z of 0.85 for all the groundfish in the Gulf of Mexico susceptible to bottom trawls. This estimate is based on the difference between fall and winter apparent biomass in the resource surveys described by SAW/82/-

GCP/4. New estimates of Z based on the same method appear in the Background Document for the Draft Groundfish FMP (GMFMC 1980b). They are Z = 2.15 for 1973-74, Z = 1.10 for 1974-75, and Z = 0.92 for 1975-76. Estimates of Z based on differences in biomass might be expected to be underestimates, because a given amount of biomass will be represented by a fewer number of fish as the fish grow.

In the Background Document for the Draft Groundfish FMP (GMFMC 1980b), a fishing mortality (F) of 0.8 was calculated for groundfish as a whole on the basis of (1) 1973-74 and 1974-75 Z's, (2) discard weight, estimated from fish/shrimp ratios, and (3) landings data from the petfood and fresh fish fisheries. The F included mortality from shrimping effort, petfood effort, fresh fish effort, and recreational effort. If Z were 1.10, then M would be 0.3. Other data in the Plan that became available after the mortality estimates were made suggest that $F_{(\text{sport fish})}$ was underestimated; it should be at least ten times greater than $F_{(\text{fresh fish})}$, rather than only twice as great. The revised estimate would make total F equal to 0.95 and M equal to 0.15. An M of 0.15 or even 0.3 may be too low for croaker, if this species lives only a few years (a precise estimate of maximum age in croaker awaits ageing of large croaker). Estimates of both fish discards and recreational catch are so inadequate that no great reliance should be placed on any of these figures.

III.1.2. Growth Estimates

The various size-at-age estimates that have been made for croaker in the Gulf of Mexico are given in Table 5 from GMFMC (1980b). Analytical methods differed in detail but most were based on time series of length-frequency distributions. Results by White and Chittenden (1977) were based on growth increments on scales from fish collected during several times of the year and on seasonality of gonadal development, as well as on length-frequency distributions. The fish examined by White and Chittenden were collected near Freeport, Texas, and Lake Calcasieu, Louisiana. B. Rohr's (National Marine Fisheries Service, Pascagoula, Mississippi, personal communication) data came from the resource survey described by SAW/82/GCP/4. Roithmayr's (1965) data were from landings for the petfood industry. Herke's (1971; see also 1977) estimate was based on (1) length-frequency analysis, compensating for the effects of emigration and susceptibility to capture, (2) length at which spawning apparently occurs in nature, and (3) length reached by croaker in a coastal pond over a period of about ten months, at which time they were sexually mature. The estimate by Warren et al. (1978) was based on collections from Mississippi Sound and adjacent embayments and covered only the first year of life. Knudsen and Herke (1978) reported daily growth rates of 0.64-1.24 mm TL in early-juvenile croaker in marshes, based on marking studies with fluorescent pigments.

In the Background Document for the Draft Groundfish FMP (GMFMC 1980b), Roithmayr's estimate was referred to as the "slow growth hypothesis", Herke's as the "fast growth hypothesis", and that by White and Chittenden, B. Rohr, and Warren et al. (1978) as the "moderate growth hypothesis". The latter hypothesis was thought to be the most reliable. In the Background Document (GMFMC 1980b), the moderate-growth estimates were used to calculate the following values for the von Bertalanffy growth equation: $L_\infty = 552$, $K = 0.38$, and $t_0 = -0.01$.

Based on a literature review of age and growth work on spot, sand seatrout, and silver seatrout, Barger and Williams (1980) concluded that analysis of length-frequency distributions is a poor method for determining age and rate of growth in spot or any species of fish with differential growth rates and a protracted spawning season. Hardpart analysis was recommended as the "technique of choice" for age and growth work with spot. In the opinion of M. Chittenden (personal communication), the analysis of length-frequency distributions is a valid method for estimating age-at-size in croaker. His opinion is based on preliminary analysis of length-frequency distributions of about 250,000 croaker collected in the northwestern Gulf of Mexico throughout all seasons over almost a four-year period. Estimates based on these data appear to confirm the earlier estimates of White and Chittenden (1977). According to Chittenden (personal communication), croaker (in Texas) appear to have one distinct spawning period.

Barger and Johnson (undated) compared percent agreement between two independent investigators in identifying growth marks on croaker, spot, sand seatrout, and silver seatrout. They found the highest percent of agreement with otoliths (over 85 percent), which were recommended over scales (less than 80 percent) and vertebrae (less than 70 percent) for ageing work with these species. With regard to White and Chittenden's (1977) evidence that scale marks were valid indicators of age in croaker, Barger and Johnson (undated) noted that scales from their own samples (which came from the north-central Gulf of Mexico) were not as well defined as those illustrated in the White and Chittenden (1977) paper (White and Chittenden's samples came from the northwestern Gulf of Mexico).

The Barger and Johnson (undated) report presented some evidence that the opaque marks on otoliths of the four species were laid down annually. In a follow-up study, using fish of several sizes collected from the north-central Gulf of Mexico area during each of thirteen consecutive months, Barger and associates are developing additional evidence that the opaque marks on otoliths of these sciaenids are annual rings and can, therefore, be used for ageing.

III.2. Catch Per Unit Effort Trends

Both the landings and the catch per unit effort of the pet-food fishery declined from 1975 through 1977 (Figure GCP-1). Landings continued to decline through 1979 but rose slightly in 1980 and 1981. (Landings after 1977 cannot be shown due to confidentiality of data.) The period of record for croaker CPUE indicate two cycles with a decreasing amplitude. The CPUE data are from the Background Document for the Draft Groundfish FMP (GMFMC 1980b). They are based on landings and effort data for a representative segment of the petfood fleet that were followed through time. No CPUE data are available after 1977. The landings of food fish croaker were extremely low in 1978, despite the fact that ex-vessel prices reached a record high that year. Landings greatly improved in 1979, 1980, and 1981. According to the National Marine Fisheries Service port agent in Pascagoula, Mississippi (H. Hague, personal communication), catch rates in the petfood fishery have been "down" for the past several years. Vessels fishing for food croaker also have experienced declining catch rates, as well as a lack of large fish (R. Raulerson, National Marine Fisheries Service, St. Petersburg, Florida, personal communication). Declining catch rates for the food fish fleet are not reflected in landings since 1979, however increased landings after 1978 may be due to a larger percentage of large croaker being landed by shrimpers, rather than being discarded.

III.3. Stock Assessment Analyses

III.3.1. Production Model Analysis

A surplus production model for groundfish as a whole was prepared for the Background Document of the Draft Groundfish FMP (GMFMC 1980b). Data on catch per unit effort, landings, and effort were necessary to construct the model. CPUE was that of the petfood fleet, available for eight years (1969-1976). Landings were the total landings of the petfood fleet and the food-fish fleet plus discards, estimated by multiplying total shrimp landings for each year by a constant fish/shrimp ratio, calculated as the average of five years of data. Effort was total landings of the petfood fleet, the food-fish fleet, and the shrimp fleet, calculated as described above, divided by the CPUE of the petfood fleet. The MSY predicted by this model was 486,000 metric tons per year for 362,900 hours of effort.

The validity of the above model is questionable due to the use of a constant fish/shrimp ratio. Unfortunately, data on fish/shrimp ratios were not distributed in space and time in a manner that would adequately reflect the distribution of shrimping effort. For this reason, the resolution of data did not allow an annual breakdown. Furthermore, data on fish/shrimp ratios were available for only five years. Using a different fish/shrimp ratio each year would mean that the time series for calculating surplus production would be only five years long. Because of the problem of calculating surplus production with these data, alternative approaches were investigated in preparation for the Stock Assessment Workshop. A preliminary analysis of other time series data relevant to constructing surplus production models was made. Four time series of data were examined for their relationship with each other by means of simple linear regression. These were:

Statistic	Units	Period Years
Annual average CPUE of petfood fleet	mt/1000 hr	1967-1977 - 9
Fall croaker relative biomass from the resource surveys	mt/ha	1972-1981 - 10
Fall groundfish relative biomass from the resource surveys	mt/ha	1972-1981 - 10
Shrimp effort (brown and corrected white)	1000 days/yr	1969-1981 - 14

Shrimping effort rather than effort directed at groundfish was used in the regressions, because the discards of the shrimp fishery account for 80 percent or more of groundfish landings. Since the fish/shrimp ratio of vessels catching brown shrimp is approximately 2.67 times greater than that of vessels catching white shrimp, white shrimp effort was multiplied by 0.38 before summing the effort toward the two shrimp species. (One possible reason for the difference in groundfish catchability of vessels directing effort at the two species of shrimp is that vessels fishing for white shrimp always trawl in daytime, while vessels trawling for brown shrimp often trawl at night. Distribution of the vessels on the grounds is also somewhat different; some of the trawling for brown shrimp occurs farther offshore.) Groundfish effort was not added to shrimping effort, because catchability of directed vessels probably is different from that of vessels making a catch incidentally; therefore these two types of effort would not be additive, and the data were not available for the preliminary analysis to determine the relationship between the two.

Each data series was regressed with the other. Values for statistical parameters from the regressions are given in Table GCP-8. Only one relationship was statistically significant at alpha < 0.05. This was the relationship between groundfish relative-biomass and croaker relative-biomass. The coefficient of determination (R^2) was 0.82, indicating that 82 percent of the variation in groundfish biomass could be explained by variation in croaker biomass. Surprisingly, petfood CPUE showed no relationship with either groundfish relative-biomass or croaker relative-biomass, although fishery CPUE is usually considered to be an index of biomass. Scattergrams of relative-biomass versus shrimping effort for 1972 through 1981 are given in Fig. GCP-2. If there is any relationship between relative biomass of croaker and shrimping effort, then it is being confounded by other influencing factors. Further work with the data may uncover information that is not apparent from the preliminary analysis. No reasonable surplus production curve could be calculated from data based on croaker relative-biomass and shrimping effort.

III.3.2. Yield Per Recruit Analysis

A yield per recruit model for croaker was prepared for the Background Document of the Draft Groundfish FMP (GMFMC 1980b). An assumed natural mortality (M) of 0.3 and a growth function derived from the "moderate" growth estimates in Table GCP-9 were used in the model. Conclusions from the model were that current fishing mortality (including discard mortality) appeared to be higher than that which would result in maximum yield per recruit. An underestimate of M would lead to yield-per-recruit results indicating a greater sensitivity to fishing than is actually the case.

III.3.3. Recruitment Indices

Mississippi Sound and its embayments serve as nursery grounds for croaker and other groundfish species. The Gulf Coast Research Laboratory (GCRL) has been operating a monitoring program for croaker and several other groundfish species in this area continuously since October 1973, except for three months - October, November, and December - of 1976. Data through May 1981 were available to the Working Group.

Because of the seasonality of recruitment of postlarvae into inshore waters, samples collected in January through May contain primarily individuals smaller than 60 mm SL, while those collected June through September contain primarily individuals over 60 mm SL. The total number of croaker during each of these time periods for October 1973 through May 1981 are shown in Table GCP-10. (Since data for October, November, and December, 1976, were missing, these three months were not included in consideration so that totals for all years would be comparable. Relatively few individuals are collected during October through December, compared to the other months.) Individuals in samples collected January through May are more likely to have recently entered the estuary, while those collected from June through September are more likely to be moving offshore shortly. The former should more nearly represent spawning activity, while the latter, as pre-recruits, should more nearly indicate the level of recruitment. This separation is not as unequivocal as one might like, however, because, by this separation, there appear to be more pre-recruits than early juveniles in 1973-74 and 1980-81.

The data in Table GCP-10 seem to indicate a particularly strong year class in 1977-78. Extremely poor year classes appear to have occurred in 1976-77, 1978-79, and 1980-81. The data from Mississippi Sound do not suggest that either the entry of early juveniles into the Sound or the production of recruits in the Sound are declining over time. The importance of Mississippi Sound to croaker recruitment relative to other large estuaries east of the Mississippi Delta, such as Lake Borgne and Chandeleur Bay, is not known.

Data on the abundance of juvenile croaker in these other areas has been collected by the Louisiana Department of Wildlife and Fisheries but has not been analyzed. The National Marine Fisheries Service is currently cooperating with Louisiana Wildlife and Fisheries in preparing these data for analysis.

III.3.4. Other Fishery Indicators

III.3.4.1. Fishery Independent Surveys

According to resource survey data, a general decline in total fish biomass and the biomass of croaker is indicated in resource survey data for 1972 through 1981 (Fig. GCP-3) (SAW/82/GCP/4). Croaker biomass appears to have declined by about one-half in the ten year period. A decline in the number of croaker is also suggested (Fig. GCP-3), as is a decline in the number of spot, sand and silver seatrout (combined), cutlassfish, and sea catfish (Fig. GCP-4) (SAW/82/GCP/4). However, the downward trend in number is significant (alpha $\leq$ 0.1) only for the seatrouts. Butterfish and longspine porgy may be increasing in number, but no statistically significant trend was noted. A highly significant (alpha $\leq$ 0.01) downward trend in average size of croaker has occurred.

III.3.4.2. Ecosystem Considerations

Groundfish are a major component of the nearshore marine ecosystem of the north-central Gulf of Mexico, a system that includes penaeid shrimp, menhaden, the mackerels, and many species that are not the target of fisheries. The trophic groups of this system are linked by predator-prey relationships, competition, and mineral cycling. These trophic groups may be interdependent so that changes in the biomass of one may affect the others. SAW/82/GCP/6 used an ecosystem model (Fig. GCP-5) to determine how a change in the rate of catching or discarding groundfish could influence the biomasses of other trophic groups, including shrimp. The imposed change cascaded through the system, and effects of the change on shrimp and other groups occurred through direct and indirect pathways.

In preliminary work, the model was used to test the possible effect on shrimp biomass of the management measures proposed in the Draft Groundfish Fishery Management Plan (GMFMC 1980a). In model simulations, utilization of 50 percent of the bycatch resulted in a reduction in shrimp biomass of approximately one-third due to loss of nitrogen and organic material from the system in fish landings. When discards were reduced by approximately 50 percent through the use of selective trawls, shrimp biomass decreased initially but rebounded to former levels within two years. The immediate decline was due to competition with groundfish for common food. The recovery was due to an increase in production of food available to shrimp as well as groundfish, caused by re-adjustment of the system to higher levels of groundfish biomass. Simulation results of the two tests are shown in Fig. GCP-6 and GCP-7.

Model results are highly theoretical at this point, but do suggest the responses of the system that might be possible with a change in the rate of catching or discarding groundfish. Results suggest that the system would respond to any substantial change in the biomass of groundfish.

Many of the values used to quantify the model were crude approximations. Results are highly preliminary and should not be uncritically applied to the real world before the model is subjected to additional sensitivity testing and further refinement of input data.

III.4. Current Status

On the basis of resource survey data showing trends in croaker biomass, number, and average size, the Working Group concluded that croaker has been declining for at least ten years in the area of its maximum concentration, the north-central Gulf. Both biomass and mean average weight have been reduced by about one-half in the ten-year period. Since biomass was probably not at its original (pre-fishing pressure) level ten years ago, current biomass is less than one-half the "virgin" biomass. There is some evidence from resource survey data that spot, sand seatrout, silver seatrout, sea catfish, and Atlantic cutlassfish are also declining in this area. Because of the dominance of these species in the biomass, total bottomfish biomass of the north-central Gulf also shows a decline. There is not sufficient information at this time to determine whether groundfish as a whole or any one species of groundfish is in imminent danger of collapsing.

Two causes of the decline have been suggested: fishing pressure from shrimp trawlers and changing environmental conditions. It is possible that both could be contributing factors. Thus far, there is no statistical evidence for a relationship between groundfish biomass and fishing pressure from shrimp trawling.

Work by Norcross (1981) in Chesapeake Bay relates fluctuations in croaker recruitment to temperature in that area, which is near the northern part of the range of this species. A preliminary analysis by G. Turner (Louisiana State University, personal communication) suggests that variations in total groundfish biomass in the north-central Gulf of Mexico could be connected to variation in estuarine salinity and temperature. This is the only information we have at present that could link variations in croaker biomass to environmental variables.

IV. EFFECTS OF CURRENT REGULATIONS

IV.1. Existing Regulations

Gulf coast states have several laws restricting trawls and other gear in inland waters that could affect the fishing mortality of juvenile groundfish in estuaries. These include minimum mesh sizes on trawls in some Texas counties, prohibition of the use of double rigs and maximum cork-line and lead-line lengths on trawls in Mississippi inside waters, prohibition of unattended gill nets in Mississippi waters, and area and/or seasonal closures in most states. These laws undoubtedly reduce the mortality of juvenile fish in estuaries, but their effectiveness has not been evaluated.

IV.2. Proposed Management Measures

The Draft FMP for the Gulf of Mexico (GMFMC 1980a) proposed that efforts be made to reduce the discard of groundfish by shrimp trawlers through development and introduction of selective gear. Reducing discards by promoting or facilitating greater utilization of the bycatch was also considered by the Council but rejected. The Draft FMP was submitted by the Council to the National Marine Fisheries Service (NMFS) for review, and public hearings were held in early 1980. Based on comments by NMFS and testimony at the public hearings, the Council decided not to take further action to implement the Plan at that time. The future of the Draft FMP for groundfish is uncertain. It may be submitted to Washington, in revised or present form, at some later date.

V.1. Data Needs

Effort data from the groundfish petfood fleet were collected from 1967 through mid 1978, but have not been collected since then. Catch per unit effort declined greatly in 1977. However, we have no quantitative information to determine what happened since then. Fish/shrimp ratios from which to compute the weight of fish discards from shrimp landings have been measured only sporadically since 1978 and probably do not provide adequate coverage in time and space within years to allow rigorous between-year comparisons or analysis based on a time series. Since discards appear to make up at least 90 percent of the total catch of groundfish, it is essential to obtain an annual estimate of discards.

Regarding future monitoring of catch and effort, the Working Group made four recommendations:

(1) An analysis should be performed to determine why petfood fishery CPUE and relative biomass from the resource survey are not correlated. The analyst might try lagging the data to determine whether the two parameters could apply to different age groups. The usefulness of fishery CPUE data in monitoring the condition of the groundfish stock should be evaluated on the basis of this analysis.

(2) If the analysis suggested above indicates that petfood fishery CPUE would be a useful means of monitoring the status of the stocks, then the feasibility of reinstituting a logbook system on full-time groundfish vessels to collect catch and effort data should be considered. It should be relatively cost-effective to conduct a continuous monitoring program, because there are only eleven permanent vessels operating, and they all operate out of only two plants, both in Mississippi.

(3) Develop an analytical method to estimate annual fish discards from shrimp landings data, using the fish/shrimp ratio from NMFS resource surveys.

(4) If a reliable analytical method cannot be developed, consider instituting an observer program designed specifically to obtain fish/shrimp ratios that are representative of the distribution, in space and time, of shrimp trawling.

V.2. Research

Research and data needs for bottomfish assessment and management fall into six broad categories: (1) improving estimates of population parameters, (2) developing practical and effective methods to continuously monitor catch and effort, (3) exploring the implications of ecological interactions of groundfish in the ecosystem, (4) determining environmental influences on the biomass of croaker and other species, (5) defining biological stocks of croaker and other species and their principal spawning areas and nursery grounds, and (6) improving fishery-independent monitoring of status of stocks.

V.2.1. Population Parameters

The inadequacy of estimates on basic population parameters, such as age at size, natural mortality, and fishing mortality for croaker and other species was pointed out in the Background Document for the Draft Groundfish FMP (GMFMC 1980b). As indicated in Section III.1.2 of this report, work to improve age-at-size estimates is in progress at the Panama City Laboratory of the Southeast Fisheries Center. Further work on both age-at-size and mortality were recommended by the Working Group.

V.2.1.1. Age at Size

The Working Group recommended that the work at the Panama City Laboratory be continued to the point where age-at-size estimates are made for all four species of sciaenids from the north-central Gulf. Ageing of these species by means of otolith analysis should also be performed on samples from the northwestern Gulf of Mexico. Length-frequency analysis by M. Chittenden of a large number of samples of sciaenids and other groundfish species collected from the northwestern Gulf over almost a four-year period should be completed. Age-at-size estimates using the different techniques should be compared. The ages-at-size and maximum ages of these species in the north-central and northwestern Gulf should be compared to determine whether growth rates differ in the two areas and whether individuals of each species move toward the north-central Gulf as they reach sexual maturity. The Group also suggested that some attempt be made to determine whether the higher growth rates reported for croaker from impounded marsh areas of Louisiana are due to a difference in estimation technique or a reflection of the influence of habitat. The Working Group suggested that comparisons be made between otolith annuli of marked croaker grown in impoundments and otolith annuli of croaker of similar size collected outside marshes at approximately the same time. The growth of croaker in impoundments should be followed beyond the period of maximum growth. The feasibility of tagging and injecting with tetracycline mature croaker (as indicated by gonadal development) collected from impoundments should be explored as a means of validating growth rates after about age I.

V.2.1.2. Mortality

Two possible approaches to improving mortality estimates were suggested:

(1) Aggregate Z's could be estimated on the basis of difference in number of fish rather than difference in biomass of fish between fall and spring resource surveys. Further, a Z specific to croaker could be estimated by splitting number of croaker of the total number of fish from the resource surveys.

(2) Species-specific estimates of Z could be obtained from length-frequency distributions in resource survey data. Z's calculated for several years might be used to estimate M.

V.2.3. Stock Assessment Analysis

No stock assessment analysis of groundfish has been performed since the Background Document for the Draft FMP (GMFMC 1980b) was prepared, around 1978. Although no new information on population parameters or industrial CPUE has become available since then, resource surveys have continued to be conducted semi-annually and now provide ten years of data on relative biomass, number, size, and species composition, by weight. The Working Group recommended that questions raised by the preliminary analysis of time series data be pursued by means of further analytical work. The analysis should include consideration of environmental data.

V.2.4. Ecological Relationships

Research is needed on the relationship between groundfish biomass and magnitude of discards and the abundances of shrimp and other species in the environment. An analysis of resource-survey data for the period of record could be used to determine whether the biomasses of various trophic groups in the nearshore marine habitat have been changing over the past ten years. Such an analysis should be continuously updated as new data become available in order to assess the effect of new gear such as shrimp trawls that select against fish.

V.2.5. Environmental Influences

Needs for environmental research relevant to groundfish fall into two categories. The first is to determine whether environmental influences are responsible for changes in the relative biomass of croaker or the relative biomass of groundfish as a whole over the past ten years. The second is to determine the relative importance of different inshore waters to recruitment of croaker and other groundfish species to offshore waters. It would be particularly useful to know the importance of Mississippi Sound, relative to Lake Borgne, Chandeleur Bay, and Lake Pontchartrain, to recruitment to grounds east of the Mississippi Delta, since we have a good time series of data on juvenile abundances in Mississippi Sound. The relative importance of estuaries west of the Delta would also be worthwhile knowing, as would be some knowledge of whether estuaries on one side of the Delta contribute recruits to offshore waters on the other side. A further question is whether estuaries in Louisiana contribute recruits to the offshore waters of Texas.

Regression analyses and ecosystem models were suggested as means of exploring effects of environmental variables on biomasses of croaker and other groundfish. Time series on abundance of juveniles in Louisiana estuaries could be developed from Department of Wildlife and Fisheries data that have been col-lected since the 1960's. Time series of environmental conditions in estuaries also could be compiled from these data for use in regression analyses and models.

Regression analysis could also be used to compare time series of data on inshore and offshore abundances of croaker. Tagging, parasite, and electrophoretic work were suggested as other possible means of relating juveniles from specific estuaries to offshore groups of croaker. The possible usefulness of these and other means of addressing the questions posed should be explored.

V.2.6. Definition of Stocks

We need to know whether northwestern Gulf groups of bottom-fish are dependent to any extent on the Mississippi River and areas of the north-central Gulf. Tagging, electrophoretic, parasite, and basic life-history studies were suggested for determining the connection between northwestern and north-central groups of fish. Location of major spawning sites might also help to understand relationships between northwestern and north-central Gulf groups of croaker and other species.

V.2.7. Fishery-Independent Monitoring

At present, the periodic resource surveys cover only the area of the north-central Gulf beyond the 5 fathom line. A considerable portion of the groundfish stock may be found inside the 5 fathom line. The proportion found inside the 5 fathom line could vary from year to year, depending on environmental conditions. This could cause a variation in relative biomass to be reported on the basis of resource surveys that would not reflect the true condition of the stock. Coverage by the resource surveys should be extended inside the 5 fathom line, at least to the barrier islands or their equivalent.

Since groundfish, particularly croaker, appear to be declining in the north-central Gulf of Mexico, the Working Group urged that their status be closely monitored in that area. The importance of continuing the periodic resource surveys of the National Marine Fisheries Service was emphasized. The Working Group also noted that routine, periodic resource surveys of this type could be useful in the south Atlantic. Work to define stocks in the south Atlantic and mid-Atlantic Bights also is needed.

V.3. Management Needs

The Working Group made no management recommendation.

Table GCP-1. King Mackerel (Landings - Thousand Pounds) (Round Weight)

Year	NC	SC	GA	Florida East Coast	South Atlantic	Florida West Coast	ALA	LA	MISS	TX	Total Gulf Coasts	Total Florida Coasts	TOTAL
1970	12			4338		2372						6710	
1971	9	6		2907		2738						5644	
1972	9	1		3489		1378						4867	
1973	26	11		3712		2217						5929	
1974	40	4		4267		6133						10401	
1975	100	8	1	3697	3806	2622	0	0	0	0	2622	6319	6428
1976	154	10	4	4821	4989	2801	0	0	0	0	2801	7622	7790
1977	245	7	4	3236	3492	4950	0	0	0	0	4950	8186	8442
1978	172	13	35	3402	3622	1745	0	0	0	0	1745	5147	5367
1979	382	80	16	2800	3278	1570	0	0	0	0	1570	4370	4848
1980	769	205	14	2936	3924	3092	0	0	0	0	3092	6028	7016
1981	736	134	11	3280	4161	3060	0	0	0	0	3060	6340	7221
1982				2372*		1920*							

* Only available for January-June

Table GCP-2. Foreign Landings of King Mackerel, Thousands of Pounds (ICCAT 1981)

Year	Brazil	Mexico*	Venezuela	Mexico
1975	0	3119	5324	13527
1976	1214	3296	3963	10752
1977	1902	-	3737	12665
1978	1966	-	3047	14711
1979	2015	-	2749	17637
1980	6409	-	3459	15386

* From Mexican scientists communicated to G. Nakamura

Table GCP-3. Parameter estimates of von Bertalanffy growth equation estimated for king mackerel. Fork length in cm; age in years.

L_∞	K	t_0	Area	Source
MALES				
90.3*	0.35	-2.50	South FL	Beaumariage (1972)
96.5	0.28	-1.17	TX, LA, NW FL, SC, and NC	Johnson *et al.* (unpubl.) (1967)
116.0	0.18	-0.22	NE Brazil	Nomura & Rodrigues (1967)
113.3	0.229	-1.50	NE Brazil	Ximenes *et al.* (1978)
FEMALES				
124.3*	0.21	-2.40	South FL	Beaumariage (1973)
106.7	0.29	-0.97	TX, NW FL, SC, and NC	Johnson *et al.* (unpubl.)
152.9	0.14	-2.08	LA	Johnson *et al.* (unpubl.)
137.0	0.15	-0.13	NE Brazil	Nomura & Rodrigues (1964)
131.7	0.164	-2.00	NE Brazil	Ximenes *et al.* (1978)
MALES AND FEMALES, POOLED				
126.6	0.157	-2.63	Gulf & S. Atlantic	Williams & Godcharles (SAW/82/GCP/8)
124.9	0.185	-1.80	NE Brazil	Ximenes *et al.* (1978)
141.2	0.14	-0.14	NE Brazil	Nomura & Rodrigues (1967)

* Converted from Standard Length to Fork Length, FL = 1.09656 - 1.71, from Beaumariage (1973)

Table GCP-4. List of species specifically included in the Gulf of Mexico Draft Groundfish Management Plan, with conspecifics or congeners in the south Atlantic indicated.

GULF OF MEXICO	SOUTH ATLANTIC
Atlantic croaker *Micropogonus undulatus*	
Spot *Leiostomus xanthurus*	
Sand seatrout *Cynoscion arenarius*	Weakfish *Cynoscion regalis*
Atlantic cutlassfish *Trichiurus lepturus*	
Sea catfish *Arius felis*	
Longspine porgy *Stenotomus caprinus*	Scup *Stenotomus chrysops*
Silver perch *Bairdiella chrysura*	
Southern kingfish *Menticirrhus americanus*	
Banded drum *Larimus fasciatus*	
Star drum *Stellifer lanceolatus*	
Southern hake *Urophycis floridanus*	
Gulf butterfish *Peprilus burti*	Butterfish *Peprilus triacanthus*
Harvestfish *Peprilus alepidotus*	

Table GCP-5. Landings, value, and price of Atlantic croaker in Alabama, Mississippi, and Louisiana (combined) and in North Carolina.

Year	Alabama, Mississippi, Louisiana[a,b]			North Carolina[c]		
	Landings (mt)	Value ($1000)	Price ($/kg)[d]	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

[a] Gulf of Mexico Fishery Management Council (1980) (1968-1978)

[b] National Marine Fisheries Service, unpublished statistics (1979-1981)

[c] North Carolina Tar Heel Coast, March 1982

[d] Convert to price per pound by multiplying by 0.4536

Table GCP-6. Recreation catch estimates for Atlantic croaker in the Gulf of Mexico.

Year	Millions of Fish				Total	
	Private Boat	Charter Boat	Bridge & Pier	Shore	Millions of Fish	Thousand Metric Tons
1960[a]						18.97
1965[b]	11.00	0.28	12.75	2.79	26.82	19.45
1970[c]	15.16	18.26	10.56	5.92	49.90	62.79

[a] Clark (1962)

[b] Deuel and Clark (1968)

[c] Deuel (1970)

Table GCP-7. Ranked dominance of principal groundfish species in discards from inshore and offshore shrimp trawlers during summer months[a].

Species	Northwest Gulf	Northcentral Gulf	Northeast Gulf[b]	East Gulf
INSHORE[c]				
Croaker	1	1	2	-
Spot	4	4	1	1
Sand seatrout	2	2	3	-
Silver seatrout	3	9	-	-
Cutlassfish	7	5	-	-
Sea catfish	5	3	5	-
Longspine porgy	-	8	-	-
Silver perch	-	-	6	-
Southern kingfish	6	6	7	2
Banded drum	-	10	-	-
Star drum	9	7	-	-
Southern hake	-	-	-	-
Gulf butterfish	8	11	4	-
Harvestfish	-	-	-	-
OFFSHORE[c]				
Croaker	1	1		-
Spot	6	3		-
Sand seatrout	5	4		-
Silver seatrout	2	5		-
Cutlassfish	-	6		-
Sea catfish	-	8		-
Longspine porgy	4	2		-
Silver perch	-	-		-
Southern kingfish	-	-		-
Banded drum	-	9		-
Star drum	-	-		-
Southern hake	-	-		-
Gulf butterfish	3	7		-
Harvestfish	-	-		-

a From SAW/82/GCP/4

b Pooled summer, winter, inshore and offshore data

c Inshore is less than 10 fathoms; offshore is 10 fathoms or greater

Table GCP-8. Results of regression analyses of time-series data[a] relevant to surplus production models.

Dependent Variable	Mean	Independent Variable	Mean	No.	Intercept	Slope	R^2	F	D.W.[b]
BIOGRO	58.4	BIOCRK	26.1	10	20.7	1.44	.82	38.39	2.02
BIOCRK	26.1	SEFF	64.6	10	48.94	- .35	.15	1.40	0.91
CPUE	28.3	BIOGRO	66.2	6	24.7	.05	.15	0.71	2.16
CPUE	28.3	BIOCRK	31.0	6	28.8	- .02	.006	0.02	2.04
CPUE	26.1	SEFF	59.5	9	- 8.02	.57	.21	1.82	1.08
BIOGRO	58.4	SEFF	64.6	10	91.54	- .51	.12	1.13	1.04

[a] BIOGRO is relative biomass (kg/ha) of groundfish (all species) from resource surveys, 1972-1981.

BIOCRK is relative biomass (kg/ha) of croaker from resource surveys, 1972-1981.

CPUE is annual average catch per unit effort (mt/100 hrs) of petfood fishery, 1969-1977.

SEFF is annual effort toward brown shrimp plus 0.38 times effort toward white shrimp (1000 days) in statistical grids 11-15, 1969-1977 or 1972-1981.

[b] Durbin-Watson statistic

Table GCP-9. Total length (mm) at age of Atlantic croaker, as reported by listed sources[a].

Source	Ages 1	2	3
Roithmayr (1965b)[b]	130	170	210
Rohr (personal communication)[c]	180	263	324
Chittenden (1976)[c]	160	275	-
Warren *et al*. (1978)[c]	178	-	-
Herke (1971)[d]	245	-	-

[a] From the Gulf of Mexico Draft Groundfish Fishery Management Plan (Gulf of Mexico Fishery Management Council 1980).

[b] "Slow" growth hypothesis.

[c] "Moderate" growth hypothesis.

[d] "Fast" growth hypothesis.

Table GCP-10. Number of croaker collected in standardized sampling routine in Mississippi Sound and embayments for the periods January through May (1974-1981) and June through October (1974-1980)[a].

Year Class	January through May	June through September
1973-74	5,406	9,288
1974-75	10,011	2,476
1975-76	12,899	4,512
1976-77	5,649	2,182
1977-78	21,952	20,991
1978-79	3,982	2,666
1979-80	10,142	10,336
1980-81	1,085	1,302

[a] Unpublished data of Gulf Coast Research Laboratory, Ocean Springs, Mississippi (H. Perry, personal communication).

Figure GCP-1. Landings (A) and catch per unit effort (B) of the groundfish petfood fishery for periods of record. (Landings data after 1977 cannot be shown due to confidentiality of data. Catch per unit effort data are not available after 1977.) Catch per unit effort data are from C. Roithmayr (National Marine Fisheries Service, Pascagoula, Mississippi, personal communication).

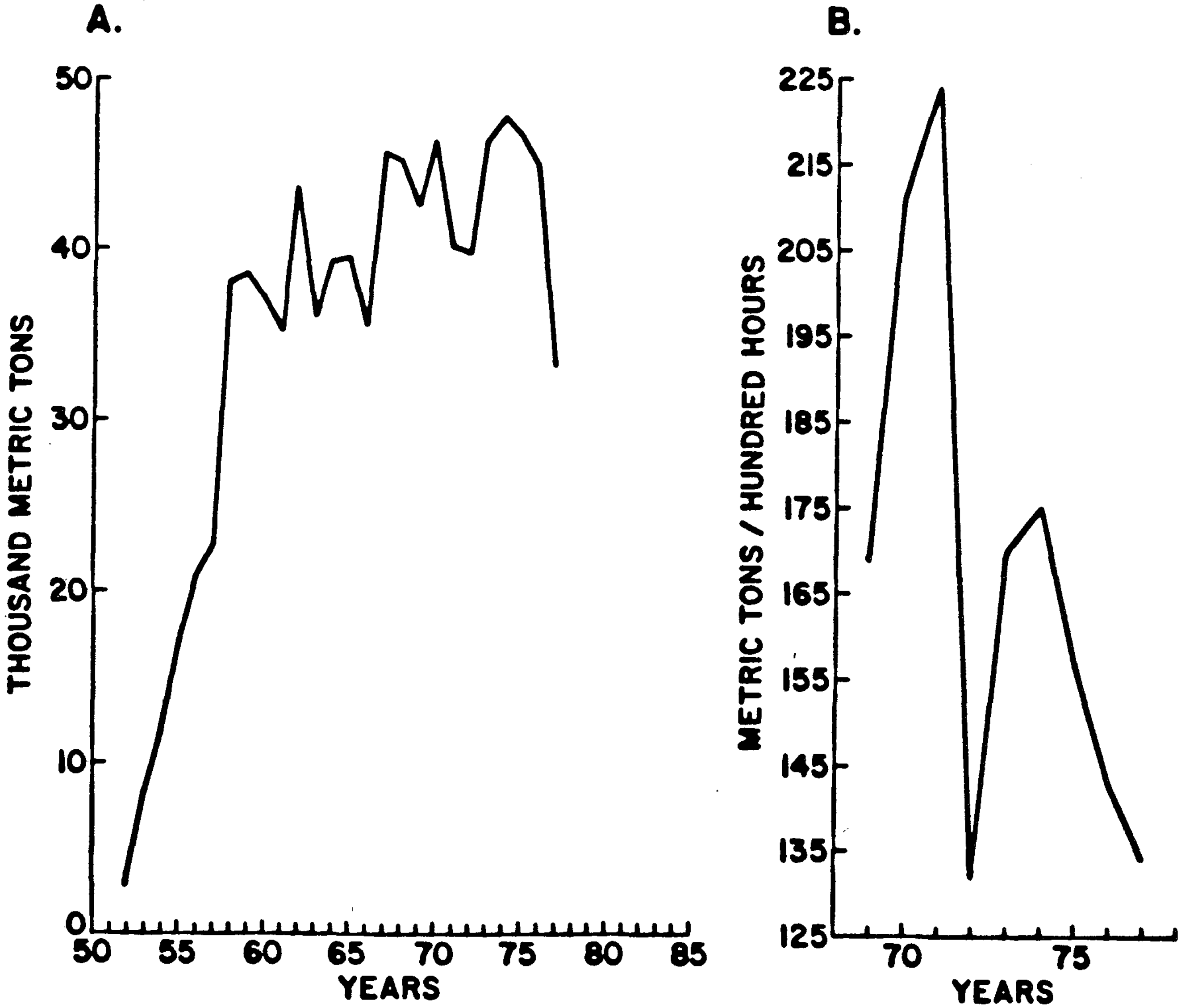


Figure GCP-2. Scattergram of groundfish relative-biomass (A) and croaker relative-biomass (B) from resource survey data (taken from graphs in SAW/82/GCP/4) versus annual adjusted shrimping effort. Adjusted shrimping effort is total annual effort for brown shrimp plus 0.38 times total annual effort for white shrimp in statistical grids 11-15.

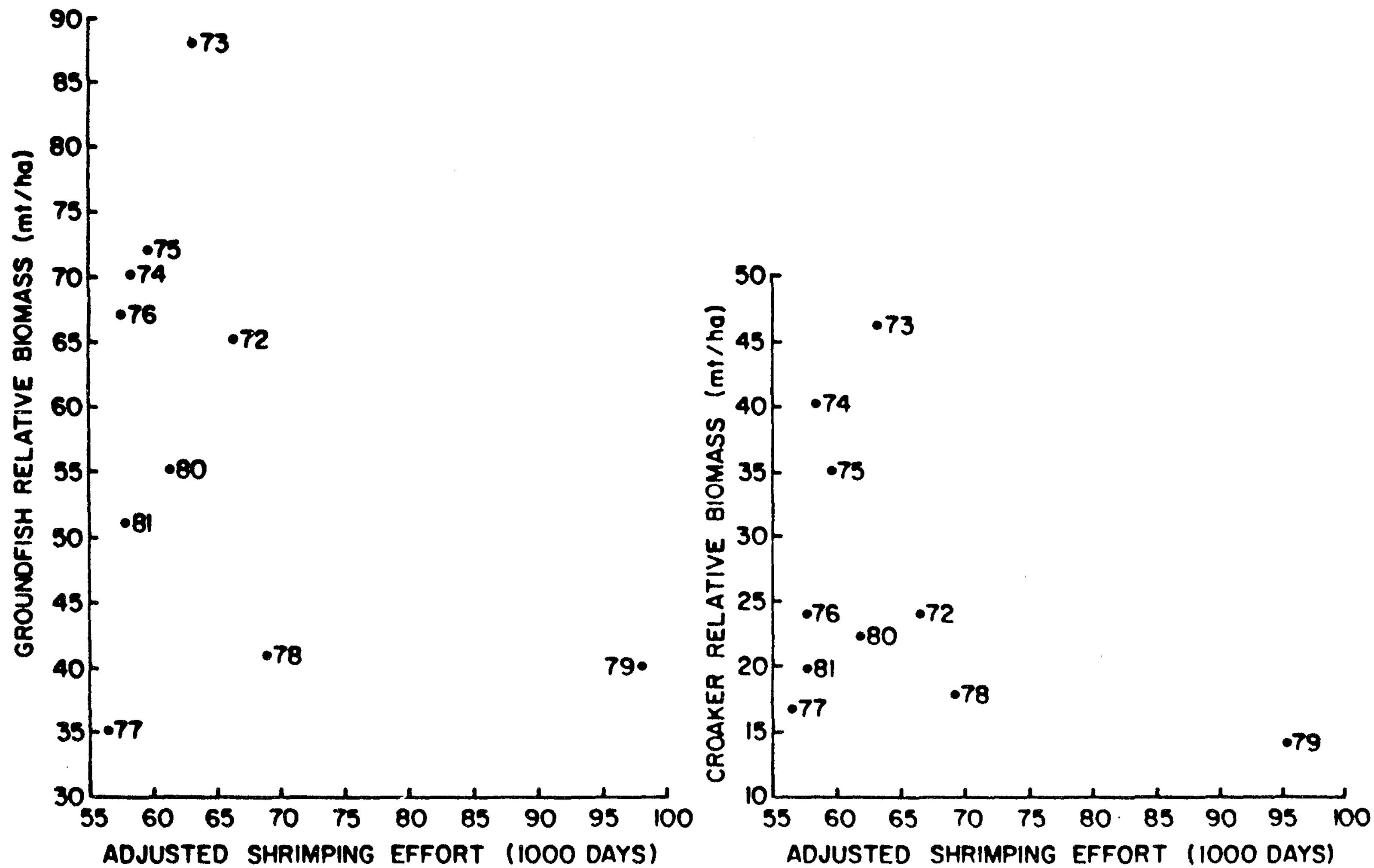


Figure GCP-3. Regression analysis of croaker density, croaker biomass, croaker mean weight, and total fish biomass versus year. Data are from November OREGON II resource survey cruises in the north-central Gulf of Mexico, 1972-1981 (*** indicates alpha < 0.01; ** indicates alpha < 0.05) (from SAW/82/GCP/4).

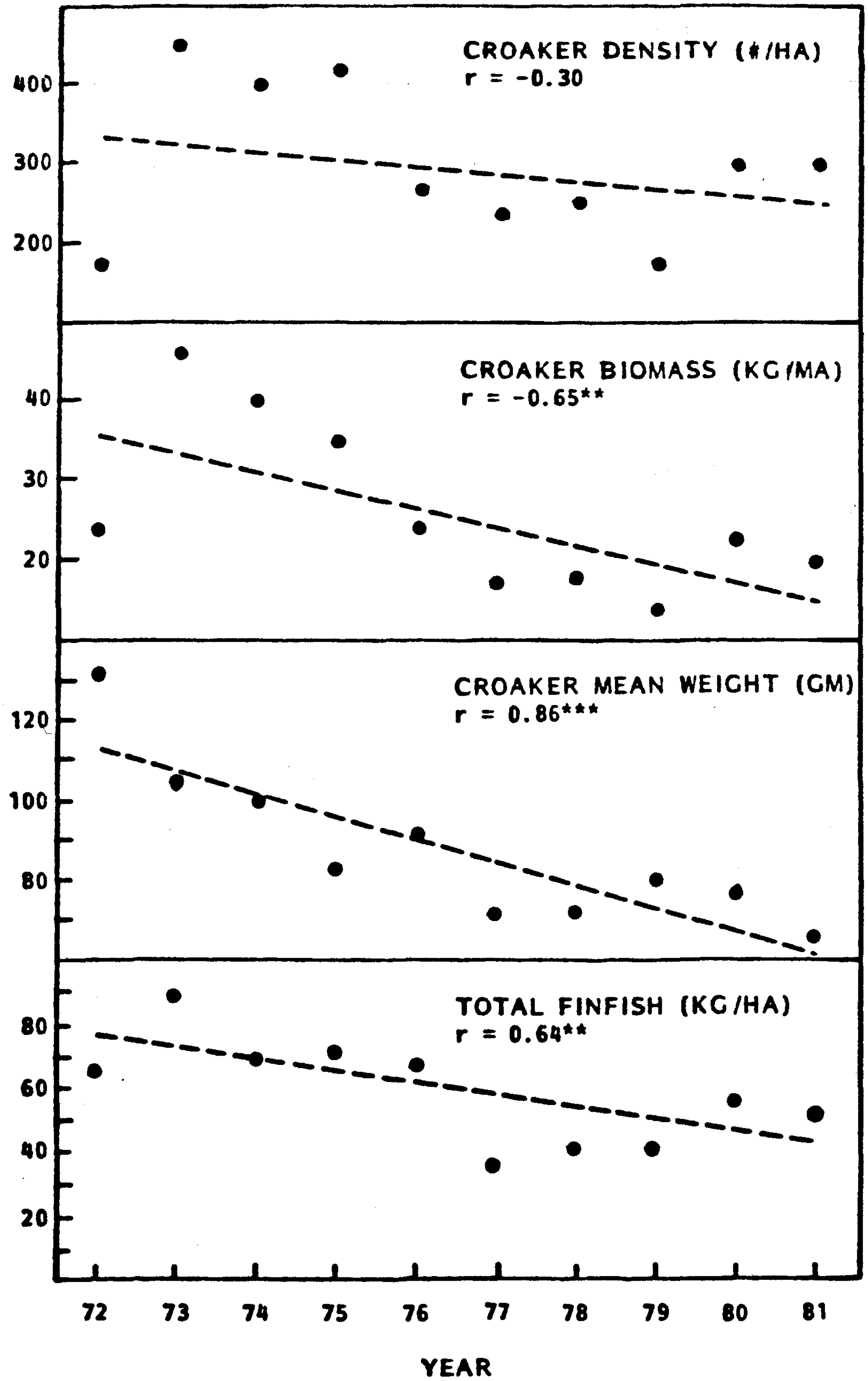


Figure GCP-4. Regression analysis of densities of selected groundfish species versus year. Data are from November OREGON II resource survey cruises in the north-central Gulf of Mexico, 1972-1981. (* indicates alpha ≤ 0.1) (from SAW/82/GCP/4).

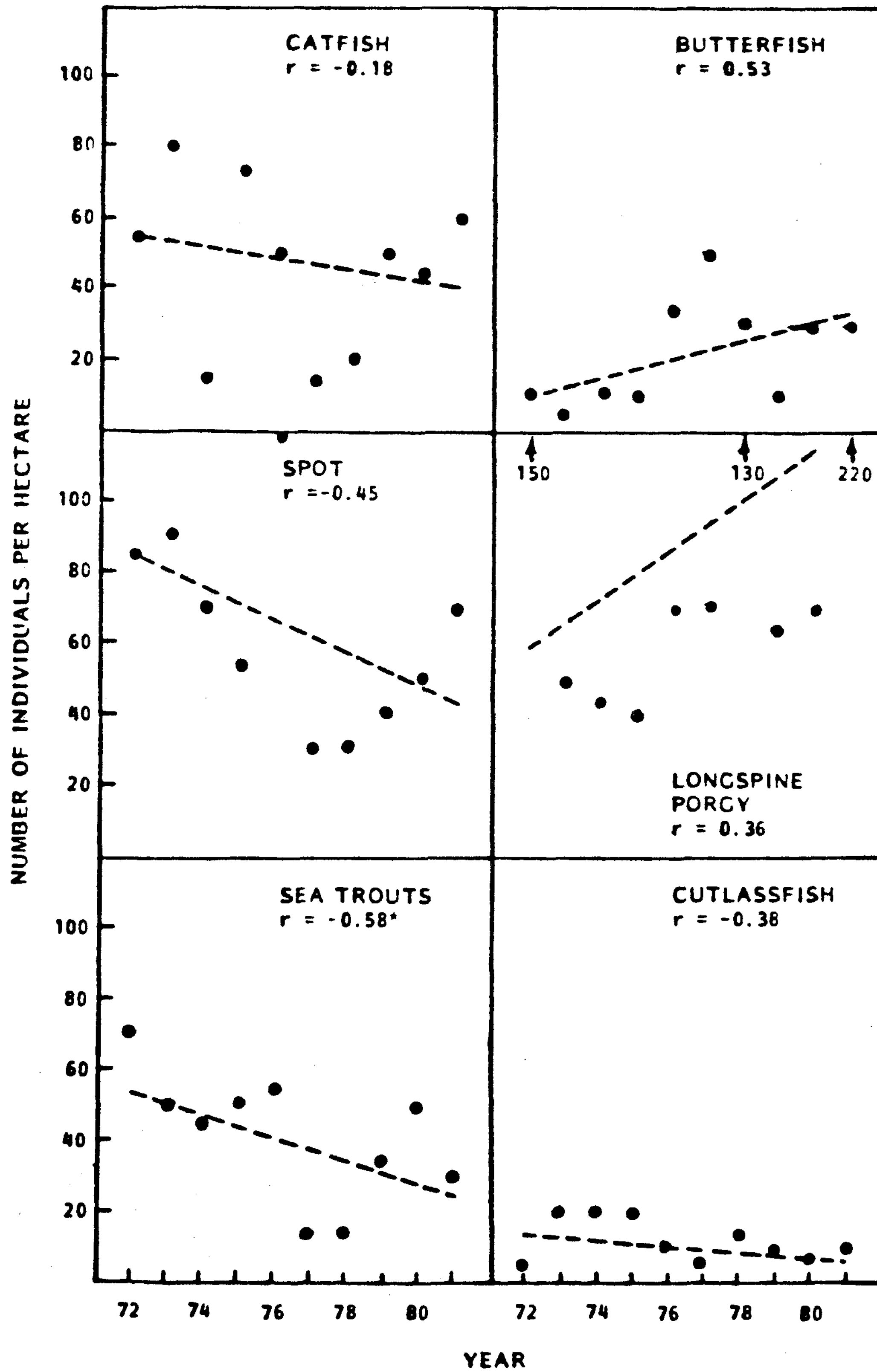


Figure GCP-5. Energy-flow model of the nearshore marine ecosystem of the north-central Gulf of Mexico (simplified from SAW/82/GCP/6).

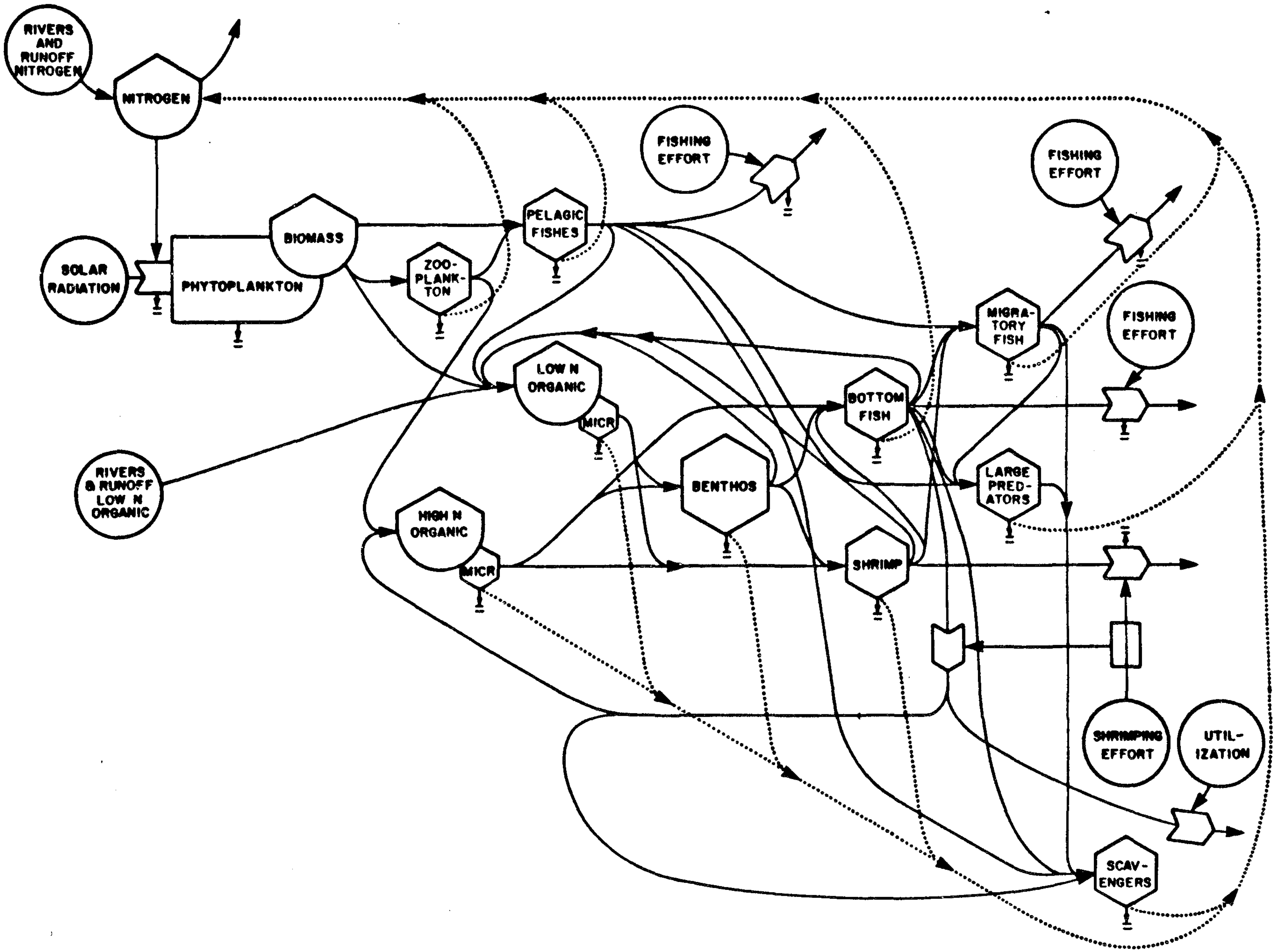


Figure GCP-6. Plotted simulation of biomasses of trophic groups of the model system, testing the effect of utilizing one-half the bycatch (from SAW/82/GCP/6). Numbers on the horizontal axis represent biweeks (15-day periods). There are 24 biweeks in a model year. The simulation spans 120 biweeks, or five years. Numbers on the ordinate represent biomass. The biomass of each stock is scaled to fit on the ordinate. Scaling factors are as follows: nitrogen, 0.01; phytoplankton, 0.01; low-nitrogen organic material, 0.0001; high-nitrogen organic material, 1; zooplankton, 0.1; pelagic fish, 0.01; benthos, 0.005; shrimp, 0.5; groundfish, 0.01; migratory fish, 1; marine mammals (large predators), 5; sharks (large scavengers), 1.

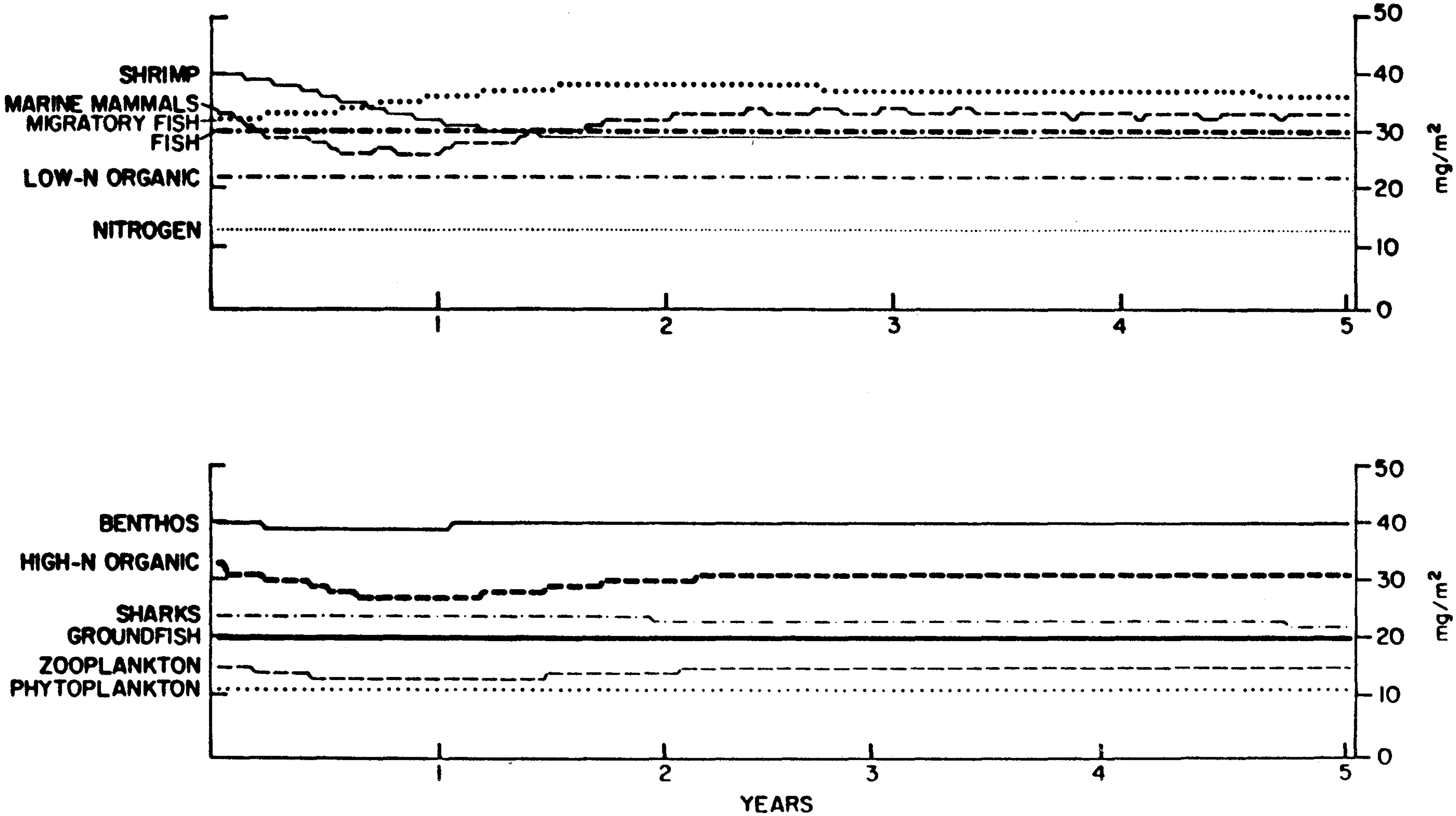
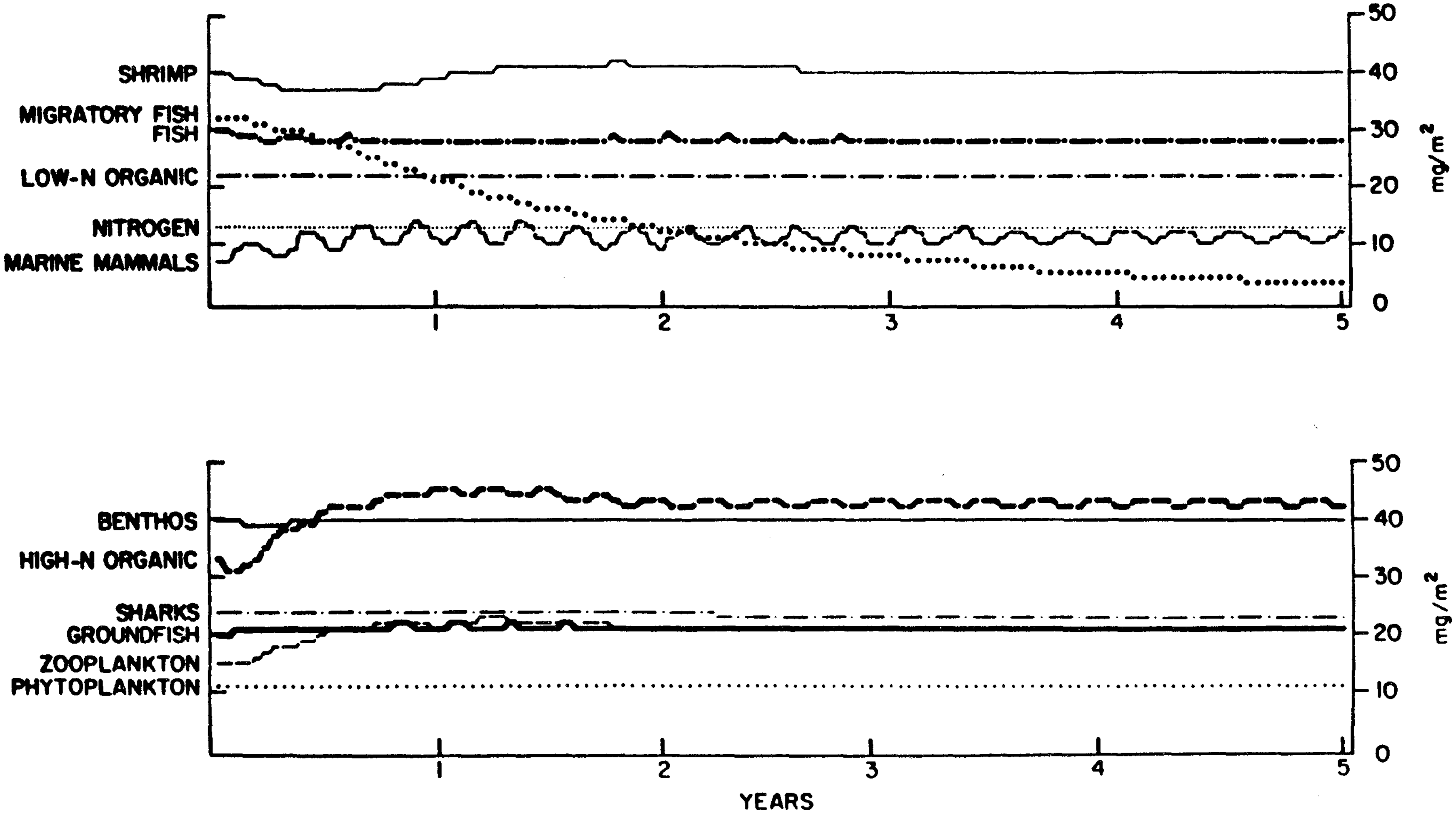


Figure GCP-7. Plotted simulation of biomasses of trophic groups (and also nitrogen) of the model system, testing the effect of reducing the fish catch-efficiency of shrimp trawls by one-half. Numbers on the horizontal axis represent biweeks (from SAW/82/GCP/6). Numbers on the horizontal axis represent biweeks (15-day periods). There are 24 biweeks in a model year. The simulation spans 120 biweeks, or five years. Numbers on the ordinate represent biomass. The biomass of each stock is scaled to fit on the ordinate. Scaling factors are as follows: nitrogen, 0.01; phytoplankton, 0.01; low-nitrogen organic material, 0.0001; high-nitrogen organic material, 1; zooplankton, 0.1; pelagic fish, 0.01; benthos, 0.005; shrimp, 0.5; bottomfish, 0.01; migratory fish, 1; marine mammals (large predators), 1; sharks (large scavengers), 1.



MARINE MAMMALS AND TURTLES (MMT)

TURTLES

There has never been a comprehensive, quantitative assessment of stocks of a marine turtle species that occurs in the United States and jurisdictional waters. Such an assessment is not immediately possible. However, in describing the status of stocks we have attempted to describe what information is currently available and has been quantified or is required for a preliminary assessment and what research approaches may provide these data.

It is noted that although five species of turtles are observed in our waters, the loggerhead turtle is used as our species of focus. It is the most abundant and thus that species for which we have the most data.

State agencies, universities and privately funded organizations support marine turtle projects of varying intensity. In addition, the U.S. Fish and Wildlife Service has responsibility over marine turtles on land. Thus, because of jurisdictional overlap and confusion, it is impossible to develop a comprehensive data base for each species. Thus, this report presents regionalized data and results reflecting the data which are currently available.

Because turtles are long-lived iteroparous species, much of the information required to adequately assess the status of stocks is only going to be derived from long-term studies. Short-term studies only provide provisional information at best and are inadequate alone to complete assessments. It is the intent of this report to provide a recommended research program specific to answering questions relative to stock assessment and provide guidance for future management needs.

I. DESCRIPTION OF FISHERIES

In 1973 with the partial implementation of the Endangered Species Act, it became illegal to capture turtles and turtle eggs, excluding green and loggerhead turtles, within the United States and areas of U.S. jurisdiction (i.e., U.S. Virgin Islands and Puerto Rico). The green and loggerhead turtles were listed in 1978. Previous to 1971, fisheries focusing on the capture of green and loggerhead turtles and secondarily on ridleys and hawksbills were operational from Virginia to Florida to Texas (Rebel 1974). Rebel (1974) presents a concise review of these fisheries by annual total pounds per species landed by state for various years beginning in 1880 and ending in 1970. Outside of Florida on an annual basis the total pounds landed for green, loggerhead, and ridley turtles ranged from a minimum of 600 pounds (1949:Virginia) to a maximum of 145,000 pounds (1933: Louisiana).

By far the most important fishery (total landed pounds) operated out of Florida principally from Cedar Key to Crystal River (Florida west coast) and secondarily Key West, Florida.

For green turtles, pounds landed in the Florida west coast from 1950-1971, a minimum of 646 pounds was reported for 1956 and a maximum of 410,455 pounds was reported in 1970. For the Key West fishery a minimum of 55 pounds was reported in 1955 and a maximum of 8380 pounds was reported in 1970. The loggerhead turtle statistics for Florida includes also ridley turtles. Thus, for loggerhead and ridley turtles for the Florida east coast and the Florida west coast, the minimum pounds landed and maximum pounds landed are: 100 in 1951 (east coast), 100 in 1959 (west coast) and 9699 in 1971 (east coast) and 26319 in 1952 (west coast).

Laws in Florida were initially applicable in May through August, or the nesting season for green and loggerhead turtles. During these months no nesting females or eggs were to be taken. In 1971, Florida imposed a minimum size limit on green turtles of 41 inches carapace length due to dwindling catches. No such limits were placed on the other fished species. In June 1971, Florida prohibited the taking of green turtles and eggs on the east coast (not including the Keys), and imposed protection of nesting females and eggs during the nesting season on the other species. On the Florida west coast a 26 inch carapace length minimum size limit was imposed on all species. In Monroe County (Florida Keys) a minimum size limit of 41 inches carapace length was imposed on all species. In 1978 all direct fishing activities were legally terminated under the Endangered Species Act of 1973. However, active fisheries for turtles and/or eggs remain outside the U.S. including (for example) Cuba, Mexico and the Dominican Republic. According to the FAO Yearbook of Fisheries Statistics (Vols. 44 and 51) the annual turtle catch in metric tons landed has been dominated since 1974 by the loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*).

II. STOCK STRUCTURE

Stocks can be differentiated at the species level. Stocks within the research purview of the NMFS are:

(1) Caretta caretta, the loggerhead turtles listed as threatened;
(2) Chelonia mydas, the green turtle listed as threatened except in Florida where it is listed as endangered;
(3) Lepidochelys kempi, the olive ridley, listed as endangered;
(4) Dermochelys coriacea, the leatherback turtle, listed as endangered;
(5) Eretmochelys imbricata, the hawksbill turtle, listed as endangered.

A sixth species, the olive ridley (Lepidochelys olivacea) is distributed along the northern coast of South America but is found primarily in the Pacific Ocean. The other five species with the exception of the Atlantic ridley are distributed worldwide. The hawksbill is considered the most tropical or warm water species and its distribution is limited to the tropics and sub-tropics. The leatherback turtle is the least temperature limited and is found during summer months feeding as far north as Nova Scotia. The green turtle is primarily a tropical and subtropical species but is known to nest as far north as North Carolina. Interestingly, this species is only considered endangered in Florida (outside of Florida waters it is listed as threatened) because it was assumed green turtles are not found north of Florida. The Atlantic ridley nests presumably only in Mexico (Rancho Nuevo) in the Western Atlantic but is regularly observed in summer months as far north as Cape Cod, Massachusetts. The loggerhead turtle appears regularly as far north as New Jersey and in summer months SAW/82/MMT/4) is commonly encountered in bays and estuaries. Because the loggerhead is the most abundant and conspicuous species in the southeast U.S. with major nesting beaches along the southeast coast, there is a comparatively large data base for Caretta. This report reflects this bias and deals primarily with this threatened species.

Beyond the species level, turtles (herein used synonymously with Caretta caretta unless indicated otherwise) are typically identified to the population level based on where females nest. Nest site fixity has been demonstrated, although quantification of these data is incomplete. However there is little evidence to determine if nesting females are genetically different between nesting beaches, which would support stock separation into discrete nesting populations. Morphometric investigations and/or comparisons of parasite loading may provide information on stock separation (Stoneburner, personal communication 1982; M. Lutcavage, personal communication 1982). A conservative approach advocates management based on discrete nesting assemblages.

No information is available on adult males or the juvenile stages to suggest the existence of stock boundaries within the Western Atlantic. However, if it is demonstrated that females are not distinct between nesting beaches then it should be assumed males and juvenile turtles also demonstrate random mixing. Stocks may thus be defined for the western Atlantic. At this time, with no evidence to define stock boundaries, stocks are limited to the western Atlantic, within nesting assemblages.

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

Mortality of eggs is defined as the percent that does not hatch. Usually a mean value is derived with some measure of dispersion.

Hatchling mortality is known only for animals in transit from nest to water and derived from observation (counts). It is assumed that mortality is high until some critical size is attained. For example, female green turtles deposit 200 eggs in a season, and there is a 1:1 "sex" ratio of eggs. This implies that only 1% (.01) of the female eggs must survive for replacement, as was demonstrated for exploited green turtles nesting in Tortuguero, Costa Rica. Loggerhead survivorship from the egg to mature female for loggerheads on Little Cumberland Island, Georgia was estimated in SAW/82/MMT/3. Given age maturity of 7 and 15 years, respectively, and given an annual decrease in population size of 3%. Frazer (SAW/82/MMT/3) estimates survivorship to be .003 and .005. The discrepancy between these estimates (.01 vs. .003 to .005) results from the greater survivorship of adult female loggerheads in Georgia vs. adult female green in Tortuguero. This demonstrates again that green turtle demographics may not be directly applicable to loggerhead turtles. Such investigations as Frazer's are encouraged for all species nesting on other beaches.

Total mortality of nesting adults can be determined from mark-recaptures such as completed in SAW/82/MMT/3 for Little Cumberland Island, Georgia nesting females. In this study, age of sexual maturity was arbitrarily designated as age "α" and data on annual recruitment and nesting cycles within and between seasons were utilized to estimate total mortality. Such studies require time series data over at least a six year period assuming a maximum intercycle interval of five years.

Incidental mortality of all species of turtle is defined as mortality resulting from fishing activities directed at nonturtle species. Such estimates are available for 1977 for turtles captured during shrimping activities off South Carolina (Ulrich 1978) and Georgia (Hillsted, Richardson and Williamson 1977). Capture rates of less than 0.1 turtles per trawl hour were reported in these studies. Estimated mortality was estimated at 40% for turtles captured. Estimates of catch and mortality of turtles are needed by species, fishery, stage class, area and time.

III.1.2. Growth Estimates

No reliable method is yet available for precise ageing of sea turtles beyond the hatchling stage. Sea turtle populations are composed of stage classes defined by sizes which are species and perhaps population-specific. Generally, populations are considered to include at least five history stages based on carapace length. These stages are:

(1) egg
(2) hatchling
(3) yearling
(4) juvenile
(5) adult

Adult females are divided into two groups. Recruits are defined as first time nesting females and age of recruitment indicates age of first nesting season. Remigrants are females returning to a beach during a subsequent nesting season.

Frequency distributions of numbers per stage based on size are derived for eggs, hatchlings, and nesting females from direct counts on nesting beaches. The number of recruits versus remigrants among nesting females is derived from tag-recapture data. It is assumed all nesting females without tags are recruits. The problem of estimating tag loss estimates has been addressed (SAW/82/MMT/3; Bjorndal 1980; Richardson 1982).

III.2. Abundance Trends
III.2.1. Eggs and Hatchlings

The number of eggs deposited in a given year is derived from direct counts or by the product of some mean value for numbers of eggs per nest and the total numbers of nests. The numbers of eggs deposited per female is used to estimate reproductive rate. Tag-recapture studies give estimates of the numbers of nests per female which multiplied by mean number of eggs per nest gives a fertility value (m_x = annual reproductive rate). It is important to note that m_x values may differ signficantly between recruits and remigrants, and further between first, second and third time remigrants. It is suggested that differences may be used as an index to separate recruits from remigrants where tagging studies are not ongoing or where discrete nesting assemblages are not identified.

The number of hatchlings produced in a year on a given beach is also determined empirically. Either the number of hatchlings in a nest are counted or the number of eggs in a nest that have hatched are counted.

Females do not nest every year, rather most nest every two, three, or four years. For green turtles if the cycle is known for a given "population" or breeding colony the multiplication of the total number of females in a cycle and the numbers of eggs per female gives a first approximation of the total number of eggs or hatchlings produced in a breeding population for one breeding cycle (i.e. two, three, or four years). If the data are available, mean values and variances may be calculated. Note that such estimates for hatchlings are only relevant for the stage prior to individuals entering the water. For loggerhead turtles, the cycle is highly variable. If the proportion by cycle is known, the total mean annual eggs produced may be adjusted to reflect mean annual fecundity per female.

III.2.2. Nesting Females

A quick estimate of the total numbers of nesting females (N_f) in a given season is derived by taking the total number of nests and dividing by the average number of nests or clutches per female. In general, these data are available by state or nesting beach, again based on the hypothesis of discrete nesting assemblages. Multiplying by the modal interbreeding cycle (two, three, or four years usually) gives a rough estimate of total number of nesting females. The mode is preferred for loggerheads because of the variability in cycle length. Numbers can be corrected (weighed) when the interbreeding cycle is enumerated by frequency of cycle (SAW/82/MMT/3). These data are derived from tag-recapture studies, and are generally available for loggerhead and the Atlantic green turtle.

Because turtles deposit eggs on land, the numbers of nesting females can be estimated from direct counts. For example, SAW/83/MMT/2 used aerial and ground counts of nesting crawls to estimate the numbers of loggerhead females in the southeast U.S. in 1980. The estimate provided by SAW/82/MMT/2 is 18297 $\pm$ 13032 ($\pm$ 2 SE as approximate 95% confidence intervals). SAW/82/MMT/2 discussed the major sources of error from utilizing these data.

These include the variability in turtle nesting activity which was not measured. Presumably, daily replication would allow measurement of this variance component. Secondly, the small sample sizes and restricted sampling produces biases of unknown magnitude. And, the reliance on untested assumptions regarding turtle distributions, nesting behavior and sampling methodology provoke a conservative interpretation to these results as suggested by the large variance associated with N. A second independent estimate of nesting females on an island by island basis was completed in the Draft of the Recovery Plan for Marine Turtles (1982). This permits analysis of discrete nesting assemblages within the southeast United States.

An estimate of female green turtles nesting in Florida is presented in the Technical Draft of the Recovery Plan for Marine Turtles. It is estimated that 200-300 green turtles nest on Florida beaches and the trend seems to be toward increased nesting activity. According to this Technical Draft, the number of leatherback females nesting in the continental U.S. is "less than a dozen". Neither the ridley nor hawksbill regularly nest in the United States. Occasional ridley nests are observed on Padre Island, Texas (L. Ogren, personal communication, 1982). Two confirmed hawksbill nests were reported on Key Biscayne apparently deposited in October 1981 (R. Witham, personal communication, 1981).

III.2.3. Juveniles and Adults - Pelagic Habitat

In an attempt to avoid problems when making the above assumptions that SAW/82/MMT/2 made for aerial surveys of nesting beaches, the NMFS has initiated a pelagic aerial survey which may provide more precise abundance estimates by species within the southeast United States. SAW/82/MMT/4 is a detailed statistical evaluation of the 1979 field data and concluded that while expensive, aerial surveys may be the most efficient means available to estimate the abundance of juveniles and adults (Table MMT-1). Excluding the difficulties in evaluating observer behavior, the primary objection raised regarding the provision of numerical estimates is correcting for the amount of time turtles spend below the surface. SAW/82/MMT/4 presented a correction model when dive times are available. SAW/82/MMT/8 presents preliminary results of using radio tags on <u>Caretta caretta</u> to estimate surface times and surfacing rates. These results encourage the use of radio tags to calculate surface times which ideally should be measured for each species, seasonally and by area. In the absence of this information, abundance estimates are minimal and represent the numbers of turtles that are at the surface when the aircraft is in-flight.

Radio tagging has also provided information on the movements of adult and juvenile turtles within the pelagic habitat. Turtles may "hibernate" during winter months. Pelagic aerial surveys provide abundance estimates that are biased low during this period, if hibernation occurs. It is necessary to continue radio tagging studies for all species to measure the magnitude of this bias.

III.3. Stock Assessment Analyses
III.3.1. Recruitment Indices

Annual recruitment of nesting females may be estimated when the total (or a sub-sample of) nesting population is tagged. An estimate of annual recruitment is available for turtles nesting on Little Cumberland Island, Georgia (Richardson 1982). Richardson (1982) estimates annual recruitment at 30% since 1973.

Age of sexual maturity may be estimated from growth studies such as Mendonca (1981) who estimated age of sexual maturity for loggerheads in Florida to be 10-15 years.

III.3.2. Density Dependence

It appears that nesting habitat availability may eventually be limiting to turtle nesting along in the southeast U.S. coast. One hypothesis is that the number of nests that are viable and unmolested is a function of numbers of nesting sites available and number of nests deposited (i.e. a female deposits one or more nests per season). Thus, by chance alone a nest could be destroyed during the course of nest excavation, throughout a nesting season. However, the probability of nest destruction increases as the number of total sites available decreases, if females do not disperse to other nesting beaches.

This was demonstrated as a density-dependent mechanism for green turtles nesting in Australia. With the decline in available nesting habitat it is hypothesized that such an effect may have been or will be observed for turtles nesting in the southeast United States. The alternative hypothesis is that given a decrease in nesting habitat, females will disperse and find suitable nesting habitat outside the southeast U.S. One place where these hypotheses could be tested is in Cape Romain, South Carolina which apparently is eroding significantly on an annual basis.

III.4. Current Status

No population estimates are available for unexploited densities by species. Thus, it is not possible to compare existing densities with historical densities. Only one long term study has been completed in the U.S. with the purpose of deriving population estimates and provide an assessment of the status of the extant stock. This study is ongoing at Little Cumberland Island (LCI), Georgia. The LCI study was initiated in 1964. Richardson (1982) supports the hypothesis that since 1973, this nesting population is stable. SAW/82/MMT/3 supports an alternative hypothesis using the data from 1964. This second hypothesis suggests an annual decrease of 3% in the nesting population since 1964.

According to the Technical Draft of the Recovery Plan for Marine Turtles, the stock of Atlantic ridley turtles nesting on Rancho Nuevo has declined over at least the past fifteen years. The number of green turtle nests encountered in Florida has increased since 1976.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

Current management procedures require total protection of all life history stages. Such management programs include beach protection, hatchery programs and head starting.

V. RECOMMENDATIONS

V.1. Data Needs

V.1.1. Stock Definition

(1) Genetic evidence of variability between nesting females of "discrete" assemblages. If no genetic variability exists among nesting females, we assume random mixing of males of juveniles.

(2) Compilation and examination of morphological characteristics relative to gradients over time, area, age class and sex.

(3) Examination of parasite composition.

(4) Composition and examination of turtle distributions by time, area, age class and sex.

V.1.2. Catch Statistics - Fishing Mortality

(1) Incidental mortality of sea turtles by species, fishery, age group and time.

V.1.3. Natural Mortality

(1) Information which will provide estimates for juvenile stages.

(2) Estimates of egg predation rates.

V.1.4. Age of Recruitment Into Breeding Population

(1) Growth data of captive and wild populations by area.

(2) Mark-recapture information on juvenile stages.

V.1.5. Population Sizes

(1) Stock wide estimates for juveniles and adults relative to stock definition.

(2) Sex ratios by stage, area, time.

(3) Trends of numbers of nesting females by area, time, and habitat.

V.1.6. Density Dependence

(1) Estimates of dispersal rates of females from reduced nesting habitats.

V.2. Research

The recommended research approach is as follows:

V.2.1. Stock Definition

(1) Genetic/biochemical investigations.

(2) In addition to large scale it is recommended that for pelagic surveys individuals from known locations be marked in some way to be identifiable from the air. Locations may include nesting beaches (adult females) and incidental capture sites, for all age classes.

(3) Mark-recapture on studies to determine dispersal of females from nesting beaches.

(4) Radio tagging to determine distributions of males and juveniles if appropriate.

(5) Examination of distribution and behavior on offshore hard bottom habitats.

V.2.2. Catch Statistics

(1) Compilation of existing estimates provided by Hillsted, Richardson, and Williamson (1977) and Ulrich (1978) under NMFS contract; and NMFS Pascagoula Lab derived estimates from experimental TED trawls. Incidental capture from other fisheries must be investigated, such as longline, etc.

(2) Observer program in areas of shrimping effort, particularly in cooperation with existing assessment or fishing monitoring programs at the state level.

V.2.3. Natural Mortality

(1) Natural mortality will be estimated from total and man-induced mortality estimates.

V.2.4. Age of Recruitment

(1) Marking program targeting where juveniles predictably occur, through cooperative effort of existing fishery assessment programs by state.

(2) Develop comparative growth models based on wild populations.

V.2.5. Population Size

(1) Continuation of long-term funded programs such as that on Little Cumberland Island.

(2) Continuation of methods such as radioimmunoassy or proctoscope programs to identify sexes. It is likely that during trawling programs blood samples, and/or tissue samples could be taken to provide sex structure information when a protocol is developed.

(3) Pelagic and nesting beach surveys stratified by time and area when possible and corrected for time spent at surface from radio tagging studies.

V.3. Management

It is anticipated when an assessment of stocks is completed management policies will be based on population size estimates resulting in maximum net productivity. At this time, no new management procedures are recommended.

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 U.S. jurisdictional waters appears in Table MMT-2. Research on marine mammals at the Southeast Fisheries Center was initiated in FY-79 and has been oriented to provide advice for management of the live capture fishery for *Tursiops truncatus*, the bottlenose dolphin, in the southeast.

I. DESCRIPTION OF THE FISHERIES

The stock(s) of *Tursiops truncatus* in southeastern U.S. jurisdictional waters have supported several fisheries since at least the 1700's (Mead 1975). Among these are the now defunct seine-net fisheries at Cape Hatteras and Cape Lookout and a small harpoon fishery in Tampa Bay (Stearns 1887). The estimated catch from Cape Hatteras and Cape Lookout between 1883 and 1914 was 20,892 *Tursiops* (Mead 1975). This fishery remained active until 1929.

The present take of *Tursiops* is limited to the live capture fishery for public display and scientific research (Asper 1975), potential bycatch in fisheries directed at other species (Mead 1975), and by the shooting of "nuisance" porpoise (Caldwell and Caldwell 1972, Mead 1975). The reported removals from the population of *Tursiops* in the southeast since inception of the MMPA are presented in Table MMT-3. Pre-Act removals from Florida waters were documented since 1953 when the State of Florida established a permit and inspection program (Odell *et al*. 1975). The magnitude of annual removals due to bycatch and shooting is not documented.

II. STOCK STRUCTURE

The structuring of reproductively isolated subsets (i.e. stocks) of the *Tursiops* population in southeastern U.S. jurisdictional waters is unknown. There are few data with which to examine this question.

Species in the genus *Tursiops* are worldwide in distribution (Nishiwaki 1972). In the western north Atlantic Ocean *Tursiops truncatus* is known from Venezuela to Nova Scotia (Leatherwood *et al*. 1976). This species is thought to be principally distributed in inshore and estuarine waters throughout the southeastern U.S.

Atlantic and Gulf coast waters (Schmidley 1981). Recent data from the Cetacean and Turtle Assessment Program at the University of Rhode Island demonstrates a disjunct distribution for this species in waters from Cape Hatteras to Nova Scotia. Between Cape Hatteras and the Delmarva Peninsula, Tursiops are found in relatively high abundance nearshore and in waters over the shelf break (> 90 - 2000 m, see Fig. MMT-1). The offshore distribution is continuous from Cape Hatteras to Georges Bank.

Several authors (Caldwell 1955, Caldwell and Caldwell 1972, Anonymous 1975) have suggested that some degree of reproductive isolation exists between Tursiops found in nearshore and coastal waters and those offshore. The offshore form is thought to be of larger size, darker in coloration, and with a different parasite loading than those inshore (Caldwell 1955, Schmidley 1981). Other morphological differences including cranial skeletal variations may also exist. Duffield (1981) has found differences in the blood composition of Tursiops sampled in the Indian-Banana River complex and a single animal sampled from five miles offshore. Chromosomal banding differences (Duffield 1982) support the blood protein findings. Duffield's results tend to support the hypothesis of reproductive isolation between inshore and offshore morphs of Tursiops. The data, however, are limited by small sample size and, as of yet, give no indication of the degree of isolation.

There may also be varying degrees of reproductive isolation between inshore groups of Tursiops. Several studies (Caldwell 1955, Shane 1977, Gruber 1979, Shane and Schmidley 1979, Wells et al. 1981) have presented evidence of home ranges for Tursiops in certain embayments. The degree to which this may influence limiting genetic exchange between groups of Tursiops in the different embayments is unknown.

III. STATUS OF THE STOCKS

At present there is no comprehensive estimate of the size of the stock(s) of Tursiops in southeastern U.S. jurisdictional waters. The abundance of Tursiops in certain "priority" regions of the Florida Atlantic and Gulf coasts has been estimated, however. A summary of these estimates is presented in Table MMT-4. These estimates are considered negatively biased due to terms that remain to be estimated (SAW/82/MMT/6).

Estimates of the vital parameters for this species are also limited and somewhat contradictory. According to Odell (1975), Tursiops females attain maturity at about 5-12 years of age while males mature at ages 10-13 years. Spring mating results in a calf on year later and a calving interval of two years was observed in free-ranging animals in Florida (Odell 1975). Females presumably are reproductive through 25 years of age (Odell 1975).

According to Sergeant _et al_. (1973), males and females are mature at about 90% of asymptotic length (270 cm, males; 250 cm, females). Recruitment into the sexually mature population may occur between 6 and 12 years of age in females and between 7 and 15 years in males (Sergeant _et al_., 1973).

In an examination of the possibility of seasonal calving in _Tursiops_, SAW/82/MMT/7 found that calving may not be seasonal in the Indian-Banana Rivers and Charlotte Harbor, Florida. However, results from the Mississippi Sound; Aransas-Copano-San Antonio Bays and Apalachicola-St. Joseph's Bays, Florida; surveys suggest that while calving may occur during any month, a peak occurs in the spring and/or summer months. These results are consistent with those of animals captured in Florida waters and maintained in aquaria in Florida (Ridgeway 1972) and California (Kirby 1981).

Immigration to and emigration from inshore groups of _Tursiops_ has been suggested in several studies. Duffield (1981) presented evidence suggesting matings within the Indian-Banana Rivers between "offshore" and "inshore" _Tursiops_ occurs. She described preliminary results and chromosome examination in addition to haematologic evidence and protein electrophoresis suggesting a calf from the Indian-Banana River complex to be an "intermediate" type of hybrid between inshore and offshore characteristics.

Mead (1975) and Hogan (1975) support the possibility of north-south migrations of _Tursiops_ along the southeast Atlantic coast. Thus, immigration may occur from offshore areas to coastal areas or from north-south movements. The net numerical effect of movements between inshore and offshore and north-south migrations is not known.

Estimates of mortality rates are not available for any age or life history stage class. No data are available on differential mortality of sexes affecting sex ratios. Because the net effect of movements of animals on population abundance is not known it is impossible to separate migration from mortality estimates. This is confounded by the present inability to define stock boundaries.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

The current management practices for the *Tursiops* population in the southeast is to limit the annual live-capture take from specific population sub-units to 2% of the average estimated abundance of each sub-unit. The sub-units are defined on geographical bases and only for regions where live capture has been conducted historically or may be conducted in the near future. The present recommended quotas are based on the best available data for the following regions (also see Tables MMT-3 and MMT-4):

REGION	RECOMMENDED QUOTA
Florida	
Indian-Banana River	6
Tampa Bay	10
Charlotte Harbor	5
Charlotte Harbor to Crystal River	8
Crystal River to Mobile Bay	7
Destin-Ft. Walton Beach	2
Apalachicola-St. Joseph's Bay	1
Mississippi Sound	35
Texas Coast	17
Aransas-Copano-San Antonio Bays	5
Corpus Christi Bay and south	0

The effect of the current management procedures on the stock(s) in question has not been quantitatively analyzed. The validity of the 2% quota rule remains to be tested as does the current assumption of discrete stocks for each of the management units.

V. RECOMMENDATIONS

V.1. Data Needs

In order to assess the effects of exploitation on *Tursiops*, one requires definition of the number, size, and status of the stocks being exploited. The data requirements include estimates of (1) stock species density and abundance, (2) rates of recruitment into the stock and the fishery, (3) age/stage specific natural and fishing mortality (fishing mortality may be interpreted as permanent removal from the wild gene pool to include live-capture), (4) stock discreteness, and (5) emigration and immigration. Data on the size and status of other marine mammal stocks, especially endangered cetaceans, are also required.

V.2. Research

Current research on *Tursiops* is directed at addressing a portion of the data needs. Localized estimates of species abundance in "priority" embayments are being made to provide interim quota recommendations. Tagging studies are being conducted to evaluate the dynamics of herds within certain embayments. This research, however, is being pursued independent of an understanding of stock definitions. Future research should focus on stock-specific rather than geographic-specific designs. Suggested research topics and approaches follow.

V.2.1. *Tursiops truncatus*

V.2.1.1. Stock Structure

(1) Comparison of the genetic variability of inshore-offshore and long-shore units of *Tursiops* as indexed by haemotological, isozyme, chromosome banding, and/or mt-DNA studies.

(2) Comparisons of breeding cycles between long-shore groups using hormone level indices and further examination of the proportion of calves in the population.

(3) Comparative study of the size-frequency distributions of long-shore and inshore-offshore units sampled by photogrammetric means.

(4) Comparative study of the size-frequency distributions of exploited and non-exploited regions of the population range using photogrammetric means.

(5) Morphological comparisons using museum and stranded specimens.

V.2.1.2. Status of the Stock(s)

(1) Comprehensive estimates of stock abundance based on (a) weighted mean densities from present samples, if appropriate, or (b) sampling survey designed on the basis of stock definition.

(2) Estimation of bias terms inherent in aerial sampling data including (a) proportion of time submerged, and (b) environmental and survey-specific terms using current and future data.

(3) Estimates of abundance using turtle aerial survey data.

(4) Relative abundance indices using cooperative research programs on an opportunistic basis with state agencies such as the Georgia Department of Natural Resources.

(5) Examine potential impact of fisheries directed at other species such as purse seine and gill net fisheries.

(6) Catch and effort history of live-capture fishery from published and gray literature.

(7) Estimates of age/stage-specific survivorship based on length frequency data from photogrammetric techniques.

(8) Age-at-length and length of first reproduction relationships based on published and gray literature, captive animals, and stranding data.

(9) Estimates of immigration and emigration based on current tagging studies.

V.2.2. Other Cetaceans

(1) Estimate abundance of stock(s) of cetaceans other than *T. truncatus* based on current and future aerial sampling data.

(2) Comprehensive sampling and estimation of abundance of large, endangered cetaceans, especially right whales.

(3) Coordinate marine mammal opportunistic sighting network for southeast.

V.3. MANAGEMENT

It is recommended that management of *T. truncatus* live-capture fishery be continued under the present scheme until research results indicate otherwise.

Table MMT-1. Kelker index density estimates (D) for Caretta caretta, computed for each dedicated survey and sampling block. Estimates are accompanied by variance estimates (V(D)) and estimates of the number of turtles (N) present at the surface.

Survey	SAMPLING BLOCK A	B	C	D	E	F	G	H	I
1	0[1]			0	0	0	0	0	0
	0[2]	NE[4]	NE	0	0	0	0	0	0
	0[2]			0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	.0119
	0	0	0	0	0	0	0	0	3.00E-05
	0	0	0	0	0	0	0	0	34
3	0	0	0	0	0	0	0	.0059	.0100
	0	0	0	0	0	0	0	4.58E-04	2.10E-05
	0	0	0	0	0	0	0	48	33
4	0	0	0	0	0	0	.0121	.2584	.0582
	0	0	0	0	0	0	2.80E-05	3.55E-04	2.21E-04
	0	0	0	0	0	0	107	2120	195
5	0	.0046	0	0	0	.0353	.1596	.1117	.1590
	0	1.00E-06	0	0	0	1.30E-05	3.55E-04	2.64E-04	7.29E-04
	0	48	0	0	0	348	1313	916	534
6	0	0	0	0	.0094	.0048	.0733	.0449	0
	0	0	0	0	3.54E-04	7.20E-05	1.41E-04	1.50E-04	0
	0	0	0	0	97	481	603	368	0
7	NE	0	NE	0	0	0	.0197	.0841	.1974
		0		0	0	0	4.60E-05	2.34E-04	8.15E-04
		0		0	0	0	162	689	663
8	0	0	0	0	0	NE	0	0	.0098
	0	0	0	0	0		0	0	2.90E-05
	0	0	0	0	0		0	0	33

[1] D
[2] V(D)
[3] N
[4] No Effort

Source: SAW/82/MMT/4

Table [a]MMT-2. 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 bocealis, 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
Lissodelphis truei, 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 Shmidley 1981, Winn et al., 1979, and Leatherwood et al, 1976.

[b] Endangered species status abbreviations: Y, yes; N, no; E, considered extinct.

Table MMT-3. Summary of permanent removal from the wild. Tursiops truncatus: (1973-1981)

Location	YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981 (Jan-July)	TOTAL	Average Per Year
Florida, Indian River	-	-	10	6	15	5	7	9	5	57	6.3
Florida Keys	15	-	-	-	-	-	-	-	-	15	1.7
Florida West Coast	-	-	15	5	16	5	-	8	5	54	6.0
Florida Panhandle (Destin-Port St. Joe)	-	5	-	7	3	4	-	4	2	25	2.8
Mississippi Sound	-	15	7	2	8	24	14	11	-	81	9.0
Texas	6	-	5	-	2	17	13	14	-	57	6.3
TOTAL	21	20	37	37	44	55	34	46	12	289	32.1

Average Annual Take (1973-1981)

Florida	16.8
Other	15.3
TOTAL	32.1

CURRENT STATUS OF TURSIOPS PERMANENTLY REMOVED FROM THE WILD:

Currently Alive	188
Capture Mortalities	13
Other Mortalities	86
Animals Escaped	2
TOTAL	289

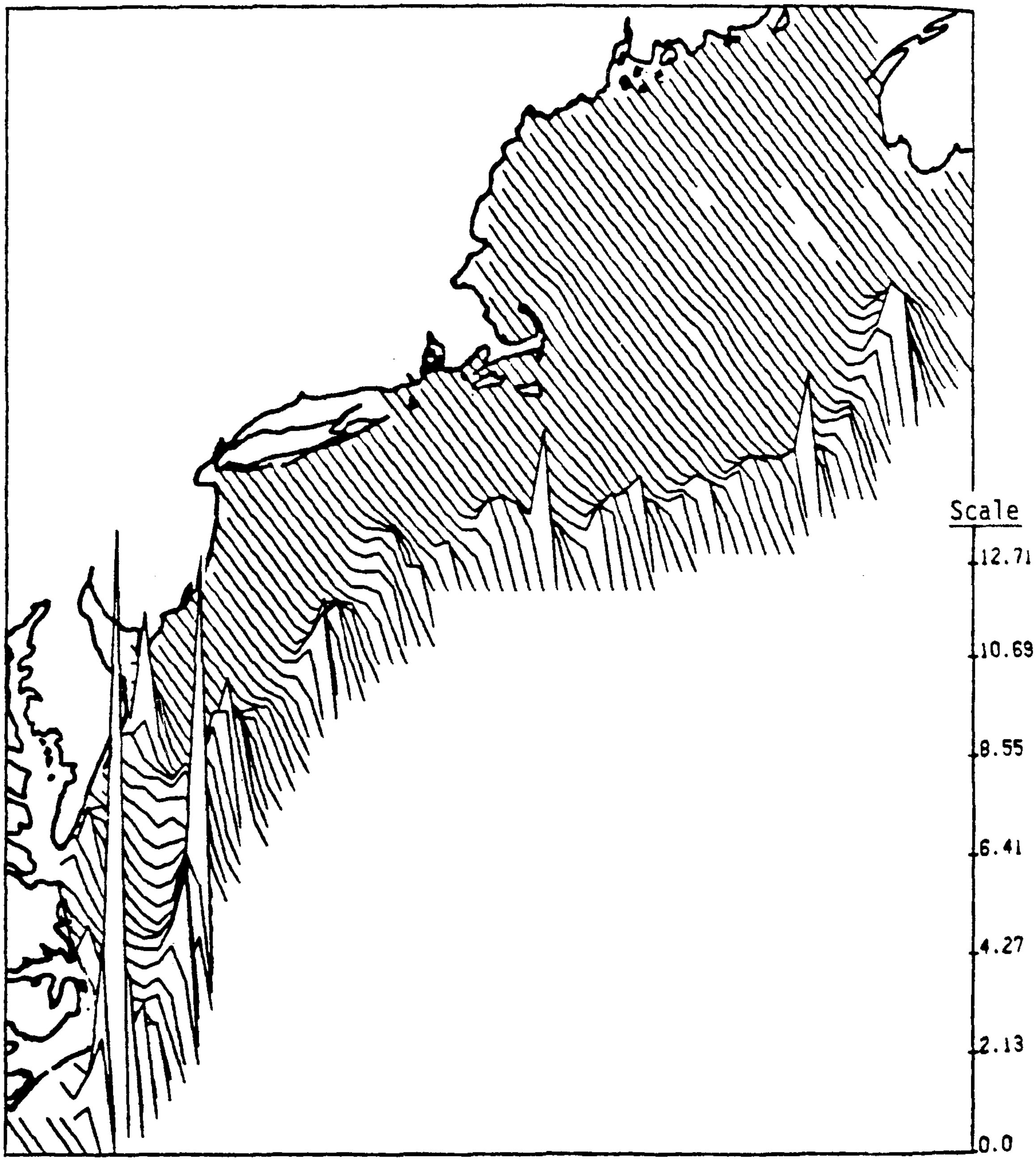
[a] Data provided by U.S. Marine Mammal Commission (P. Major, personal communication, August 1981)

Table MMT-4. Summary of preliminary population estimates of *Tursiops* from best available data for areas surveyed.

SURVEY AREA	ANALYSIS SOURCE	YEAR	MEAN ANNUAL POPULATION ESTIMATE
Charlotte Harbor to Crystal River	Odell & Reynolds	1975-1976	385
Charlotte Harbor (270 n.mi.^{2})	Thompson	1980-1981	243
Tampa Bay (880 n.mi.^{2})	Thompson	1979	449
Indian-Banana Rivers (235 n.mi.^{2})	Thompson	1980	281
Destin-Ft. Walton Beach	Odell & Reynolds	1975-1976	78
Apalachicola-St. Joseph's Bays (183 n.mi.^{2})	Thompson	1980-1981	48
Mississippi Sound	Leatherwood & Platter	1979	1749
Rockport, Texas	Thompson	1980-1981	263

[a] Adapted from table presented in memo from W. Fox to W. Gordon dated May 17, 1982, re: Establishing Interim Quota for the Take of Bottlenose Dolphins (*Tursiops truncatus*) in the Southeast Region.

Figure MMT-1. The average annual relative abundance of Tursiops truncatus from Cape Hatteras, North Carolina to Nova Scotia during the period of October 1978 -January 1982. A disjunct distribution between Cape Hatteras and the DELMARVA peninsula with peaks in abundance in nearshore and shelf break waters is evident. These data were presented courtesy of the Cetacean and Turtle Assessment Program, University of Rhode Island under contract AA551-CT8-48, U.S. Bureau of Land Management, NY OCS Office.



MENHADEN AND COASTAL HERRINGS

ATLANTIC MENHADEN

I. DESCRIPTION OF FISHERIES

I.1. Catch Trends

Landings of Atlantic menhaden caught by purse seine between 1940-1981 have ranged from 161 to 712 KMT. Over the last decade landings were between 250-400 KMT (Table MCH-1). Over 90% of the landings in 1975-79 occurred in New Jersey, Virginia, and North Carolina ($\bar{x}$ = 300 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).

Catches by other gear principally enter the crab or lobster bait and pet food market. 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 1955-81 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 but since 1976 has included 4-6 vessels; 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 has included from 64 vessels in 1957 to 4 in 1973 and 19 have been active in the last two seasons.

Present day vessels are significantly different than 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 applicable throughout the fishery. Nominal effort (Table MCH-1) is the apparent or deployed amount of effort and is herein defined as vessel-week of activity. Over the last nine years effort has averaged about 1200 vessel-weeks per season. Chesapeake Bay ranged between 552-667 vessel-weeks of effort since 1972.

II. STOCK STRUCTURE

Based upon tagging and length-age of fish in the catch the stock is considered one population (Nicholson 1972, 1978a and Dryfoos *et al.* 1973). There is some evidence for alternate hypotheses from meristics and electrophoretic studies. The population exhibits a complex migratory pattern by size and age with larger and older individuals occurring in northern waters. A north-south migration takes place in spring and fall. The working group accepts the one stock hypothesis for stock assessments of 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) and from tag data was 0.52 (Dryfoos *et al.* 1973). Deriso *et al.* (1980) using cohort analysis applied to tag data and weighted least squares nonlinear regression gave 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 scientists employ .45 for age one and older fish. 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. Additional research effort is needed to evaluate contributions of various factors to natural mortality, but it is not highly critical to understanding stock performance.

III.1.2. Growth Estimates

Data on growth rate were presented in SAW/82/MCH/6 and Deriso *et al.* (1980). Season and density dependent effects on growth in the first year of life have led to development and use of area specific growth estimates for length and weight, and von Bertalanffy curves in population analyses. Deriso *et al.* (1980) presents menhaden length and weight estimates by area by season by age and level of abundance. Their analyses suggest a strong relationship between number and length in recent years but the relationship is not nearly so clear cut in the years that the population was declining. The data might be confounded due to shifts in area of fishery operation between the period of population decline and recent years.

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

Landings per vessel week (Table MCH-1) ranged from 147 MT in 1967 to 376 MT in 1972. CPUE has exceeded 310 MT/vessel week since 1979 and has generally been increasing since the mid-1970s. Due to the changes in vessel characteristics and fishing technique, CPUE data are not considered useful for trend analysis.

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 present values for age at entry and effort).

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 management value and should be used only are rough approximations (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 management objectives. However, the larger yields 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 (1974-76 seasons) was 77 grams (SAW/82/MCH/6). A more recent unpublished Y/R estimate (1976-78 season) was 55.28 grams with approximately equivalent fishing effort. The proportional contribution of younger age groups to the landings has been increasing and the average size at age is decreasing. Both density-dependent growth as evidenced by size of juveniles in the fall and at older ages (Fig. MCH-2 and Table MCH-5) and allocation of fishing effort in the North Carolina fall fishery are keeping the Y/R depressed.

Given the hypothetical case of no fishing maximum biomass would occur at approximately age 3.25 (Fig. MCH-3). Present yield is approximately 50% of the maximum obtainable with age at entry of 3.5 and an F multiple of 2.0. Increases in Y/R from present levels are expected with other reduced fishing mortality or increased age at entry. Changes in the age at entry would change the current allocation of Y/R as well as the catch in the five fishing areas (Table MCH-3) as would reduced effort (Table MCH-4). Losses would occur in the North Carolina fall fishery.

III.3.3. Stock Recruitment Analyses

Recruitment since 1970 has varied by a factor of five. Summaries of recruitment data are contained in Deriso et al. (1980) and Nelson et al. (1977). Environmental influences on recruitment are very great and may mask any existing spawner-recruit relationship. A current study is updating the environmental model presented in Nelson et al. (1977). Present data do not suggest a strong spawner-recruit relationship during the period 1955-76 (SAW/82/MCH/6, 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.3.4. Virtual Population Analysis (VPA)

VPA analysis has been applied to Atlantic menhaden data. It includes quarterly estimates of fishing mortality and population size to accurately reflect the seasonal nature and sequence of the purse seine fishery. Fishing mortality is high for Atlantic menhaden, averaging over 75% for ages one and older in recent years. For the period 1973-76 age two fishing mortality averaged about 90%. A variety of techniques have been employed to develop starting F values for the analyses. These include several iteration techniques to approximate slopes of catch curves. Pope's 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 for area and age specific values).

III.4. Current Status

Recent descriptions are given in SAW/82/MCH/6. Stock size has apparently increased in number of individuals as evidenced by a strong showing of the 1979 and 1981 year classes, but the population has a strongly truncated age structure and the present fishery is heavily dependent upon age one and two fish (pre-spawners). The spawning stock size is probably lower than former years and the risk to the fishery of successive year-class failures is great. Yield/recruit trend is lower for 1976-78 period than for the 1974-76 period. All estimates (Y/R) indicate a trend toward harvesting of younger fish and the present yield is only aabout half of the hypothetical maximum. Y/R greater than present levels are attainable with reduced fishing effort and older age at entry.

National Marine Fisheries Service forecast for the 1982 season is 340 KMT (1000 vessel-week effort). This estimate takes the reduced purse seine activity in the mid-Atlantic and New England reporting areas during 1982 into account. The 1982 landings will contain a lower proportion of age 3+ compared to recent years.

The independent coastal states from Maine to Florida have jurisdiction over the resource and fishery (see SAW/82/MCH/6, Section 3). 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) and one state (Maryland) does 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.

Since the catch is made mostly in internal waters and the territorial sea, MFCMA provisions do not apply.

IV. EFFECT OF CURRENT MANAGEMENT PRACTICES

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 tag recovery programs; the purse seine fishery voluntarily provides daily catch records, plant production data and Captain's Daily Fishing Reports which give the core landing statistics and basic fishery activity data needed for stock assessment. 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 density dependent effective effort which would be adequate for management purposes (SAW/82/MCH/4).

V.2. Research

SAW/82/MCH/6 included an array of research topics. Essential components specified were evaluation of the unit of effort and development of a predictive capability for landings based upon abundance of young menhaden. The Atlantic Menhaden Management Board (AMMB) also has directed that a mesh selectivity study be conducted based upon the assumption that future management of the fishery might utilize mesh regulation. Further applications of the tagging data base should be made for refinement of stock assessment parameters. Fishery independent assessments of the older portions of the population are believed possible in the North Carolina area during the fall fishery.

V.3. Management

AMMB (see SAW/82/MCH/6, pp. 112-113) on 19 May 1982 approved a management measure to be effective in the 1983 season which would shorten the season in each reporting area by four weeks. Analyses of Y/R project 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. Y/R with present effort and age at entry would rise 5.7% (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. Progress to date: New Jersey has developed a draft regulation and is in the final public comment phase for implementation. No other state has initiated action at this time.

AMMB adopted no other management recommendations at its May 19, 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 concurrent 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 action. Further, future actions should seek improved Y/R and a broadened age structure in the population as called for in the management plan.

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 1981 catches fluctuated between 447 and 820 KMT (Table MCH-6). The bulk of the present day purse seine landings occur in Louisiana (67%) and the remainder in Mississippi (33%). 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 purse seine. A relatively small amount of unreported catch for commercial and recreational bait also occurs.

I.2. Effort Trends

During recent years (1964-1981) the number of vessels in the fishery have fluctuated between 65 and 82. During the development of this fishery, many modernization changes 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/82/MCH/7 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 1981, 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 replacements for older ones.

II. STOCK STRUCTURE

The Gulf menhaden fishery is believed to exploit a single stock or population of fish. Although tagging studies of pre-estuarine 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 indicate no significant populations on either side of the Mississippi Delta (SAW/82/MCH/7). 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 and averaging 1.1 (SAW/-82/MCH/2). Current population dynamics analyses use the value of 1.1.

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: $L = 252.9$; $K = 0.47$; and $t_0 = 0.36$. 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 in vessel-ton-weeks range from 3.71 MT in 1946 to 0.78 in 1967. There is no major trend in the CPUE values in the Gulf fishery (Table MCH-6). Due to the changes in vessel characteristics and fishing techniques, CPUE data are not considered useful for trend analysis.

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

Estimates of MSY using nominal effort and catch and a standard Schaefer surplus production model has been increasing with the addition of more recent data, for example: Chapoton (1972) obtained an estimate of 430 KMT for the 1946-1970 seasons; later for 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 544 KMT (Fig. MCH-6).

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

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

Under average fishing rates observed for the 1964-1977 seasons, using VPA techniques, yield per recruit was estimated to be 17.11 grams. Y/R 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). Unweighted mean F values used for age 1-4 were 0.6595, 1.8262, 1.9376, and 2.5226, respectively. 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 currently underway in Louisiana (V. Guillory) addresses environmental influences upon survival of young fish.

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 Table MCH-7.

III.4.1. Current Status

The Gulf fishery is currently fully exploited and appears to be reasonable 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 1982 season is 650 KMT. Caution is warranted since the forecast landing is 100 KMT above the estimated MSY. Increases in effort could lead to problems in sustained yield from the population.

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 Fishery Management Commission (GSFMC) in 1977 (SAW/82/MCH/7). Management of the fishery is by 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 in turn informs the management board (state fishery agency personnel) if and when any action is required.

IV. EFFECT OF CURRENT MANAGEMENT PRACTICES

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 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 evaluate the effects of any management measures adopted and offer management recommendations as deemed necessary.

V. RECOMMENDATIONS

V.1. Data Needs

SAW/82/MCH/7 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 included: (1) monitoring of the fishery for information on age, size, catch, juvenile abundance, fishing effort, migrations, and in general the well being of the resource; (2) determining, if possible, an effective unit of fishing effort; and (3) estimating the MSY. These items have received top NMFS efforts and funds and considerable progress appears to have been made. The states are principally monitoring the estuarine habitat and performing law enforcement activities. Louisiana and Texas also conduct juvenile surveys and other biological research as noted above. 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 understanding of the resource. (The Gulf shrimp fishery bycatch should be examined for Gulf menhaden, but see "Coastal Herrings" review which follows for a more detailed work project.

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

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". 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 and SAW/82/MCH/5.

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. 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 and SAW/82/MCH/5. 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 (*Anchoa hepsetus*)

This anchovy is somewhat 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, which grows to around 150 mm in length, 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 Herring (*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) ranges from 150 to 1500 KMT (SAW/82/MCH/5).

III.2.2. Scaled Sardine (*Harengula jaguana*)

This small fish (usually _ 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 (SAW/82/MCH/5) estimates potential yield for the whole Gulf at 150-650 KMT. Total mortality was estimated to be 1.08, with the average age in the population being 1.83 years and age of recruitment 0.9 years. Size at age data are available for both sexes (Table MCH-8); maximum size may be as long as 300 mm in length.

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 (SAW/82/MCH/5) estimates potential yield from the Gulf at about 400 KMT annually. Total mortality is estimated to be 1.37, with the average age in the population being 1.63 and the age of recruitment being 0.9. Length at age data are available (Table MCH-8). Maximum size appears to be about 225 mm in the Gulf, while fish in eastern Atlantic populations may exceed 300 mm.

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 or northwestern Gulf. A directed bait fishery in Florida lands less than 500 MT annually. Potential yield from the Gulf is about 120 KMT annually, with 100 KMT from the eastern Gulf. Recruitment occurs at an age of about six to nine months. Total instantaneous mortality is estimated to be 1.09 with an average population age of 1.69 years and recruitment at 0.5 years. Length at age data are available (Table MCH-8). This species is a very important prey for reef and coastal pelagic piscivorous fishes.

III.3.2. Rough Scad (*Trachurus lathami*)

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 (*Chloroscombrus chrysurus*)

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 in place. Authority mixed between states and MFCMA depending upon species and area in which 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 begin determining population age structures, growth rates and natural mortality rates. 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 food of predator fishes in the Gulf of Mexico. Their role in food chain dynamics and their importance in sustaining the predator populations needs 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 catch in the Atlantic menhaden fishery, 1955-81.

Year	Fishing Effort (vessel-weeks)	Total Catch (thousands of MT)	Catch (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

Table MCH-2. Atlantic menhaden purse seine landings by area, 1940-1981.

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]		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						380.4

[1]Combined to retain confidentiality of landings data
SOURCE: ASMFC 1981, added 1981 values

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 1974-76 fishing season at an array of ages of entry, expressed as percentages of current yield per recruit. (Source: ASMFS 1981)

Age at Entry	Percent Y/R at F-multiple				
	.50	.75	1.0	1.25	1.50
2.0	16	18	16	14	13
1.5	13	13	11	8	6
1.0	10	8	4	0	-3
0.5	7	5	(77.57 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 rates for the 1974-76 fishing season. (Source: ASMFC 1981)

Area	Current (g)	Age of Entry 1.0	1.5	2.0
		Change (%)		
North Atlantic	9.66	6	24	45
Middle Atlantic	12.07	6	24	45
Chesapeake Bay	37.53	6	11	12
South Atlantic	13.80	6	0	3
N.C. Fall Fishery	4.11	-30	-19	-51
TOTAL	77.57*	4	11	16

*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 calculates overall Y/R instead of simply summing the areas. Thus, differences are due to rounding.

Table MCH-5. Estimated number of Atlantic menhaden spawners, number of eggs produced, and number of fish recruited at age 1 for the 1955-75 year classes from VPA with M = .40. (Source: ASMFC 1981)

YEAR CLASS	Estimated Number of Spawners (in thousands)	Estimated Number of Eggs Produced (in trillions)	Number of Recruits at Age 1 (in thousands)
1955	1,619,999	181.60	5,342,764
1956	1,214,417	142.22	6,645,566
1957	580,361	78.80	3,070,584
1958	437,673	48.60	13,906,034
1959	1,108,727	87.43	2,021,986
1960	626,859	71.91	2,827,775
1961	2,788,975	152.85	2,093,833
1962	1,162,970	110.71	2,113,109
1963	375,225	45.82	1,651,159
1964	180,752	19.28	1,802,819
1965	126,957	11.40	1,308,699
1966	59,863	4.59	1,836,736
1967	121,183	10.97	1,186,185
1968	188,187	17.00	1,583,598
1969	125,693	16.87	2,556,678
1970	143,751	15.97	1,386,416
1971	195,856	22.88	3,349,700
1972	272,175	26.58	2,551,916
1973	111,289	11.36	2,804,031
1974	95,375	12.97	3,348,387*
1975	107,633*	8.88*	7,214,126*
1976	143,084	7.10*	

*Preliminary estimates

Table MCH-6. Fishing effort and catch in the Gulf menhaden fishery, 1946-81.

Year	Fishing Effort (Thousands of Vessel-Ton Weeks)	Total Catch (Thousands of Metric Tons)	Catch/Vessel-Ton Week (Thousands)
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	578.6	1.19
1975	535.6	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	623.7	701.3	1.12
1981	619.8	552.6	0.89

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

Year	Number at Age (Millions) 2	3	4	Total Spawners (Millions)	Number of Eggs (Trillions)	Spawning Biomass (Metric Tons)	Resultant Recruitment (Millions)	Recruitment Biomass (Metric Tons)
1964	2,696.3	206.4	7.2	2,909.9	36.0	305,468	12,887.8	410,347
1965	1,749.9	138.2	9.7	1,897.8	23.7	200,150	7,519.5	239,421
1966	1,461.1	55.1	6.8	1,523.0	18.4	156,426	12,138.2	386,480
1967	722.2	18.2	-	740.4	8.8	74,980	12,090.0	384,946
1968	1,644.3	62.6	0.2	1,707.1	20.4	174,407	25,424.7	809,522
1969	1,994.4	58.7	-	2,053.1	24.4	208,518	16,396.8	522,074
1970	5,026.0	67.8	-	5,093.8	59.7	511,669	20,898.9	665,134
1971	3,472.8	382.4	2.9	3,858.1	48.8	412,040	12,618.5	401,773
1972	3,565.8	239.0	3.4	2,608.2	32.8	277,323	19,889.0	633,266
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	61.6	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	46.5	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)	(61.0)	(543,194)		

( ) Preliminary Estimates
Source: Nelson and Ahrenholz (1981)

Table MCH-8a. Estimated lengths and weights at age for coastal herrings, based on 1981 samples. Lengths were back calculated from otolith-fork equations and weights were then determined from length-weight relationships.

Species	Age	Fork Length (mm)		Weight (g)	
		Males	Females	Males	Females
Spanish sardine	1	97.0	93.8	11.8	10.6
	2	143.4	144.5	39.6	40.6
	3	168.7	166.5	65.6	63.0
Thread herring	1	105.8	108.5	17.3	18.8
	2	151.7	160.8	55.1	66.5
	3	178.7	190.3	93.4	114.3
	4	-	203.6	-	142.0
Round scad	1	135.5	136.7	31.5	32.4
	2	160.4	159.3	53.4	52.3
	3	169.4	-	-	63.4

Table MCH-8b. Age composition of 1982 catches of coastal herrings, based on random samples of aged fish.

Species	Age	Number in Sample	Estimated Percent in Age Group
Spanish sardine	0+	174	24.4
	1+	355	49.9
	2+	176	24.7
	3+	7	1.0
		712	
Thread herring	0+	12	3.2
	1+	250	67.2
	2+	92	24.7
	3+	17	4.6
	4+	1	0.3
		372	
Round scad	0+	863	65.8
	1+	340	25.9
	2+	105	8.0
	3+	3	0.2
		1311	

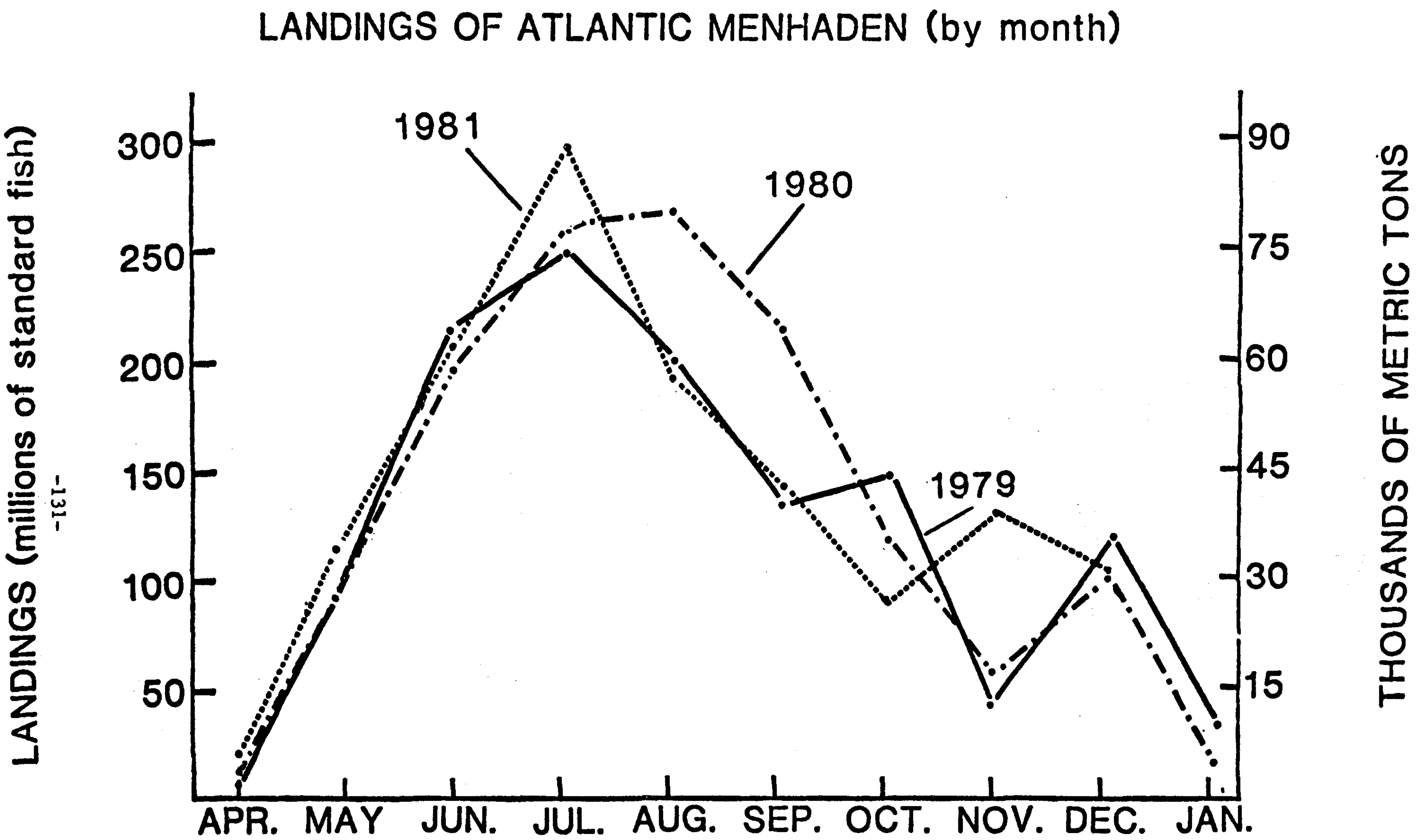


Fig. MCH-1. Landings of Atlantic menhaden by month in 1979-1981.

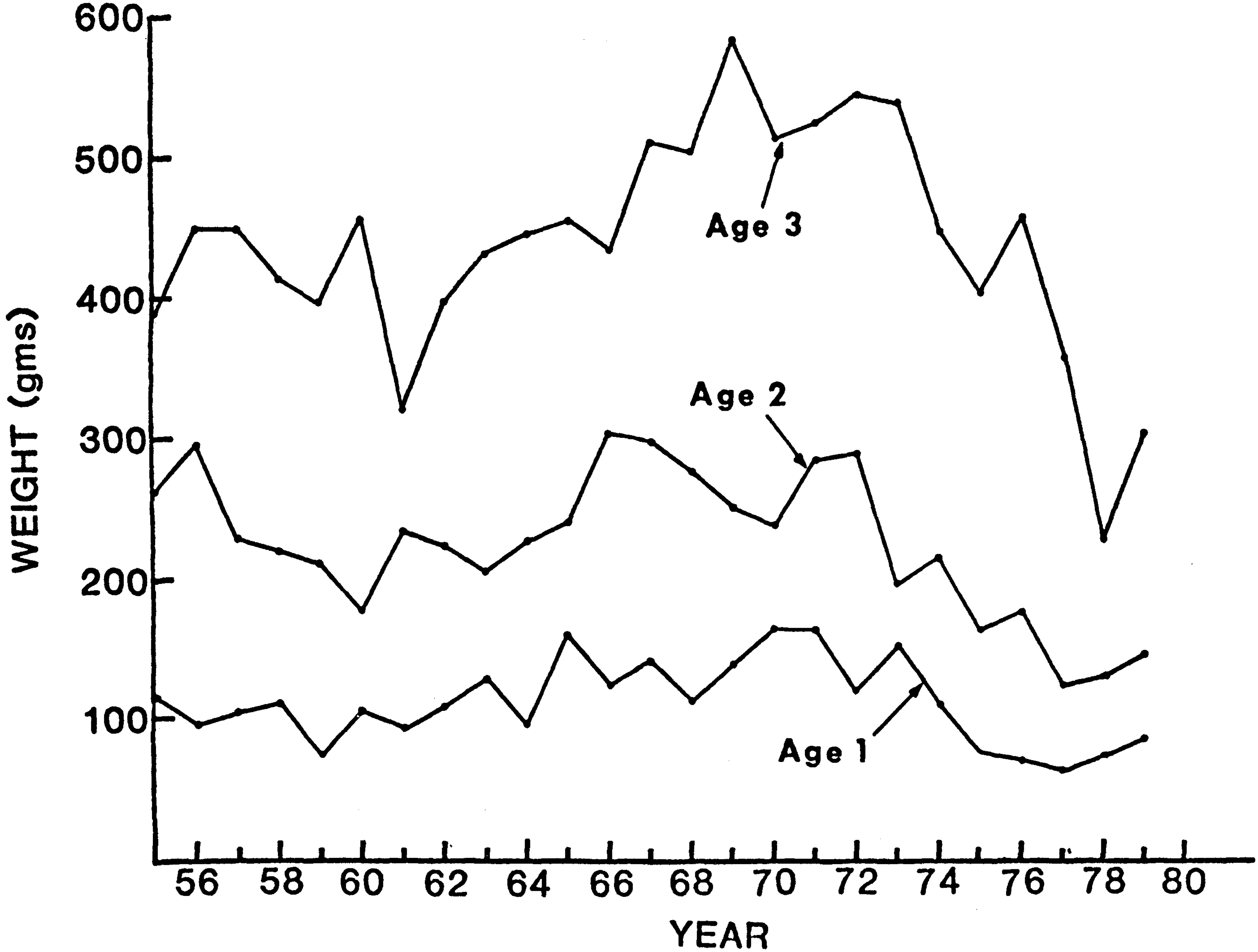


Fig. MCH-2. Average weight by age of Atlantic menhaden versus year.

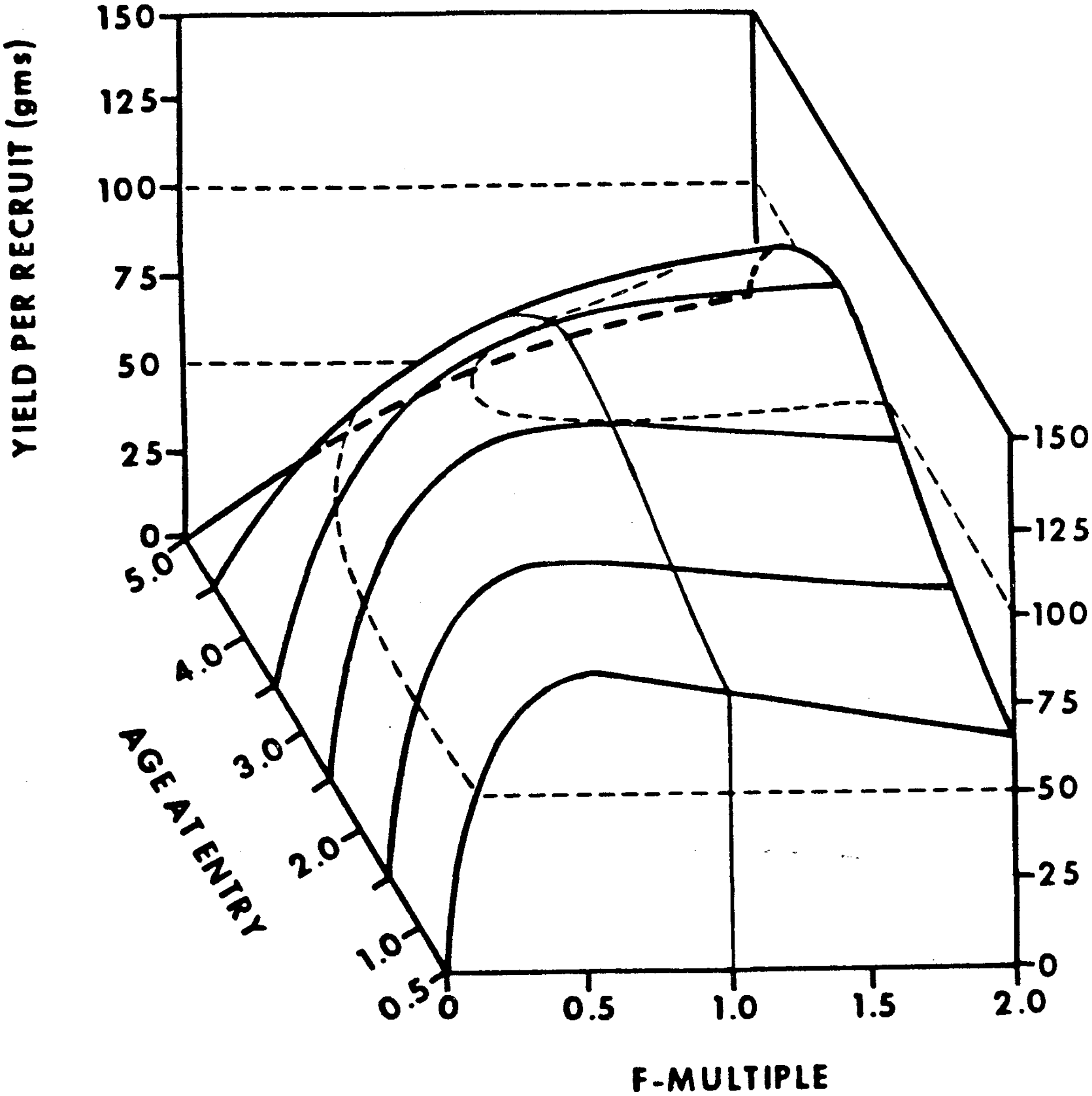


Fig. MCH-3. Overall yield per recruit of Atlantic menhaden under current conditions (F-multiple of 1.0, and age at entry of 0.5) using average fishing mortality values by quarter and area for the 1974-1976 fishing seasons.

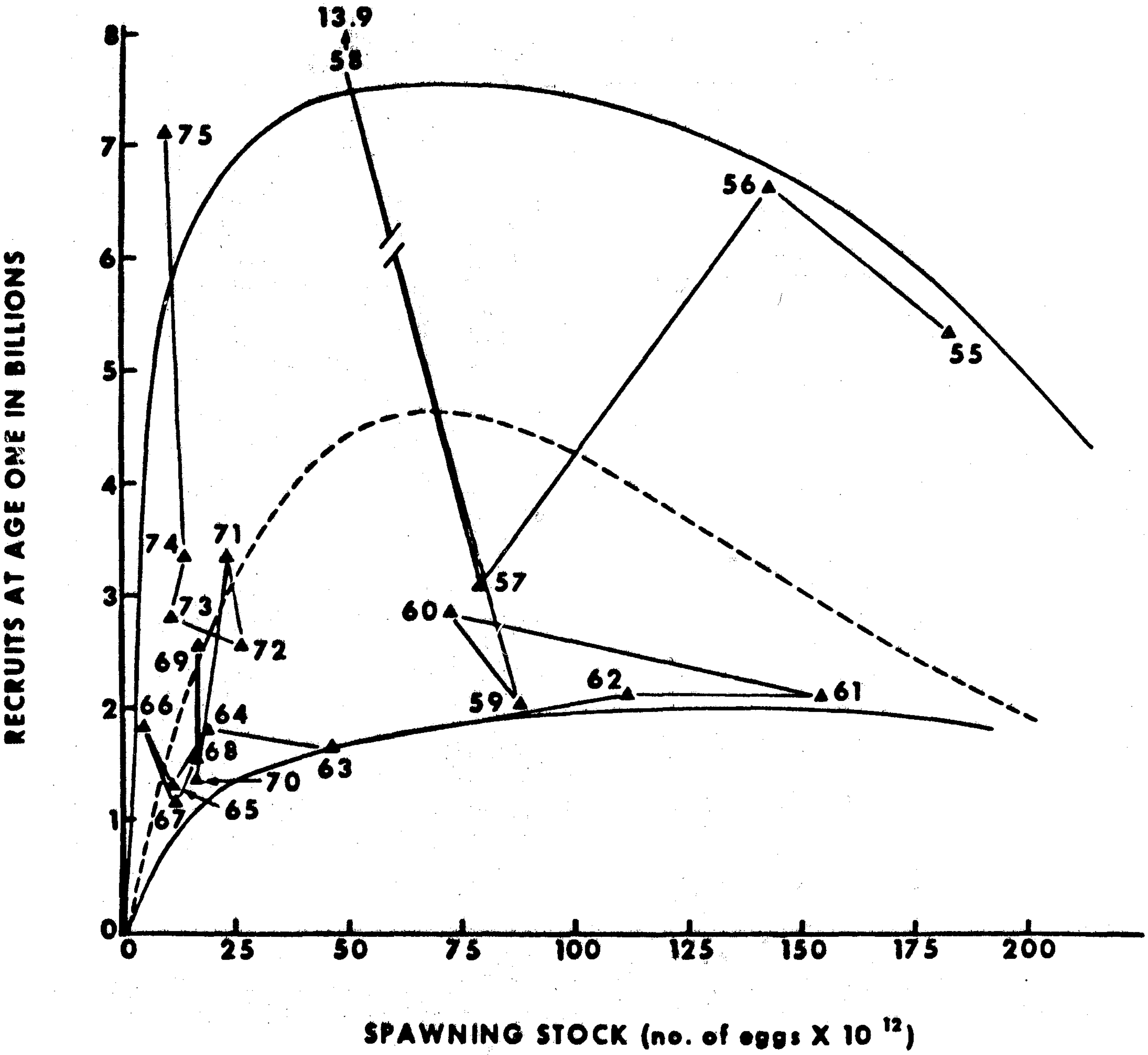
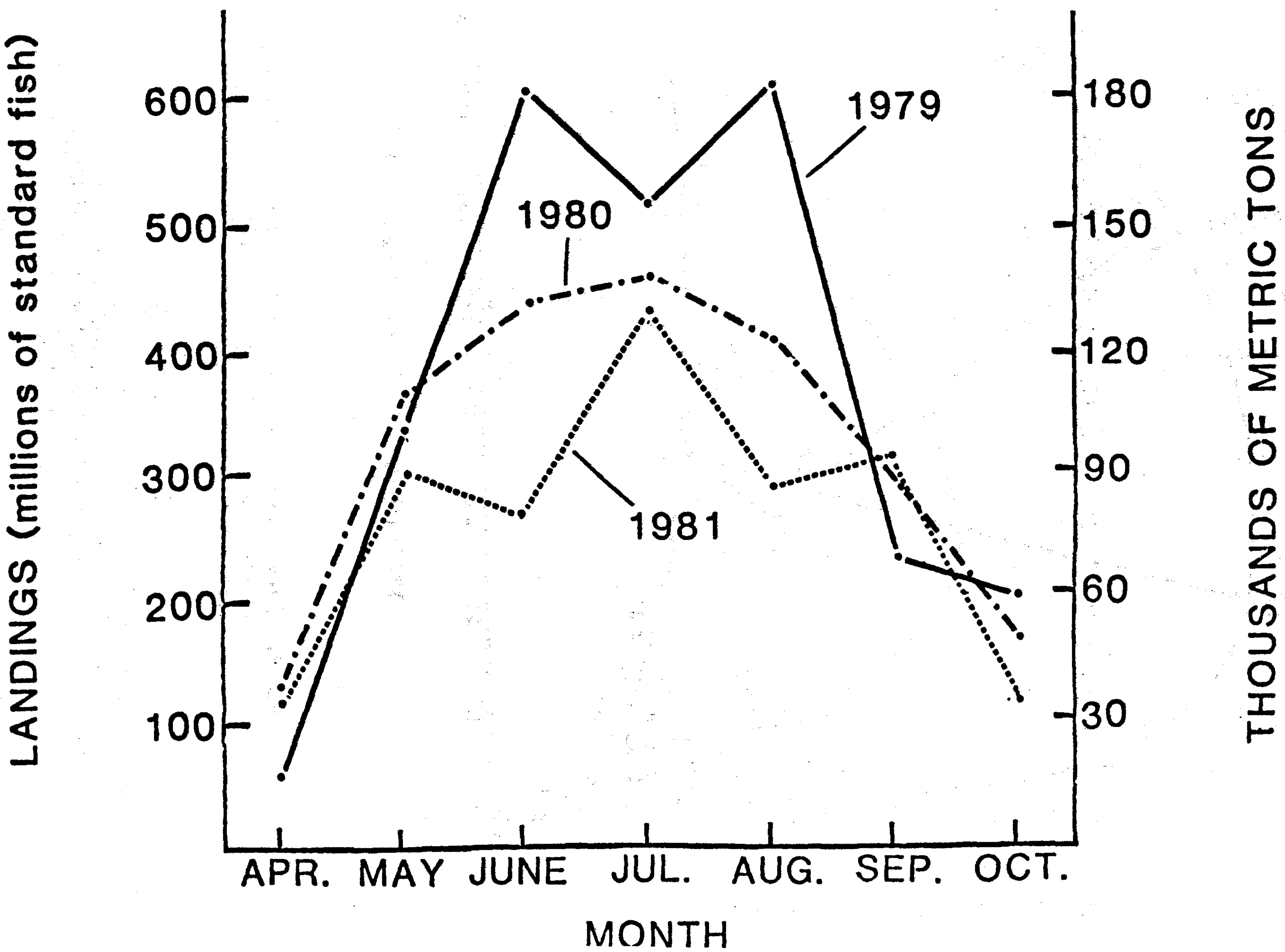


Fig. MCH-4. Stock-recruitment relationship of Atlantic menhaden. Dashed line is fitted Ricker curve. Solid lines are approximate confidence intervals.

LANDINGS OF GULF MENHADEN (by month)

Fig. MCH-5. Landings of Gulf of Mexico menhaden by month in 1979-1981.



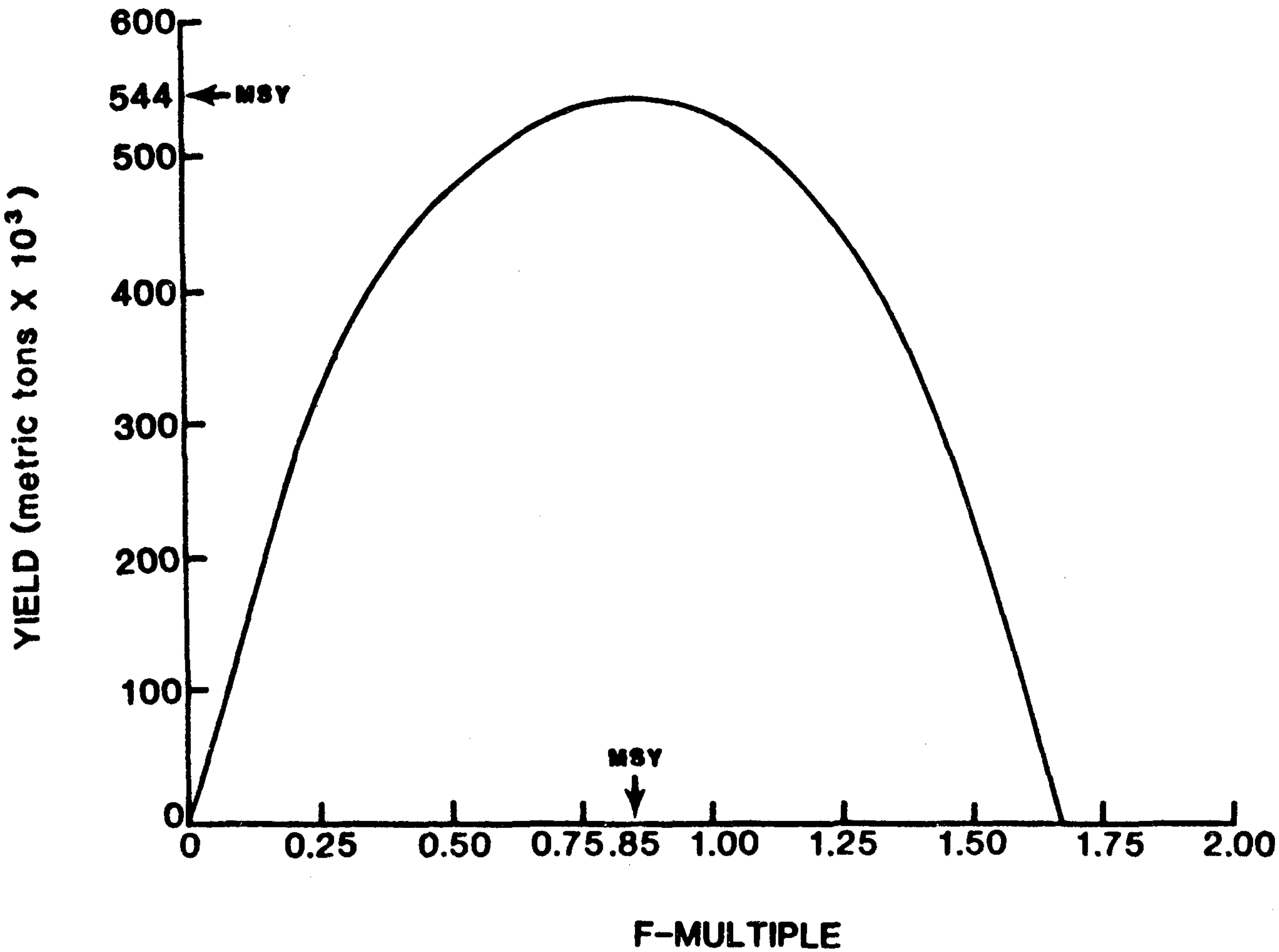


Fig. MCH-6. Sustainable yield predicted by a deterministic population simulation model of the Gulf menhaden fishery at multiples of the average fishing mortality (F-multiple = 1.00) for the 1964-1977 fishing season. See SAW/82/MCH/8.

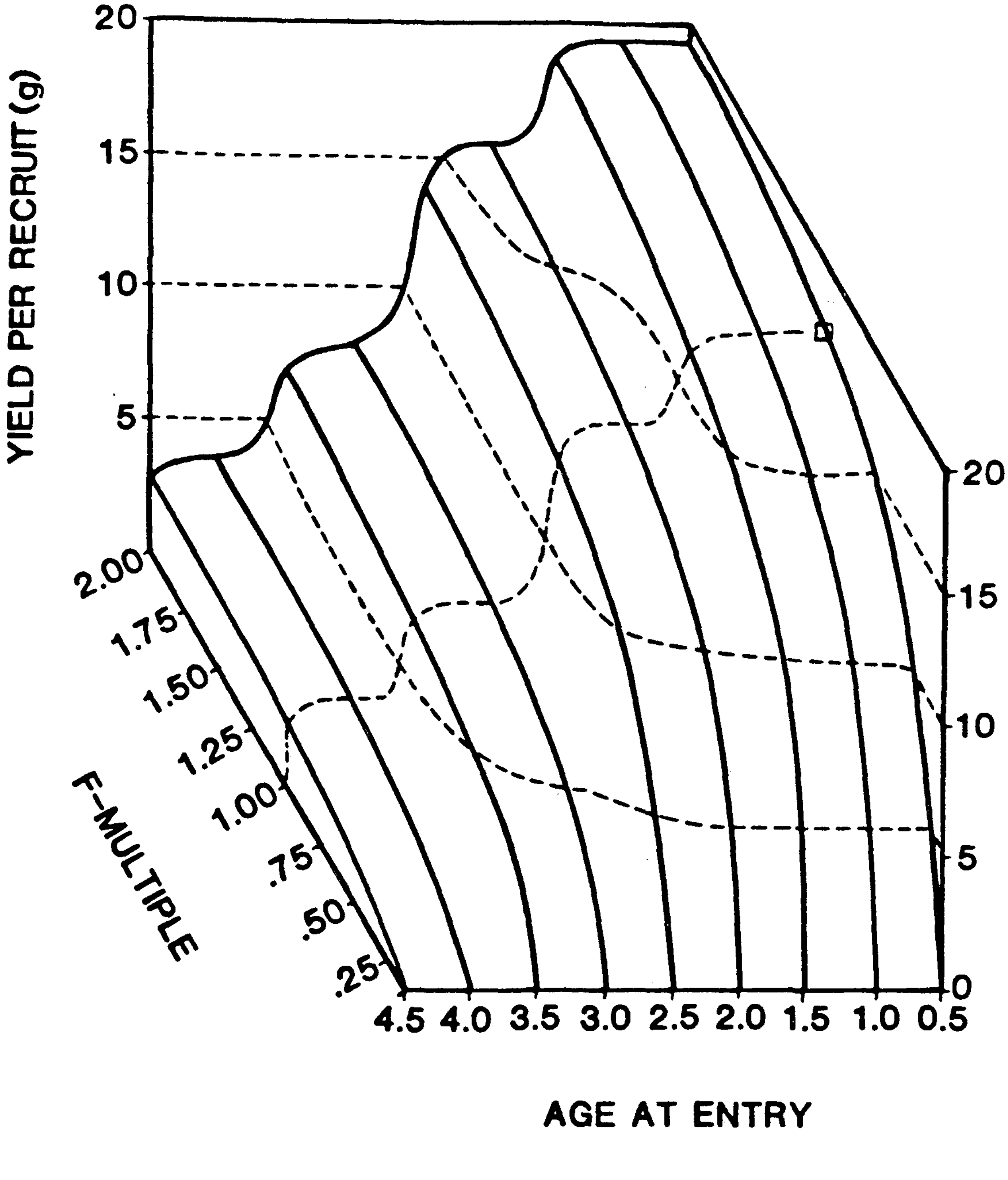


Fig. MCH-7. Yield per recruit of Gulf menhaden under average conditions of growth and with multiples of average fishing mortality by 3-month interval (F-multiple = 1.00) for the 1964-1977 fishing seasons (average conditions indicated by □).

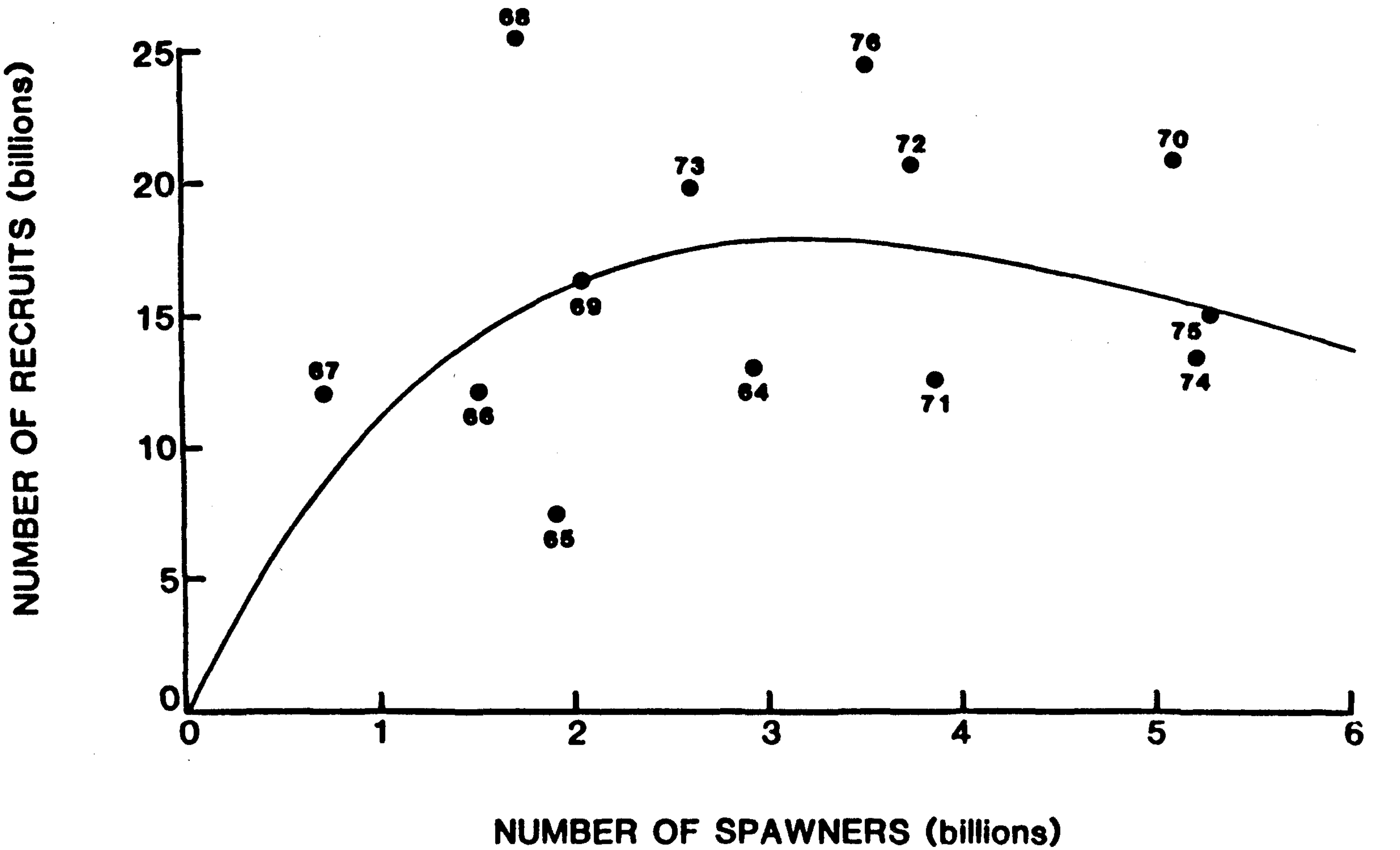


Fig. MCH-8. Ricker spawner-recruit relationship for number of spawners and recruits at age 1 of Gulf menhaden estimated as of January 1, for the 1964-1976 Gulf menhaden year classes.

REEF FISH AND REEF RESOURCES (RFR)

REEF FISH OF THE SOUTH ATLANTIC REGION OF THE UNITED STATES

I. DESCRIPTION OF FISHERIES

Fisheries for reef fish and other 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 Straits and Gulf Stream. The majority of effort is 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 gears: (1) hook and lines, (2) traps, (3) trawls, and (4) bottom longlines. Additional minor commercial activities include spearfishing and capturing spiny lobsters by hand by divers and a gill net (locally called "stab net") fishery off the east coast of Florida.

In 1979, 17 hook and line vessels landing catches of snappers and groupers were based in South Carolina. An estimated twenty North Carolina vessels and two Georgia vessels were engaged in the hook and line fishery. The NMFS reported a total of 1,071 hook and line vessels and boats along the east coast of Florida, including Monroe County, in 1979.

The trap fishery north of Cape Canaveral is directed primarily at black sea bass, while that off the east coast of Florida and the Florida Keys targets mainly large groupers, particularly red and black groupers, and gags, and makes significant catches of gray and mutton snappers. Currently there are about 50 vessels active in the sea bass trap fishery (off the Carolinas) and in 1980 there were 108 vessels fishing 4000 traps for reef fish off Broward, Dade, and Monroe Counties, Florida. The present number of Florida trap boats is unknown but fewer than in 1980.

About 30 vessels trawl for reef fish between Cape Fear and Cape Canaveral. In 1981 there were about 5-10 vessels using bottom longlines off North and South Carolina and 25-35 off Florida.

I.2. Recreational

In the recreational fishery there are approximately 46 head boats operating between Cape Hatteras and Cape Canaveral, and approximately 49 between Cape Canaveral and Key West.

In 1979, there were 134 charter boats operating in North Carolina, 49 in South Carolina, 30 in Georgia, and approximately 428 along the east coast of Florida. Only about 11 percent of the total effort of the North Carolina charter boat fleet in 1979 was bottom fishing.

The number of private vessels engaged in the recreational fishery is unknown but large (100,000). Recent estimates of landings of South Atlantic reef fishes in the recreational catch are given in Table RFR-1. Recreational fishing effort consists primarily of hook and line fishing, spearfishing, and catching spiny lobsters by hand. A considerable proportion of the diving effort utilizes SCUBA.

II. STOCK STRUCTURE

Habitat suitable for colonization by reef fishes off the Atlantic coast of the United States occurs on the continental shelf from Key West, Florida northward to Cape Hatteras, North Carolina. Well-developed coral reefs extend from Key West to Miami, giving way to lower-relief, rocky ledges with minor scleractinian coral growth, sponges, and octocorals through northern Florida, Georgia, and the Carolinas to Cape Hatteras. The Florida Straits, and further north the Gulf Stream, usually flow within one to sixty miles of shore in this region, maintaining subtropical/tropical oceanographic conditions on the shelf. At Cape Hatteras, the Gulf Stream turns eastward, creating a subtropical/temperate ecotone. Distributions of South Atlantic reef fish are in general sharply curtailed north of this ecotone.

Factors which appear to regulate the distribution of snapper and grouper species in the South Atlantic region include water temperature and depth. Both juvenile and adult movement of these species has been noted using tagging studies and underwater observation; however, these movements appear to be within the confines of the oceanographic characteristics of the South Atlantic region. Snappers and groupers appear to change locations mostly in the space/time scale of diurnal migrations and patch to patch movements.

The extent to which South Atlantic region reef fish may be treated as a unit system, that is, where fishing in other areas has little or no effect on South Atlantic stocks and where subgroups within species have homogeneous population characteristics, largely depends on the source(s) and transport of larva. The distribution of larval reef fish in space and time in the South Atlantic region is not well understood. Quite likely, the distribution of larval reef fishes is affected by oceanographic features such as the Gulf Stream. If these features were to cause significant mixing between ocean masses, then it would be invalid to consider the South Atlantic reef fish species as separate stocks. However, at present there is no conclusive evidence, such as electrophoretic studies demonstrating common genetic characteristics between stocks of the same species, that oceanographic features are significant factors in distributing larval reef fishes between the South Atlantic region and other ocean masses. The possibility that subgroups are separable by genetic or other population characteristics exists within the same species in the South Atlantic region has also been poorly investigated. Therefore, as a working hypothesis, species of reef fishes in the South Atlantic region may presently be assumed to be single stocks which are addressed as units independent of other stocks of the same species in other areas.

III. STATUS OF STOCKS

III.1. Population Parameters

The von Bertalanffy growth model has been fitted to age-length data for a variety of reef fishes of the South Atlantic Bight: red porgy, vermilion snapper, white grunt, red snapper, black sea bass, red grouper, gag and tomtate (SAW/82/ RFR/1, SAW/82/RFR/4). A range of natural mortality rates were also estimated for all these species except tomtate using available catch curve data, relationships between the natural mortality rate (M) and the growth constant of the von Bertalanffy growth equation (K), and published estimates (SAW/82/RFR/1). Range of estimates of the fishing mortality rate (F) for all these species except tomtate was estimated using the relationship of Z, F and M for the years 1972-75 (SAW/82/RFR/1). Total mortality rates have been estimated for tomtate for the years 1974-78 (SAW/82/RFR/4). The average for these years was $Z = 0.89$.

III.2. Catch Per Unit Effort Trends

No CPUE trends have been examined.

III.3. Stock Assessment Analyses

III.3.1. Yield Per Recruit Analysis

Beverton-Holt equilibrium yield per recruit relationships were calculated for a range of values of age of recruitment, fishing mortality rate and natural mortality rate (SAW/82/RFR/1). Table RFR-2 lists the parameters used and the geographic location(s) of the data necessary for their estimation. It should be noted that the South Atlantic Fishery Management Council in cooperation with the National Marine Fisheries Service recently calculated Beverton-Holt equilibrium yield per recruit relationships for these eight species and also gray snapper, yellowtail snapper, speckled hind, scamp, red hind, and graysby for the South Atlantic snapper-grouper complex FMP.

III.3.1.1. Red Porgy

Age at recruitment varied from 2.1 to 5.0 years depending on gear. Age of maturity of females was estimated as 5.0 years. Most recent measurements of F, obtained by subtracting M from Z, ranged from 0.30 to 0.45 for 1972-74. At these levels of F when M = 0.35, only marginal gains can be made in yield per recruit by manipulating the age of first capture (Fig. RFR-1). If F is higher then the relative importance of manipulating the age of recruitment to maximize yield per recruit increases. If M equals 0.20 at 1972-74 F levels and higher, yield per recruit can be improved substantially by increasing the age of recruitment. It is likely that present values of the fishing mortality rate exceed those of 1972-74.

III.3.1.2. Vermilion Snapper

Age of first capture to the fisheries appear to be 3.3 to 4.5 years depending on gear, perhaps somewhat less for the trawl fishery. A range of estimates of M from 0.25 to 0.5 are available. This implies, based on the relationship Z = F + M, that the 1972-73 average estimate of F ranged from 0.27 to 0.42. If M = 0.25 at 1972-73 F levels, 80% of the maximum possible yield per recruit at the current age of recruitment was obtained (Fig. RFR-2). Increasing the age of first capture did not increase yield per recruit at these F levels for M = 0.25 and M = 0.40.

III.3.1.3. White Grunt

Estimated age of first capture was 4.4 to 5.9 years. Estimated M ranged from 0.37 to 0.57. Average F, estimated from Z - M for the years 1972-75, ranged from 0.16 to 0.36. At these F levels and estimated M values 66% to 84% of the maximum possible yield per recruit at the current age of first capture can be achieved without changing the age of first capture (Fig. RFR-3).

III.3.1.4. Red Snapper

Red snapper recruit to the fisheries at five to six years. The natural mortality rate was estimated to be in the range 0.16 to 0.25. The fishing mortality rate was assumed to be in the range 0.25 to 0.40. At these F levels and age of first capture, 91% to 95% of the maximum possible yield per recruit will be harvested (Fig. RFR-4).

III.3.1.5. Black Sea Bass

Approximate recruitment age of black sea bass is four years. M estimates ranged from 0.3 to 0.5. Low (1981) suggested F was at least 0.3 in 1978-79. At this level of F and age of first capture, 80% of the maximum possible yield per recruit is harvested (Fig. RFR-5).

III.3.1.6. Red Grouper

Red grouper from the Campeche Bank were used for this yield per recruit analysis. However, it was believed that the red grouper is a general model for the Y/R responses of the *Epinephelus* groupers. M was estimated to range from 0.16 to 0.24. The model suggests a maximum yield per recruit of about 1300 g at F = 0.3 and an age of first capture of eight to ten years (Fig. RFR-6). Most of this yield (77% of the maximum possible) can be taken if F is as small as 0.1 and age of first capture vary from 4 to 10 years.

III.3.1.7. Gag

Age of first capture of gag occurs as early as one year, but on average occurs between three and six years. M is estimated to be in the range of 0.20 to 0.35. If F = 0.3 at M = 0.2 and age of first capture is three to six years, then 83% of the maximum possible Y/R will be harvested (Fig. RFR-7). The gag model is likely to be similar to other *Mycteroperca* groupers.

Both *Mycteroperca* and *Epinephelus* groupers are usually protogynous; it is important to prevent overfishing to the extent that too few individuals reach the age of sex change, which could harm the reproductive capacity of the stock.

IV. EFFECT OF CURRENT REGULATIONS

Florida has banned the construction and use of fish traps and has a 12-inch (total length) minimum size limit for red, black, and Nassau groupers, gags, and jewfish. Presently there are no regulations on reef fish fisheries in the FCZ of the South Atlantic region. However, the South Atlantic Fishery Management Council has recently voted to pass laws on minimum mesh sizes for trawls and fish traps, zones where fish traps are and are not permitted, minimum sizes for black sea bass, yellowtail, red, and vermilion snappers, and red and Nassau groupers, and possibly protection of large jewfish. At present it appears that most of these laws will be in effect by January 1, 1984. There has been no evaluation of the effect of current regulations on the status of reef fishes in the South Atlantic region.

V. RECOMMENDATIONS

V.1. Data Needs

Catch and effort statistical collection needs to be improved to include catch by species, commercial gear, sex and size, effort by time and area strata. Special emphasis should be placed on obtaining catch data from the recreational fisheries.

V.2. Research

(1) Resource survey approaches to determining indices of abundance should continue to develop to establish time series of sufficient length and replication to separate statistically significant changes from sampling variance (SAW/82/RFR/5). Research in this area should include methods of direct observation (submersibles, television, and divers) to establish fisheries production per habitat type, methods of quantifying habitat by type and optimal sampling schemes to assure the process is cost effective. Trawl and bottom longline data should be used for abundance estimates both in areas where direct observations are and are not feasible in order to correlate the results with those obtained by direct observation and to obtain interpretable results where direct methods are not possible.

(2) Estimation of age-reproduction relationships are needed to determine the effect of protogyny. Simple sex determination may require histological research.

(3) Estimation of annual current mortality rates are needed.

(4) Research on stock definition is needed, to be addressed perhaps through selective tagging programs and/or larval surveys.

(5) Research is needed to address the problems of fishing on multiple species systems where there are shifts in species dominance and multiple equilibria. Strategies for managing these systems must be developed.

V.3. Management

Yield per recruit analyses showed that for several reef fishes, there is potential for measurably increasing yield per recruit by increasing the age of first capture if fishing mortality rates are above those of the middle 1970's, if the population parameters are relatively constant throughout the South Atlantic region, and fishing and other activities outside this area have little or no effect on South Atlantic reef fish stocks. This option should be explored.

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 are enumerated in Table RFR-3. 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. Squirrel fishes, 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 1974 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). 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. Since 1979 the trend may have reversed, but final data are not yet available (Table RFR-4).

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 catch and effort data and due to the problems of stock identification discussed in the previous section. 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

Some CPUE and effort data for the St. Croix and St. Thomas shelves were presented to the workshop (D. Olsen, personal communication). These data represent the total catch of reef fishes in these areas and total number of traps used within a year. The trap fishery comprises approximately 80% of the total catch of reef fish (D. Olsen, personal communication). CPUE shows a decline as the number of traps increases (Fig. RFR-8). There also has been a trend of declining CPUE and increasing effort over time (D. Olsen, personal communication). Additionally, the CPUE per unit area indicates that the St. Thomas shelf has been only approximately 25% as productive as the St. Croix shelf.

These data are complicated by the fact that a trap-year is not a very good measure of the actual use of the trap, i.e., effective effort. Also, the catch encompasses many species which may have switched dominance in the catch and/or in the populations over the time series. However, the observed declines are very marked. This fact, coupled with local perception of the availability of reef fishes, indicates that the resource may have declined significantly.

III.2. Puerto Rico Reef Fish

The CPUE of trap fisheries in Puerto Rico are of a similar scale as those of the U.S. Virgin Islands. Although there is some uncertainty about landings levels since 1979, it appears that the total catch has declined over that period (Ignacio Morales-Santana, personal communication). Since the amount of effort did not appear to have changed substantially, and since this period followed a period of increasing trend in the catch from 1971 to 1978, then this may indicate that the fishery is declining in productivity.

III.3. Spiny Lobster

The average size of landed lobsters in Puerto Rico was declining in the period prior to 1978 (Arthur Dammann, personal communication). In the U.S. Virgin Islands, where there was a minimum size limit in effect, the average size was relatively constant during the period and somewhat larger than that of Puerto Rico.

Size frequency surveys were conducted throughout Puerto Rico and the U.S. Virgin Islands in 1980/81. A similar survey was conducted in Puerto Rico in 1978/79. Much smaller surveys were done in St. Thomas-St. John and St. Croix in 1978. The results of these surveys were reported (SAW/82/RFR/3). The average size in the Puerto Rican landings increased between the two survey periods. However, the increase may have been influenced by the fishermen's perception that an impending size limit was already in effect. Thus, it is premature to conclude that the mortality rate has decreased or that there has been a response of the lobster stocks. However, the limited data available do not indicate that there is any immediate danger to the spiny lobster resource.

IV. EFFECT OF CURRENT REGULATIONS

The U.S. Virgin Islands has a minimum carapace size limit of three inches on spiny lobsters. 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.

V. RECOMMENDATIONS

V.1. Data Needs

Data needs given for the South Atlantic region are also needed for Puerto Rico and the U.S. Virgin Islands. However, special emphasis should be given to obtaining catch by species and size statistics for the smaller reef fishes utilized more fully in this area.

V.2. Research

Research recommendations are the same as those for the South Atlantic Bight with special emphasis on developing strategies for managing multispecies assemblages and on the effects of ciguatera on the fisheries and consequent dynamics of the fishery, with emphasis on size selective harvesting.

V.3. Management

Available data do not allow definitive statements on status of reef fish resources in the U.S. Virgin Islands and Puerto Rico. However, apparent declines in total fisheries productivity and CPUE with increasing effort in selected shelf areas indicate that the resources may be approaching or have surpassed their maximum productivity. This situation bears careful monitoring.

GULF OF MEXICO REEF FISH

I. DESCRIPTION OF FISHERIES

The fishery for reef fishes in the Gulf started in the 1850's and has expanded in both area and species targeted since that time. Landings of snappers since 1965 have declined (from 14.8 thousand tons in 1965 to 7.7 thousand tons in 1974), but landings of groupers have been steady (12 thousand tons) (GMFMC, 1981, Table 10). Catch trends of some individual species (e.g. red snapper) declined by a factor of two between 1965 and 1976. Changes in the fishery in recent years have included an increase in the number of recreational fishermen, who fish primarily in nearshore areas; a shift of the commercial hand line fishery to deeper, offshore, or more distant waters; and the introduction of bottom longlines and fish traps as new gear types in the fishery.

Reef fishes (snapper, grouper, and similar species) in the Gulf of Mexico inhabit mainly reef or hard bottom areas of the continental shelf. Reef fishes are the target of important fisheries in the Gulf. These fisheries comprise approximately 1700 commercial fishermen (FMP 1981) and many of the estimated 3.2 million recreational fishermen who fish in the Gulf (Fisheries of the U.S., 1981). Commercial fishermen use hooks and lines, bottom longlines and traps. Recreational fishermen and commercial-recreational fishermen who operate charter and head boats use hooks and lines and spears. A foreign fishery primarily for groupers, and to a lesser extent for snappers operated off west Florida prior to 1976 and took an average of 1800 tons per year.

II. STOCK STRUCTURE

As with the South Atlantic region reef fishes, movements of adult and juvenile reef fishes have not been marked, and the distribution of larvae is not well understood. Also, the interchange with Mexican fisheries is not known. Therefore, as a working hypothesis the Gulf of Mexico reef fishes may presently be considered as single stocks of fish. However, this is largely conjecture.

III. STATUS OF STOCKS

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 has remained fairly stable over the years 1965-74 (GMFMC 1981).

III.3. Stock Assessment Analyses

III.3.1. Production Model Analysis

Some stock assessment work has been done on the reef fish resources in the Gulf of Mexico FCZ (GMFMC 1981). In particular, production models were fitted to the aggregated catch and effort data on snappers and groupers combined and on sea bass. The former analysis indicated that snapper-grouper production was relatively stable at approximately 51 million pounds per year during the years 1965-74. Production may well be approaching a maximum (GMFMC 1981). Sea bass production was estimated as 500,000 pounds annually.

III.3.2. Yield Per Recruit Analyses

No yield per recruit analysis was presented for Gulf of Mexico reef fish. However, it can be assumed that the response of the stocks will be similar to that of South Atlantic region reef fishes of the same or similar species.

III.3.3. Fishery Independent Indices

SAW/82/RFR/5 presents a summary of indices developed from (1) bottom longlining, and (2) trawl surveys. Additionally, comparisons were made with small scale studies using submersibles, traps, handlines, and mark-recapture methods.

The trawl survey estimates indicate that the mean size of juvenile red snapper, the range of sizes in the catch and the biomass were variable from 1973 to 1981, but show no apparent trend. Estimates of the mortality rate of young of the year red snapper after recruitment to the trawl sampling grounds were made for the 1974, 1975, 1979 and 1980 year classes. The estimates were 72.9%, 78.4%, 97.7% and 99.4%, respectively. The latter two appear to be excessive, leaving the usefulness of the estimates in question.

Estimates of catchability coefficients for traps on *Balistes*, *Epinephelus*, *Calamus* and *Mycteroperca* were presented (SAW/82/RFR/5). These were obtained by examining catch rates of the traps, direct observation of the traps and reef submersible and population estimates from submersible and mark-recapture. Results show the relative greater vulnerability of *Calamus* in this study area (Table RFR-5). Additionally, SAW/82/RFR/5 presented submersible-derived density estimates for eleven species of reef fishes from Rum Reef on Florida middle grounds in the Gulf of Mexico.

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 may be impacted. At the present time the status of individual stocks is 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 given for the South Atlantic Bight are the same as for the Gulf of Mexico with special emphasis on catch by size and species from the important recreational fishery.

V.2. Research

Research recommendations are the same as those given for the South Atlantic region.

V.3. Management

Assuming that yields per recruit are similar between South Atlantic and Gulf of Mexico reef fishes, there may be potential for increasing yield per recruit by increasing the age of first capture. This should be explored.

GULF OF MEXICO 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 of the landings are from southwest Florida and the Keys. While about 2300 permits to land stone crabs in the state of Florida are currently issued annually, it is estimated that about 20% of the permits are used by commercial stone crab fishermen. However, the recreational catch is thought to be very small.

About 200 small boats operated by one or two men and 100 vessels utilizing three men are currently in the commercial fishery. The number of traps used has increased steadily since the 1960's to the present level of about 400,000 traps. The landings have also increased greatly, with recent catches being 1.6 to 2.6 million pounds of claws.

Crabbing is prohibited between May 16 and October 14. There is a minimum claw size of 2 3/4". It is illegal to land whole crabs, except in the Everglades National Park. Both claws are harvested and the live crab returned to the water on the fishing grounds. Within the Park, the whole crab must be held.

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 the catch is from this area. Thus, the fishery is considered to be directed at a single stock.

III. STATUS OF STOCKS

III.1. Population Parameters

No estimates of vital rates were presented.

III.2. Catch Per Unit Effort Trends

Estimated CPUE (total landings divided by total number of traps used per year has steadily declined from over 20 pounds to under 7 pounds of claws per trap year in the last twenty years (Fig. RFR-9). However, this measure may not accurately reflect abundance of stone crabs. The number of traps used each year does not account for infrequent harvesting ("trap pulls") of some traps nor for using some traps only during part of the fishing season. Several factors could influence the number of trap pulls or extent of use during the season: locating traps farther from shore, thus requiring more time and fuel to reach the traps; involvement of some crab fishermen in other fisheries; fishing out of legal sized claws in localized areas; mass migrations of crabs among localized areas; and decreasing value of the claws due to oversupply.

In the 1981-82 season there was a noticable decline in catch per trap pull over the fishing season (Fig. RFR-9) while catch and effort were the highest in twenty years. (Catch per trap pull is estimated from samples of fishermen as the sum of pounds caught in a month divided by the number of times traps were raised. These sample data have been collected in the form of fisherman logbooks only for the past three seasons.) However, even near the end of the season, the catch per trap pull was higher than during the two previous seasons, when no consistent intraseasonal trends were apparent. The high catch per trap pull may have been due to a "bumper crop" or to increased feeding activity of the stone crabs associated with unusually favorable environmental conditions, especially at the beginning of the season. Thus the decline in catch per trap pull could be reflecting a decline in crab activity rather than indexing abundance through the season.

III.3. Stock Assessment Analyses

III.3.1. Production Model Analysis

While there has been a decline in CPUE, there has been a steady, large increase in effort (number of traps) and yield (pounds of claws) since the 1960's (Fig. RFR-10). Increasing yield in spite of decreasing CPUE may be due in part to expansion of the fishing grounds. Production models have been fitted (Fig. RFR-10), but at this time a good measure of effort and expansion of grounds preclude reliable estimates of a production curve and MSY. There is no evidence that the current yield exceeds MSY. However, the fishery may be saturated in some areas since some researchers have indicated that nearly all legal sized claws in localized ares are taken in a season.

IV. EFFECT OF CURRENT MANAGEMENT PROCEDURES

Current management procedures include a minimum legal claw size and a closed season to protect a portion of the spawning stock. The Everglades National Park prohibits declawing female crabs. 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. No conclusive evaluation has been made of the effects of these regulations on the production of the fishery.

V. RECOMMENDATIONS

V.1. Data Needs

(1) Presently, coverage of the catch from logbooks by fishermen and dealers is incomplete and probably not representative. More representative logbook coverage of the catch and effort in space and time is needed in order to determine the location of catch and accurately estimate CPUE. Catch and effort statistics should con tinue to be taken by NMFS port agents since fisherman and dealer logbooks cover less catch then reported by port agents. Either fisherman logbooks or port agent records should indicate catch by statistical grid. Claw size sampling should be done on a continuing basis in order to monitor changes in the size structure of the population.

(2) Claw sizes and effort should be reported by statistical grid by port agents and logbooks.

V.2. Research

(1) Natural mortality rates and mortality of declawed crabs, particularly due to holding on deck before declawing should be investigated.

(2) Investigate studies for estimating growth and claw regeneration rates.

(3) Standardization of effort methods should be investigated.

V.3. Management

No changes in regulations are recommended.

GULF OF MEXICO AND SOUTH ATLANTIC SPINY LOBSTER

No new assessment documents of spiny lobster, Panulirus argus, were presented at the workshop. The following summary taken from the Fishery Management Plan for the spiny lobster fishery of the Gulf of Mexico and South Atlantic (GMSAFMC 1982) synopses the status of stock assessment work on this species.

U.S. commercial and recreational fisheries for spiny lobster are limited primarily to the east and west coasts of 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. Consi-derable quantities of spiny lobster are also taken by hand by recreational and commercial divers using SCUBA, hooka, or free-diving. Commercial divers usually use SCUBA. A small proportion of the recreational catch is from boaters using lights and bully nets at night on shallow flats and bays.

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 identified (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 by GMSAFMC (1982) assume that local spawning is an important element of total recruitment.

Estimates of growth and mortality rates are 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 estimtes of growth rates difficult. GMSAFMC (1982) estimate a growth of 5-8 mm (0.2 - 0.3 inches) in carapace length per molt over approximately four molts per year, or 20-32 mm (0.8 - 1.2 inches) per year. They estimate the von Bertalanffy growth coefficient, K, to be between 0.2 and 0.3.

Total mortality (Z) estimates for the Florida spiny lobster population range from $1.72 \leq \bar{Z} \leq 2.73$ for K = 0.20 to $2.59 \leq \bar{Z} \leq 4.09$ for K = 0.30. Published estimates of natural mortality ($\bar{M}$) range from 0.26 to 1.03. GMSAFMC (1982) estimate M over the entire lifespan of Florida spiny lobster to be 0.60. Published fishing mortality estimates range from 1.22 to 3.69.

Yield per recruit (Y/R) analysis based on the Beverton-Holt model indicates a minimum carapace length (CL) of 3.50 inches (89 mm) would maximize Y/R in the fishery. The present minimum legal size of 3.0 inches (76 mm) CL is estimated to take 91 to 93 percent of the maximum available Y/R from the fishery.

Results from production modelling show decreasing catch per unit effort (CPUE) with increasing effort over the period 1952-78 in Monroe County, Florida, which consists of the Florida Keys and Florida Bay. The fishery began taking what appears to be maximum sustainable yield (MSY) from this area in the early 1970's. Effort from 1976 through 1978 transcended that which was thought necessary to harvest MSY, but total landings in the commercial fishery remained relatively constant at approximately 5 million pounds, .9 million pounds below the estimated MSY of 5.9 million pounds for Monroe County. Based on landings data from the east coast of the U.S. north of Monroe County and estimates of unrecorded landings throughout the fishery, total MSY for the entire fishery was estimated at 12.7 million pounds.

The status of the Florida spiny lobster population is difficult to assess because of uncertainties about stock structure and the high percentages (approximately 50 percent) of unrecorded landings. Fishing mortality is relatively high, however, and the minimum legal size of 3.0 inches (76 mm) corresponds closely to size at sexual maturity. It is evident that the reproductive potential of Florida stocks is probably significantly reduced; however, total landings appear to be relatively constant. The indication is that either what remains of local reproductive capacity is sufficient and/or settlement of postlarvae originating from the West Indies or Gulf of Mexico plays the predominate role in recruitment.

Important research needs include more information on unreported landings from all user groups. Information is almost completely lacking on commercial diving and all of the recreational catch; continued research is needed on determination of larval origin, and better estimates of total, natural, and fishing mortality. Information on catch and effort, by area, for all user groups is sorely lacking. If logbooks are used, it is particularly important to obtain soak time information to facilitate estimation of effort.

Several more practically oriented research needs are also apparent. These include development of alternatives to using sub-legal sized lobsters as attractants in traps, research on regulations to minimize user conflict and systematize trap retrieval, and information on the size selectivity of wood slat traps.

Table RFR-1. Recent landings by species of South Atlantic region reef fishes by species (in thousands of pounds).

	COMMERCIAL (1981)	*RECREATIONAL (1979)
Sea Bass	1300	1900
Groupers	2800 (1978)	2200
Porgies	1800	2400
Grunts	129	1600
Tilefishes	1100	3
Triggerfish	46 (1979)	126**
Wrasses	24	Unknown
Jacks	38	1200
Snappers		
Vermilion	615 (1980)	214
Red	400 (1979)	1000
Gray	- (1979)	25
Yellowtail	500 (1979)	341

* MRFS = Marine Recreational Fishery Survey

** Headboats only

Table RFR-2. Parameter values used in reef fish yield per recruit analyses (Source: SAW/82/RFR/1)

Species	Von Bertalanffy Growth Parameters			Age of Recruitment	Weight-Length Relationship $W = aL^b$		Natural Mortality Rates
	L_∞ (mm)	K	t_0 (years)	t_r (years)	a	b	
red porgy	763	0.096	- 1.88	1.0	2.524×10^{-5}	2.8939	0.20 0.35
vermilion snapper	627	0.198	0.128	1.0	1.722×10^{-5}	2.9456	0.25 0.40 0.50
white grunt	640	0.108	- 1.01	2.0	1.452×10^{-5}	3.0214	0.37 0.37
red snapper	975	0.160	0.000	1.0	3.150×10^{-5}	2.8870	0.16 0.25
black sea bass	350	0.222	0.186	1.0	2.654×10^{-5}	3.0327	0.30 0.50
red grouper	928	0.113	0.091	1.0	2.918×10^{-5}	2.9294	0.16 0.24
gag	1290	0.122	- 1.127	1.0	1.2×10^{-8}	2.9960	0.20 0.35

Table RFR-3. Major commercial shallow water species of Puerto Rico and the U.S. Virgin Islands

FAMILY	COMMON NAME	COMMON SPECIFIC NAME	SPANISH NAME	GENUS AND SPECIES
Serranidae	Groupers	Nassau grouper	cherna	Epinephelus striatus
		red hind	nero cherna	Epinephelus guttatus
		coney	mantequilla	Epinephelus fulvus
		jewfish	mero grade	Epinephelus itajara
		yellowfin grouper	mero pinto, Guajil	Mycteroperca venenosa
Pomadasyidae	Grunts	white grunt	cachicata	Haemulon plumieri
		French grunt	condenado	Haemulon flavolineatum
		tomtate	mulita, mula	Haemulon aurolineatum
		bluestripe grunt	ronco amarillo	Haemulon sciurus
Scaridae	Parrotfishes	midnight parrotfish	judio	Scarus coelestinus
		blue parrotfish	brindao	Scarus coeruleus
		stoplight parrotfish	chaporra	Sparisoma viride
Mullidae	Goatfishes	spotted goatfish	salmonete colorado	Pseudupeneus maculatus
		yellow goatfish	salmonete amarillo	Mulloidichthys martinicus
Holocentridae	Squirrelfishes	squirrelfish	gallo, candil, foro	Holocentrus ascensionis
		longspine squirrelfish	candilero	Holocentrus rufus
Lutjanidae	Snappers	yellowtail snapper	colurrubia	Ocyurus chrysurus
		lane snapper	payado	Lutjanus synagris
		mutton snapper	sama	Lutjanus analis
		mangrove snapper	pargo prieto	Lutjanus griseus
		schoolmaster snapper	pargo amarillo	Lutjanus apodus
Balistidae	Triggerfishes	queen triggerfish	puerco	Balistes vetula
		ocean triggerfish	turco	Canthidermis sufflamen
		sargassum triggerfish	puerquito	Xanthichthys ringens
		black durgeon	japonesa	Melichthys niger
Sparidae	Porgies	pluma	pluma	Calamus pennatula
		jolthead porgy	pajonadoe	Calamus bajonado
		sheepshead porgy	pluma	Calamus penna
Labridae	Wrasses	hogfish	capitan	Lachnolaimus maximus
Ostraciidae	Trunkfish	trunkfish	chapin, gallina	Lactophrys spp.
Chaetodontidae	Butterflyfish	spotfin butterflyfish	mariposa	Chaetodon ocellatus
Pomacanthidae	Angelfishes	gray angelfish	mariposa	Pomacanthus arcuatus
Acanthuridae	Surgeonfishes	blue tang	medico	Acanthurus coeruleus
		doctorfish	medico	Acanthurus chirurgus
		ocean surgeonfish	medico	Acanthurus bahianus

* Spanish names from Fordman (1974)

Table RFR-4. Shallow water reef fish commercial landings in Puerto Rico and the U.S. Virgin Islands in thousands of pounds[1].

	PUERTO RICO[2]	U.S. VIRGIN ISLANDS[3]
1971	2,649	-
1972	2,592	-
1973	2,565	-
1974	2,661	-
1975	2,828	888
1976	3,421	882
1977	3,824	1,070
1978	4,113	1,000
1979	-	1,015
1980	-	1,180
1981	-	1,300

1The magnitude of recreational catches is estimated to be approximately 20% that of commercial catches.

2Source: Puerto Rico Dept. of Agriculture and Codremar.

3Source: U.S. Virgin Islands Dept. of Conservation and Cultural Affairs. Shallow water reef fish are estimated to be 80% of total landings.

Table RFR-5. Catchability coefficients (q) from catch per trap hour for four species of reef fish on 0.5 km^2 at Rum Reef, Florida middle grounds. Population estimates were derived from the mean of submersible and mark/recapture estimates.

Species	Population Estimate	All Sets (n = 3432) No./trap/hr	q	Sets Six Hours or More (n = 218) No./trap/hr	q
Balistes capriscus	523	0.019	0.0036	0.022	0.0042
Epinephelus morio	742	0.038	0.0051	0.119	0.0160
Calamus sp.	31,341	0.083	0.0003	0.326	0.0010
Mycteroperca phenax	7,619	0.044	0.0006	0.133	0.0017

Source: SAW/82/RFR/5

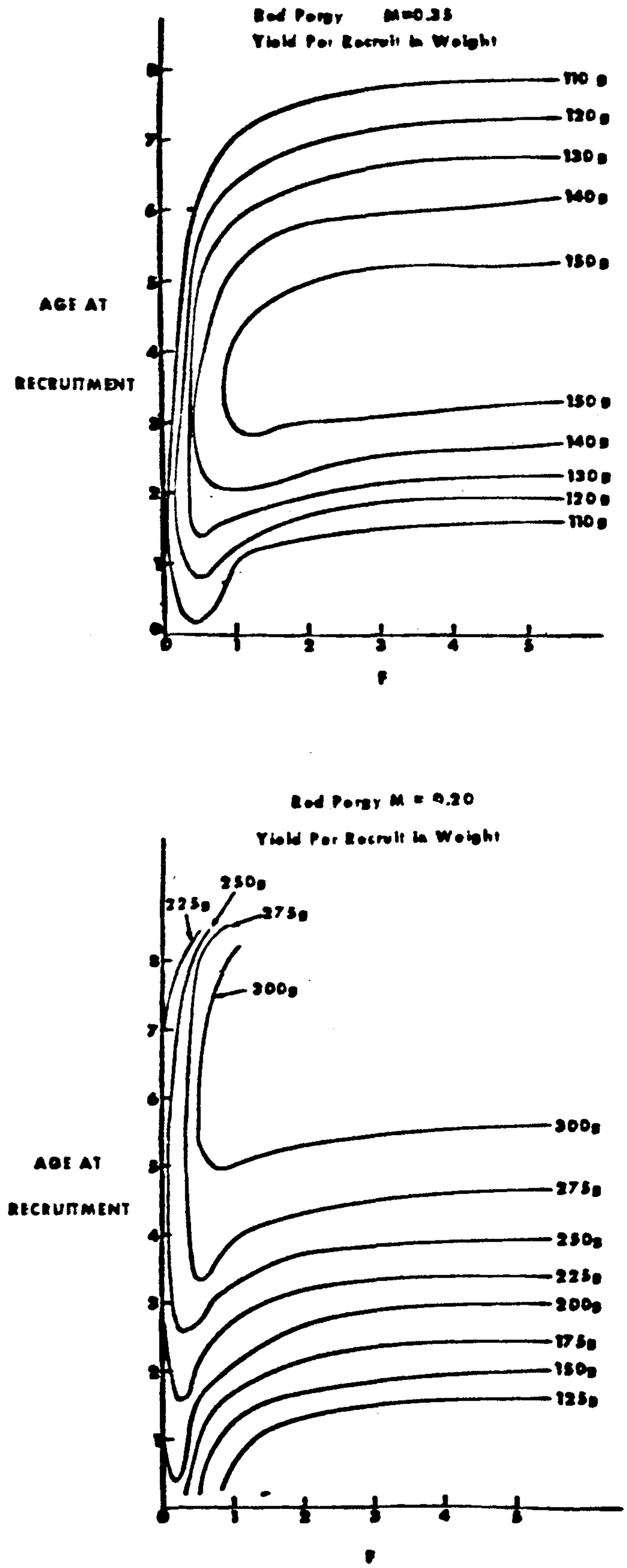


Figure RFR-1. Yield per recruit of red porgy for M = 0.20 and M = 0.35.

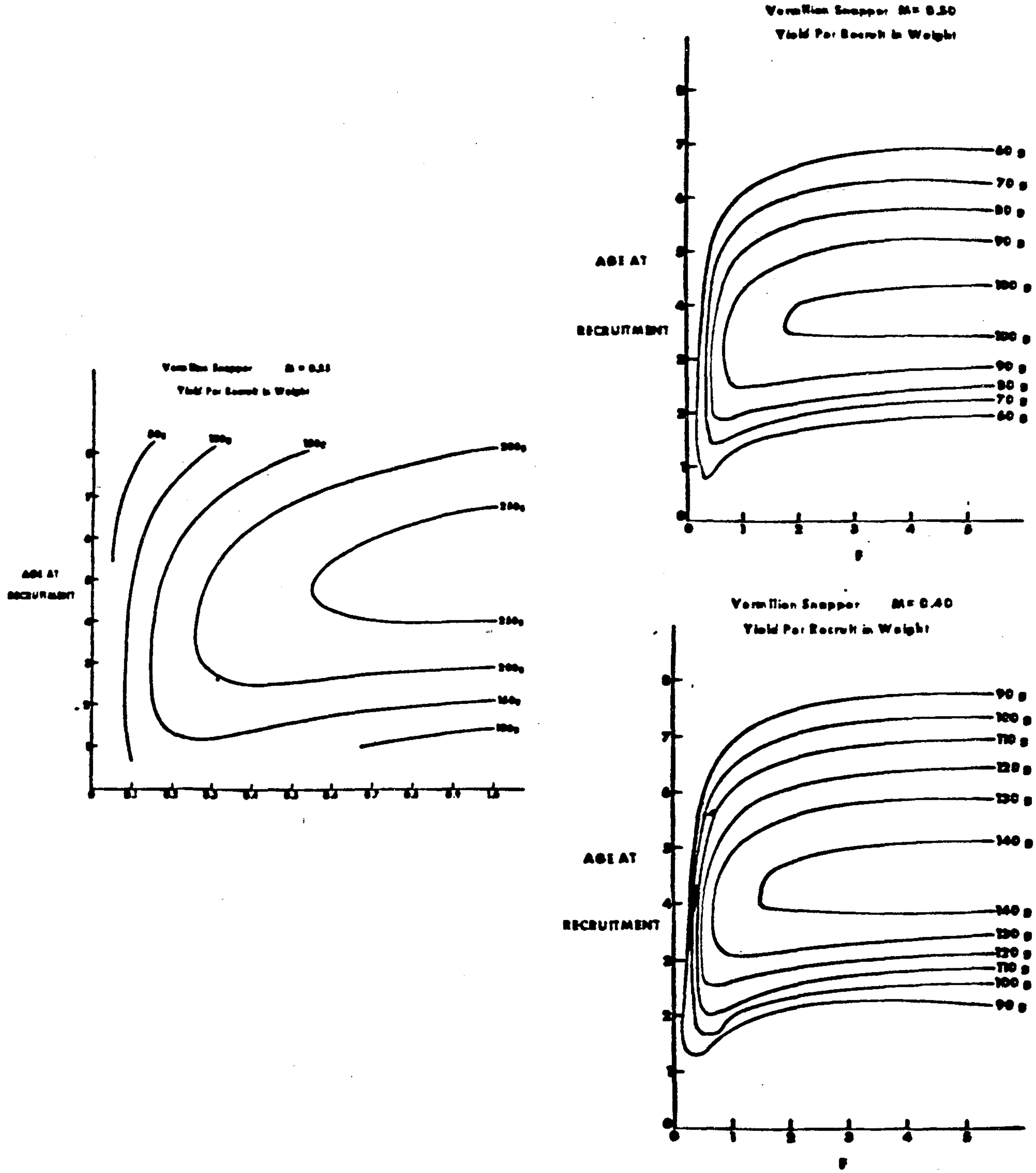


Figure RFR-2. Yield per recruit of vermilion snapper for M = 0.25, 0.40 and 0.50.

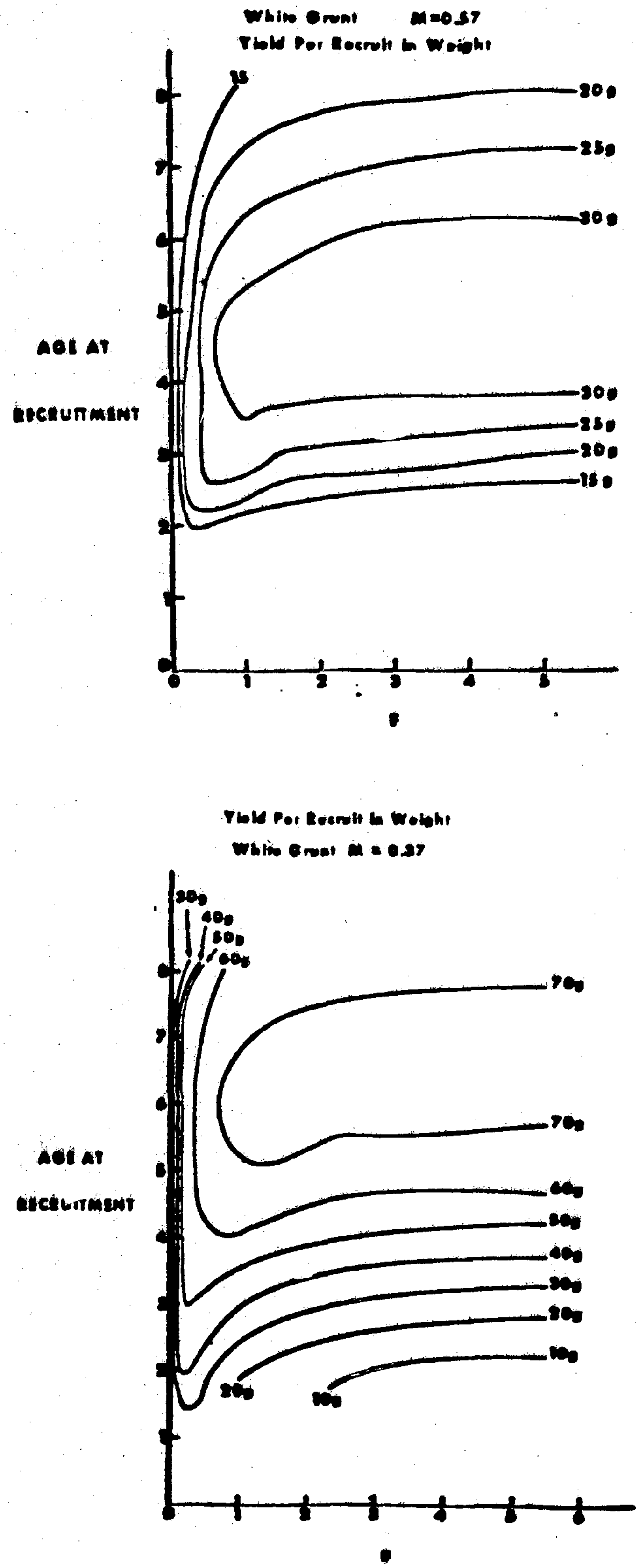


Figure RFR-3. Yield per recruit of white grunt for M = 0.37 and 0.57.

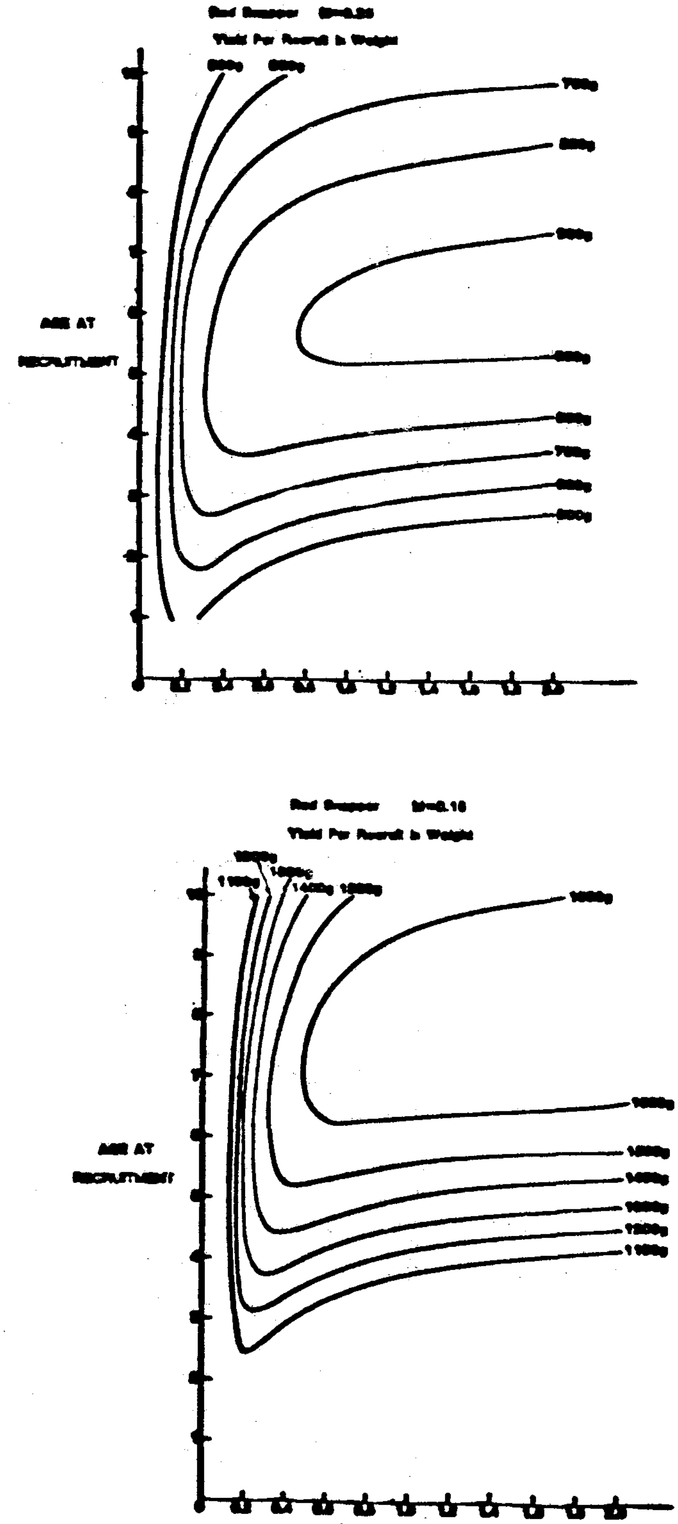


Figure RFR-4. Yield per recruit of red snapper for M = 0.16 and M = 0.25.

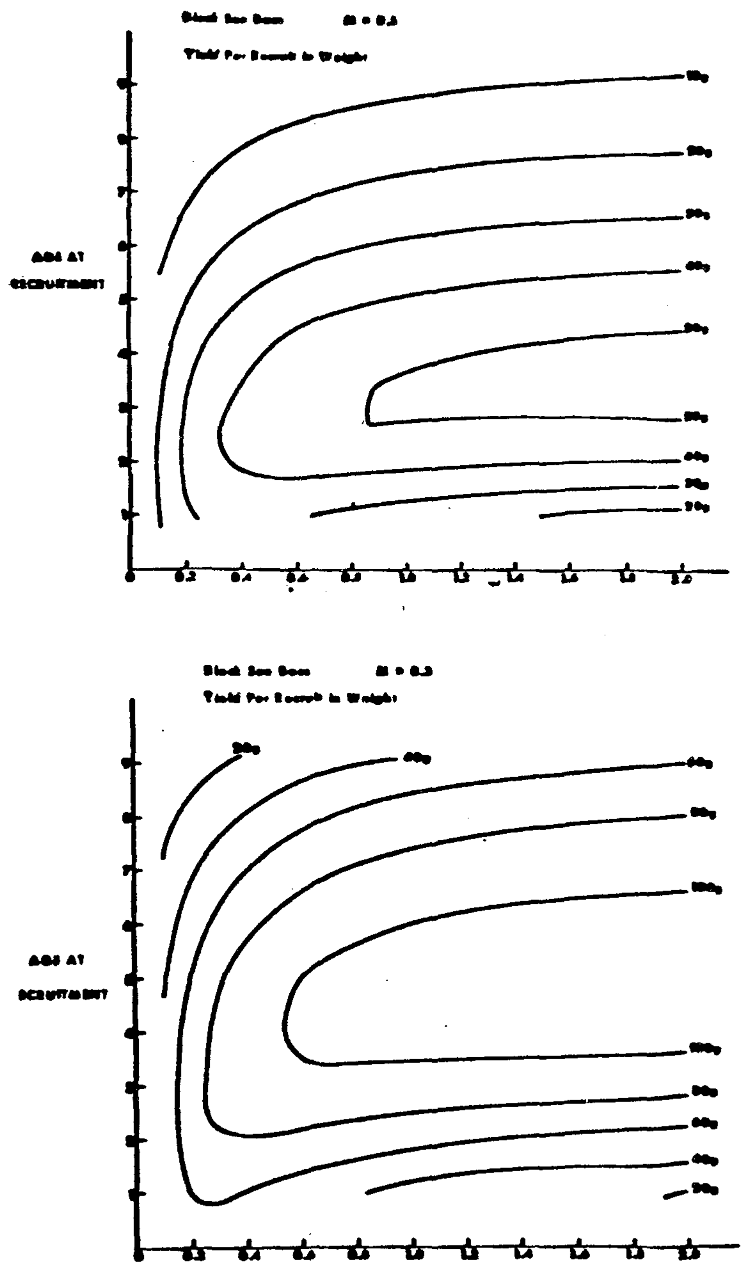


Figure RFR-5. Yield per recruit of black sea bass for M = 0.3 and M = 0.5.

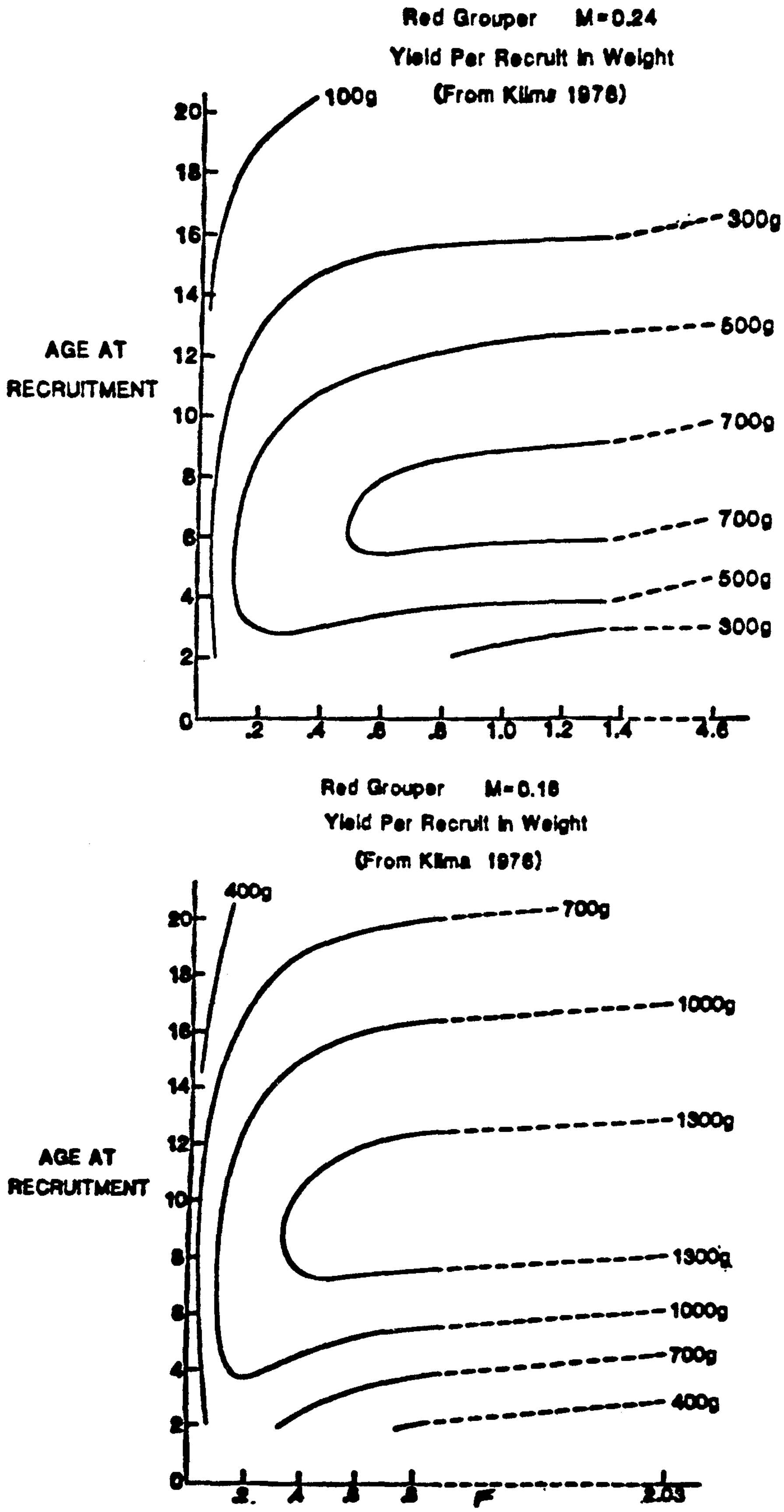


Figure RFR-6. Yield per recruit of red grouper for M = 0.16 and M = 0.24.

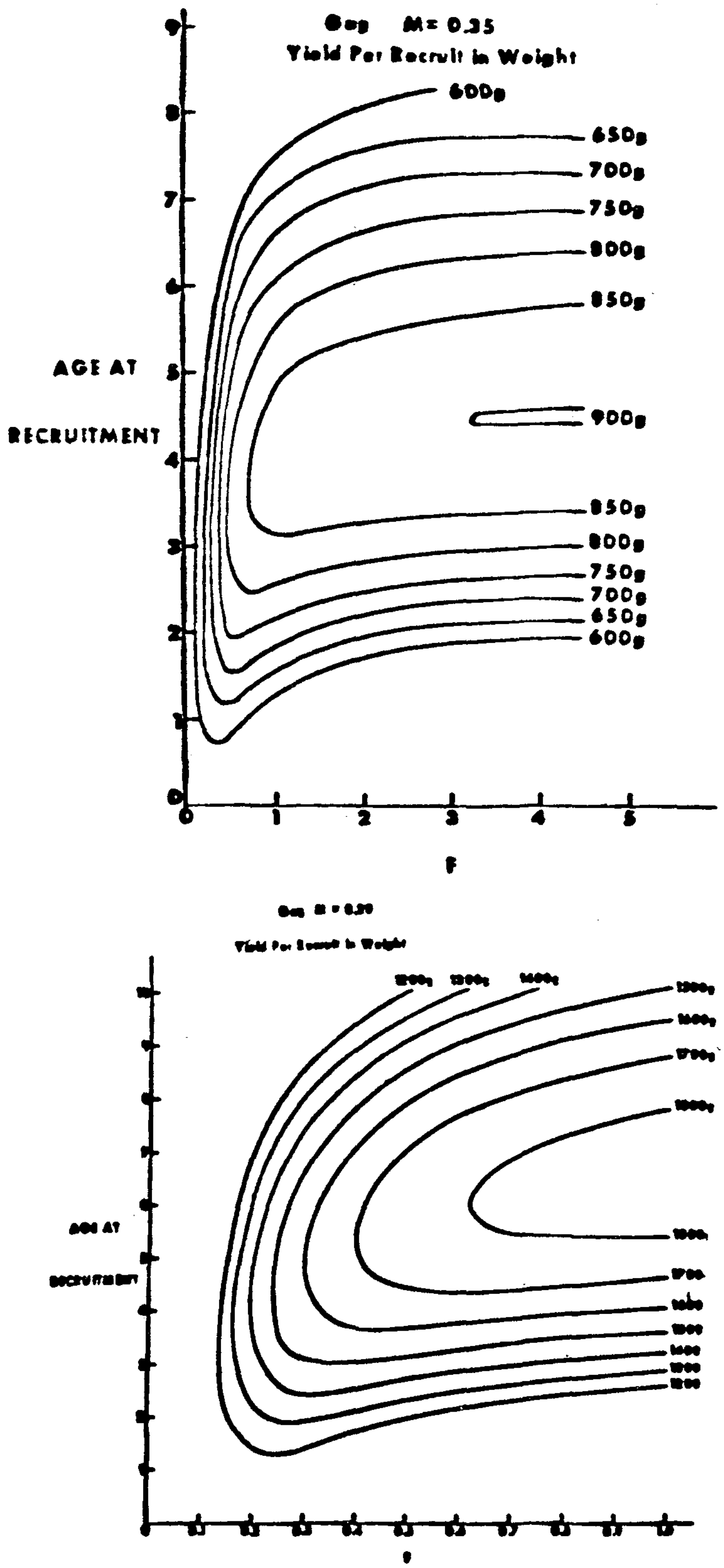
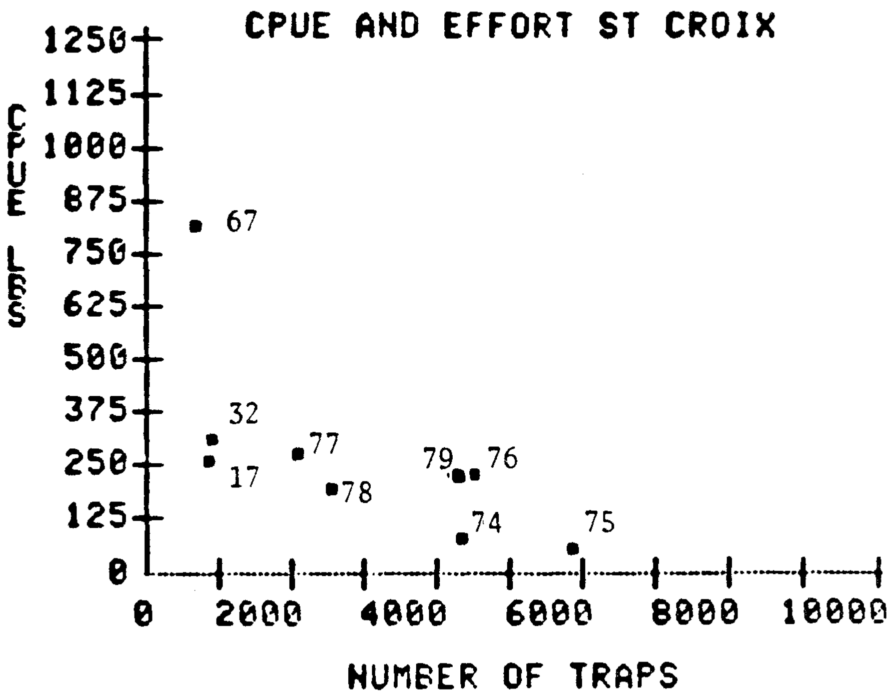


Figure RFR-7. Yield per recruit of gag for M = 0.20 and M = 0.35.



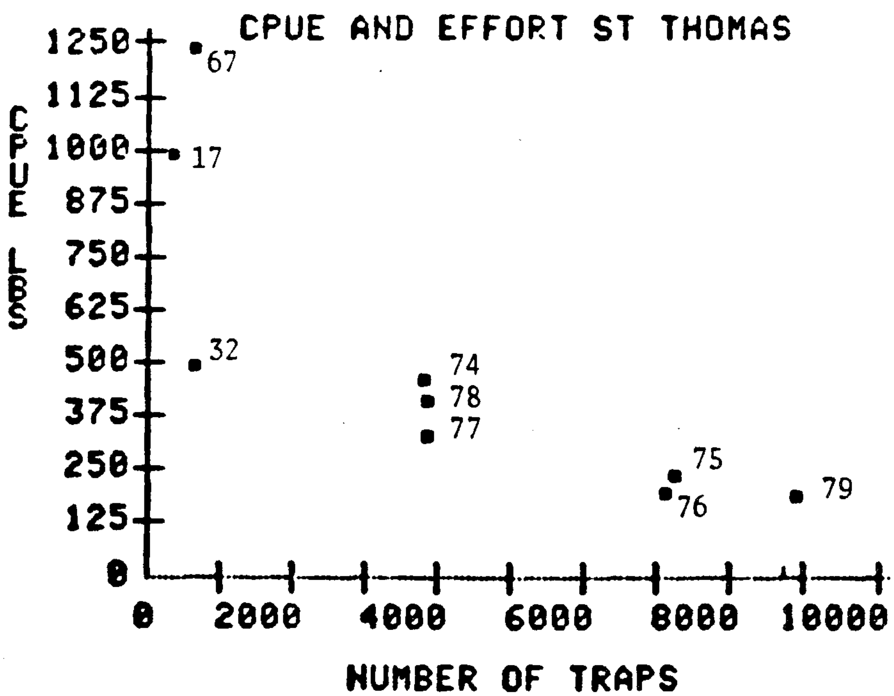


Figure RFR-8. Catch per unit effort versus effort in number of traps per year for St. Croix and St. Thomas shelves (D. Olsen, personal communication).

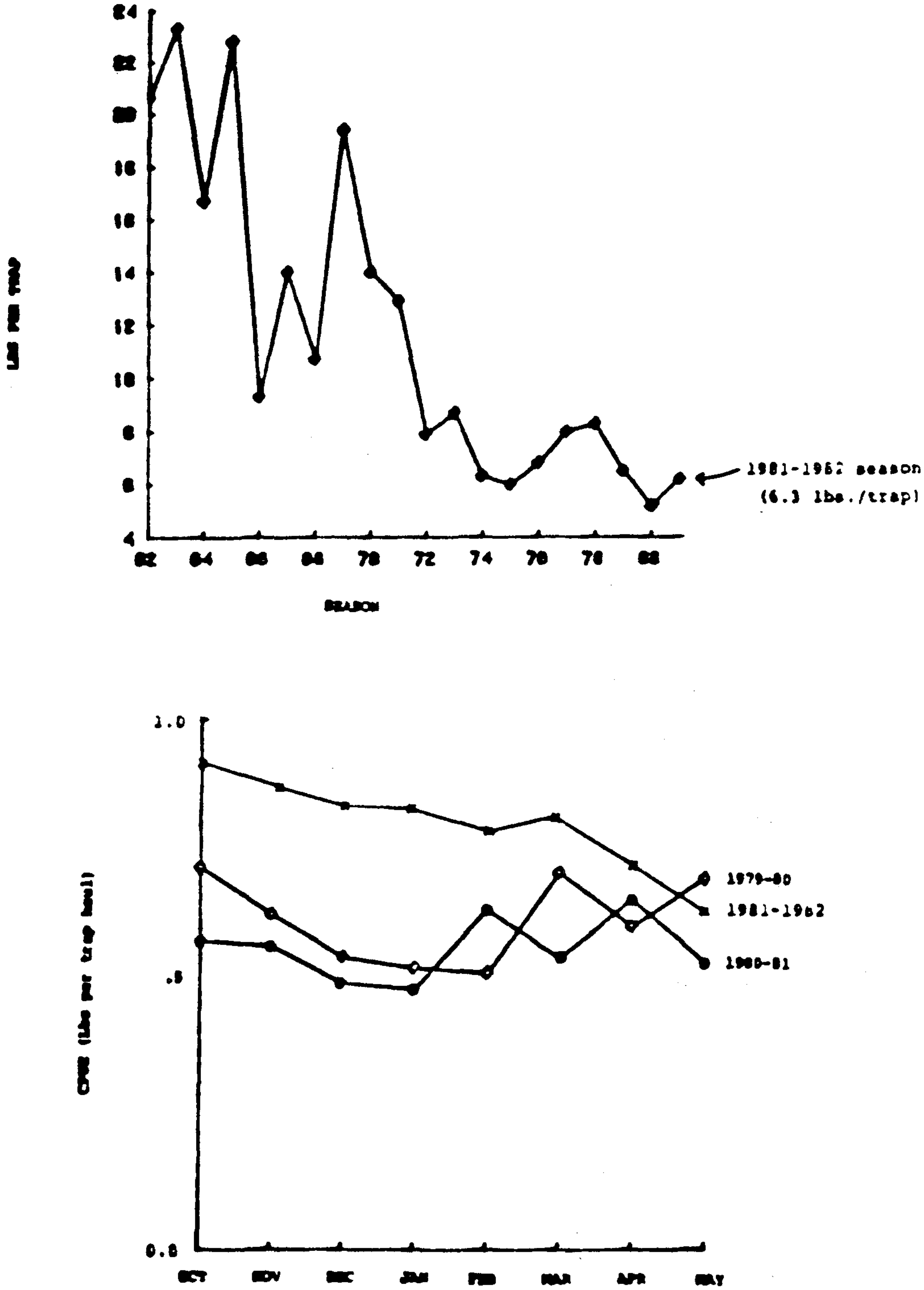


Figure RFR-9. Annual and intraseasonal catch per unit effort in the west coast of Florida crab fishery.

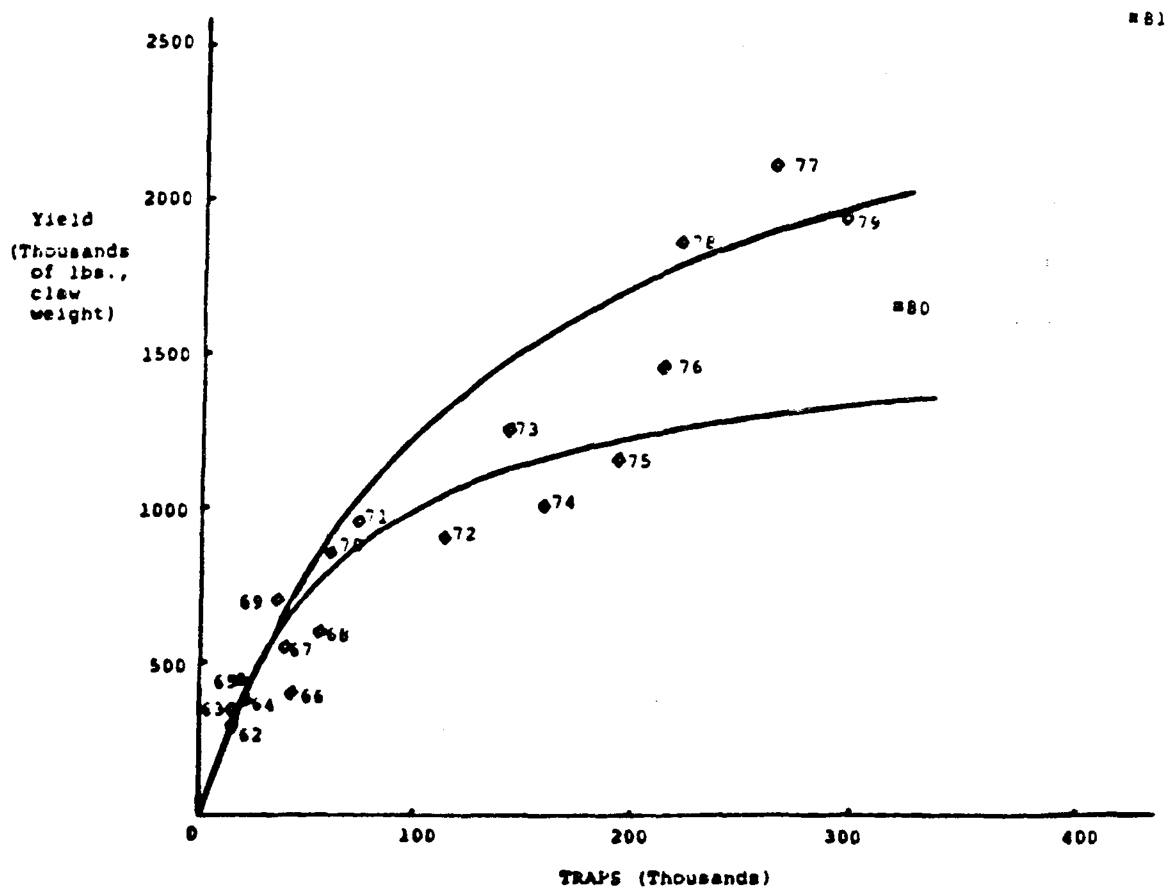


Figure RFR-10. Yield versus effort for the west coast of Florida stone crab fishery. Production curves are also drawn.

SHRIMP (SHR)

In November of 1981, the Southeast Fisheries Center and the Gulf States Marine Fisheries Commission in collaboration with the Food and Agriculture Organization of the United Nations Fishery Resources and Environmental Division sponsored a Workshop on the Scientific Basis for the Management of Penaeid Shrimp in Key West, Florida (interim report by Rothschild and Gulland, 1982). Papers and discussions presented at this Workshop were directed at international penaeid shrimp studies including U.S. fisheries. The extensive material in the Key West workshop formed the basis for the SEFC assessment work reported in this document.

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 a directed fishery. 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 fraction 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.

Brown shrimp in the Gulf of Mexico are captured mainly in the summer, with a peak inshore fishery in May and June, and peak offshore catches in July and August. Peak landings (by weight) come from inshore, and offshore between 10 and 20 fathoms. Geographically, peak production has come from the area between Mobile Bay and the Atchafalaya River, and off the Texas coast between Freeport and Port Aransas. In the Atlantic, brown shrimp are mainly captured in the sounds and nearshore waters of North and 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. Peak catches are made in 6 to 20 fathoms. The fishery is year-round, with minimum landings in the summer. In the Atlantic, pink shrimp are caught 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.

I.2. Catch and Effort Trends

Landings for Gulf brown shrimp have shown a generally rising trend, roughly doubling over the past 22 years, with considerable short term fluctuation (Fig. SHR-1). Directed effort (in nominal days fished) has shown a general upward trend, with downturns in the early 1970's, and again in 1980-81 (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. White shrimp directed effort has increased somewhat more than two-fold, as a trend, with substantial short term fluctuations (Fig. SHR-4).

Landings of pink shrimp have fluctuated since 1960, although some increase appears evident since 1971 (Fig. SHR-5). Directed effort (Fig. SHR-6) appears to have fluctuated around two levels with a low level between during the early 1970's.

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 these 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 somewhat 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

Papers were submitted on the status of Gulf brown and white shrimp (SAW/82/SHR/1) and pink shrimp (SAW/82/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 assessment activities in North Carolina in 1982, including projections for the 1982 season.

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

The "best estimate" of M for Gulf brown shrimp was 0.285 per month (SAW/82/SHR/1), but estimates are sensitive to assumptions made about catchability. Estimates ranging from 0.15 to 0.4 were derived, by varying the assumptions chosen.

The best estimate selected for M for Gulf white shrimp was 0.292 per month, but estimates ranging from about 0.15 to 0.4 can be obtained with alternate assumptions (SAW/82/SHR/1).

The estimate for M of 0.3 per month derived from mark/recapture data was used as the best available estimate for Gulf pink shrimp (SAW/82/SHR/2).

III.1.2. Growth Estimates

Growth parameter estimates for Gulf brown, white and pink shrimp have been made and are discussed in SAW/82/SHR/1 and SAW/82/SHR/2.

III.2. Catch Per Unit Effort Trends

Annual CPUE of Gulf brown shrimp has shown considerable fluctuation with no discernable trend (Fig. SHR-7). CPUE for Gulf white shrimp has shown sizeable short term fluctuations (Fig. SHR-8). The relationship of CPUE versus time of Gulf pink shrimp appears to lack any continuous trend since 1961 (Fig. SHR-9).

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

No directed surplus production models were fitted to the shrimp data. However, surplus yield results may be inferred from yield per recruit and recruitment analyses.

III.3.2. Yield Per Recruit Analysis

Based upon virtual population assessment (VPA) (SAW/82/SHR/1), realized yield per recruit of Gulf brown shrimp has remained fairly constant (Fig. SHR-10). Analyses based on Ricker-type yield models indicate no real potential for increasing yield in pounds simply by increasing fishing effort; however, some potential exists for increasing yield per recruit by delaying the onset of fishing on new recruits. Yield per recruit estimates are highly sensitive to the natural mortality rate estimates, and the available estimates of M are not very precise.

Yield per recruit of Gulf white shrimp has varied (Fig. SHR-11), but no striking trends are evident after 1960. Analyses based on Ricker-type yield per recruit models incorporating a single season-opening date indicate that current effort levels and seasonal closures are at or near optimal levels for maximizing yield per recruit of white shrimp. However, the past existence of a strong "Easter fishery" and higher reported landings for white shrimp suggest that there may be some potential for increasing yields by delaying fishing on the late fall component of recruitment. The existing resolution of the catch data and growth data limit reliable evaluation of this suggestion at present. The yield per recruit conclusions are also sensitive to the limited precision of available natural mortality rate estimates.

Realized yield per recruit for Gulf pink shrimp has hardly varied at all (Fig. SHR-12). Only minimal gains in yield per recruit are projected (using a Ricker-type yield per recruit model) both with simply increasing fishing, and with delaying fishing on new recruits.

III.3.3. Recruitment Indices

Annual brown shrimp recruitment estimated by VPA shows an increasing trend (Fig. SHR-13). Since yield per recruit has remained fairly constant, this indicates that much of the increase in yield may be attributable to improving recruitment. These results are surprising, and there is some concern that trends in unreported catch (including discards), and the limits in resolution of the basic catch data, could bias these results. Unrecognized trends in fishing mortality not accounted for in deriving "starting F" in VPA could also effect these results, but the existence of a recruitment trend was not very sensitive to changes in starting F.

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-14 and SHR-15). 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. Present indications are that no evidence exists for recruitment overfishing of Gulf brown shrimp, but the possibility of recruitment overfishing in the future should not be dismissed. Nevertheless, population models based on the fitted Beverton-Holt relationships linked to Ricker-type yield per recruit models produced maximum sustainable yield estimates of 72 and 88 million pounds (to the commercial fishery), which are quite similar to those reported using surplus production modelling techniques in the Gulf Shrimp Fishery Management Plan.

Annual recruitment of white shrimp has shown considerable short term fluctuation (over four-fold) from 1960-1981 (Fig. SHR-16). The similarity in pattern between recruitment and landings is apparent.

An apparent relationship is seen in plots of white shrimp recruitment vs. parent stock for white shrimp (Figs. SHR-17 and SHR-18) 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 interpretations of the available data indicate that exploitation is at or above the maximum surplus recruitment level. Population models based on linking these Beverton-Holt relationships to a Ricker-type yield per recruit model produce maximum sustainable yield estimates of 38 and 46 million pounds to the commercial fishery (depending on how parent stock is defined), again quite similar to estimates derived in the Gulf Shrimp Management Plan using surplus production models methods (which also indicated that most recent fishing levels may have reached or just exceeded the maximum point).

Recruitment of pink shrimp fluctuated without major trends (Fig. SHR-19).

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-20 and SHR-21). Recruitment overfishing does not appear to be an immediate concern with pink shrimp.

III.3.4. Other Fishery Indices

Average size of brown shrimp landed has decreased (Fig. SHR-22). (Multiple interpretations exist for a decline in average size, including economic factors.) Average size of white shrimp landed has declined (Fig. SHR-23). Average size of pink shrimp landed (Fig. SHR-24) has shown fairly large fluctuations, with some decline possible since an apparent maximum in the early 1970's.

III.4. South Atlantic

One paper was submitted (SAW/82/SHR/3) describing assessment activities in North Carolina for 1982, including projections for the 1982 season. Of particular note in the Atlantic fishery is the rapid rebound of shrimp populations following cold induced mass mortalities of overwintering white and pink shrimp.

Much of the available commercial statistical information for Atlantic shrimp fisheries has recently been summarized in the Profile of the Penaeid Shrimp Fishery in the South Atlantic, and has not been re-evaluated at this Workshop.

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. Papers were submitted describing some of these activities for North Carolina (SAW/82/SHR/3) and Mississippi (SAW/82/SHR/5). Summaries of other regulations (gear restrictions, license requirements, etc.) were presented in the Gulf Shrimp Plan 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 are the subject of ongoing research, and are the subject of separate reports submitted to the Gulf of Mexico Fishery Management Council. The Texas closure analyses showed that increased catch rates and yields occurred in response to both the protection of shrimp (increasing available biomass) and to the changes in effort patterns induced by the closure. Some depression of standing stock after fishing was resumed (compared to levels expected had there been no closure) was indicated. Overall, a 7% increase in yields to the offshore fishery in response to the closure was indicated, which for 1981 recruitment levels was about 4 million pounds (tails). Evaluation of the Tortugas closure has so far been limited to descriptions of shrimp size composition at stations near the closure line. Size compositions were found to be quite variable in time and space.

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 recognize 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. High Priority

(1) Design and implement programs to estimate currently unreported components of the catch on a continuing basis.

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.

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. 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 any conclusions involving yield per recruit. Addition-ally, 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.

This 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.

(4) Develop models of fleet behavior suitable for predicting and evaluating 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 (see e.g., SAW/82/SHR/4). 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.

Most of the requirements for continued collection of vessel characteristics and activity data are apparently being met for the "vessel" component of the fleet, but gaps in the available data (1960-64, 1979-current) due to incomplete data processing must be filled. Unfortunately, a distinction exists in data collection between "boats" and "vessels" (at 5 gross tons) that is completely artificial and undesirable for assessment purposes. A program is needed to collect craft and gear characteristics for fishing craft not covered by the existing data collection systems. Existence of a "boat" data base would also be useful in measuring currently unreported catch.

(5) Develop and implement a data collection program to improve resolution about species, sex, and size composition of shrimp catches on a continuing basis.

Absence of detailed information on these items severely 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 through the data collection and processing system.

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

(6) 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 exlude 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. Specific data or research recommendations should be made after results of the 1982 activity are evaluated.

V.1.1. Second Priority

(7) Develop quantitative models of shrimp migrations.
(8) Determine growth by set patterns for ages and sizes of shrimp not currently well defined in existing growth data.
(9) Improve temporal resolution to reported catch data.
(10) Determine patterns and quantity of bycatch from shrimping operations.

Longer range research needs center primarily on assessing shrimp in a community and ecosystem context. One paper submitted (SAW/82/GCP/6) dealt with some of these concerns. 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 offshore oceanographic conditions on the shrimp and shrimp fishery.

V.2. Management

No new management recommendations are made at this time.

Figure SHR-1. Reported annual landings for brown shrimp.

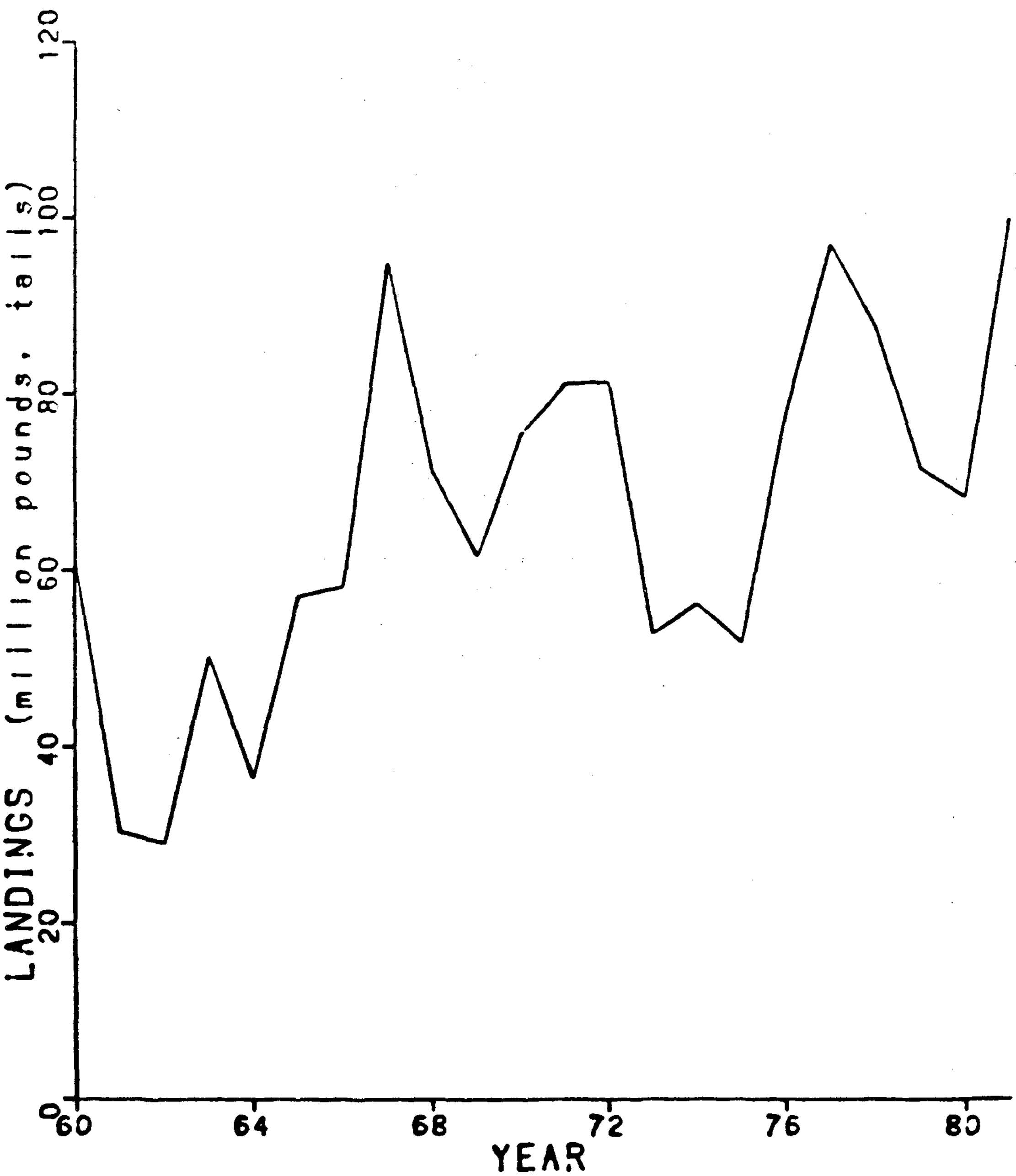


Figure SHR-2. Estimated annual directed effort for brown shrimp.

Figure SHR-3. Reported annual landings for white shrimp.

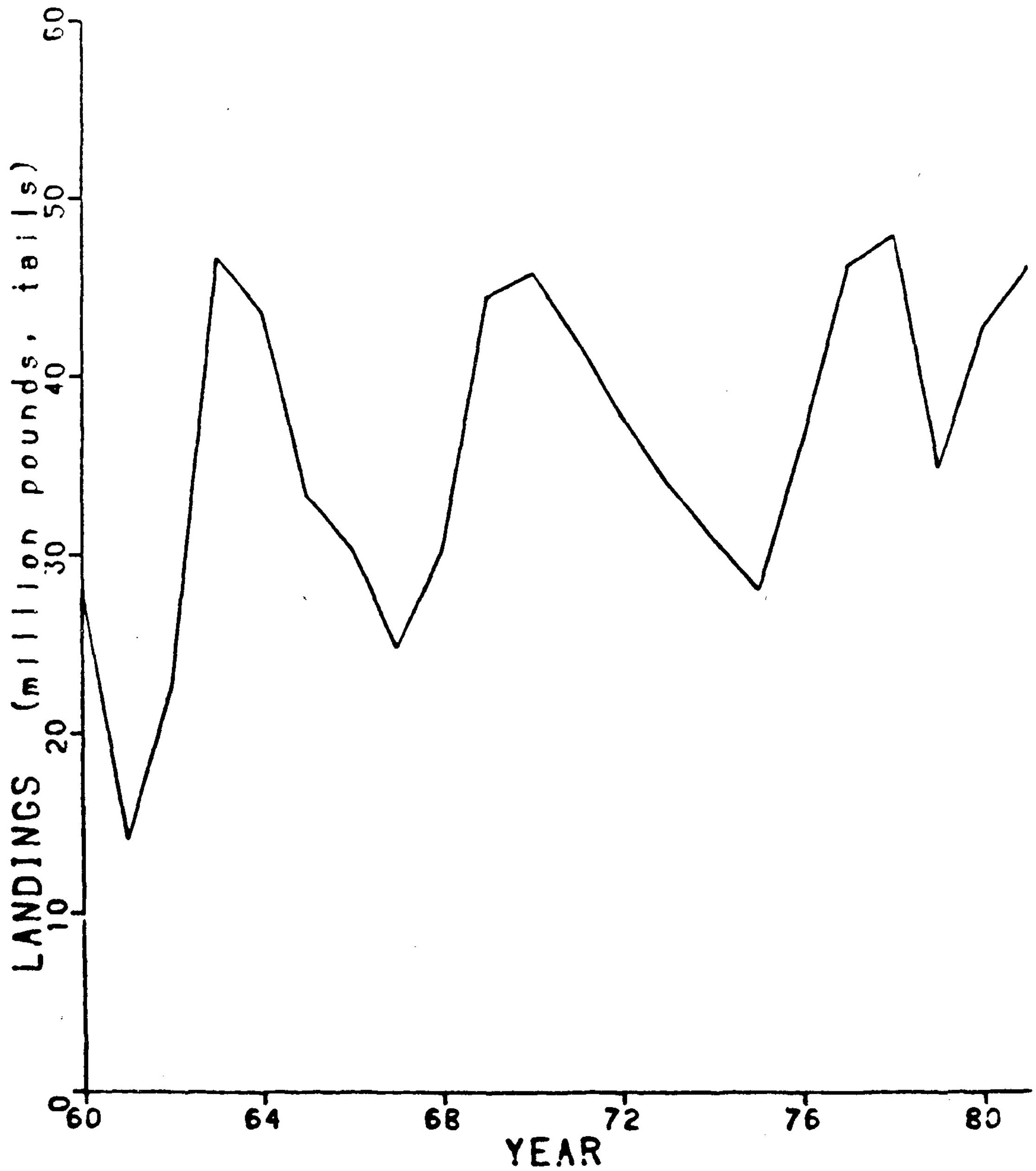


Figure SHR-4. Estimated annual directed effort for white shrimp.

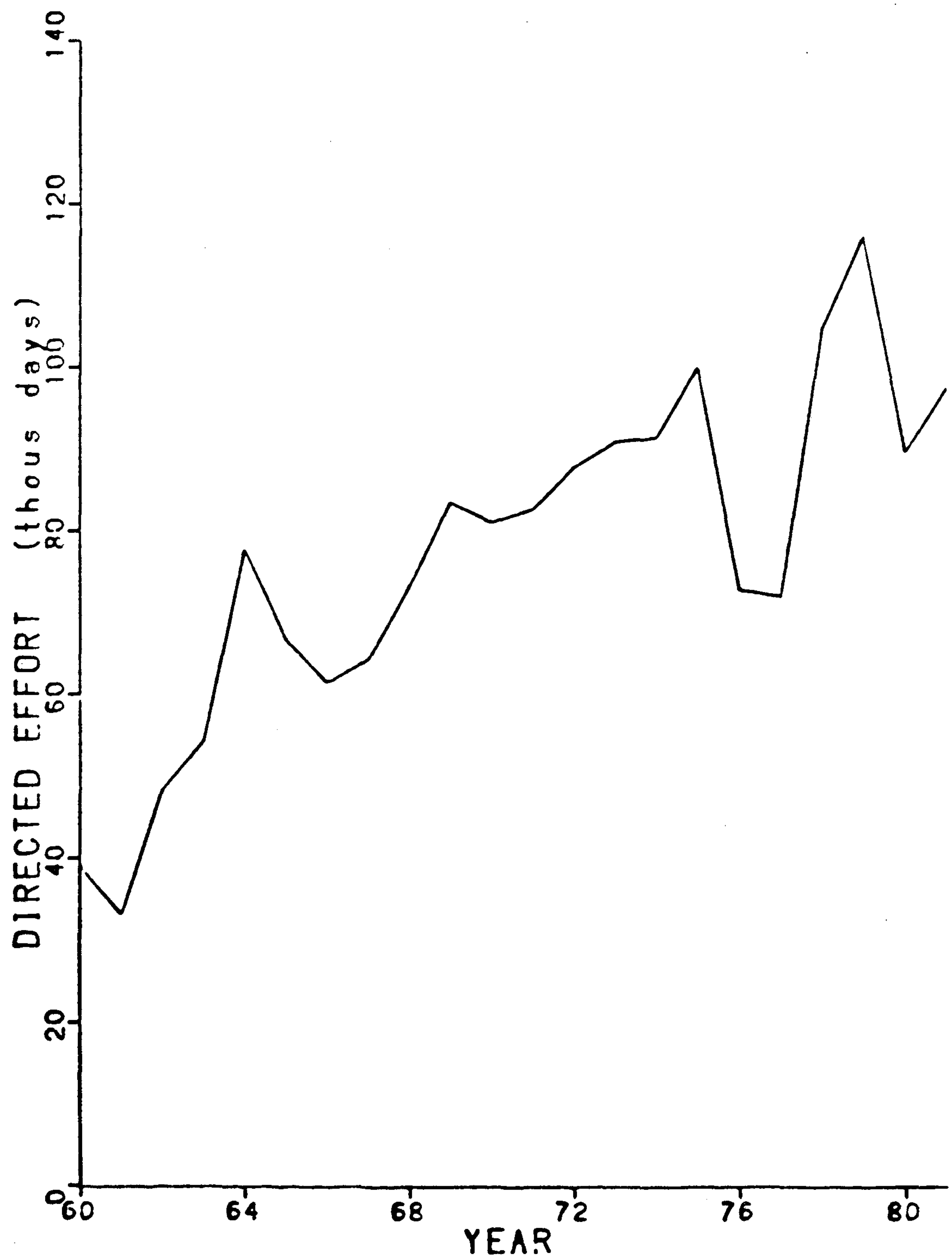


Figure SHR-5. Reported annual landings for pink shrimp.

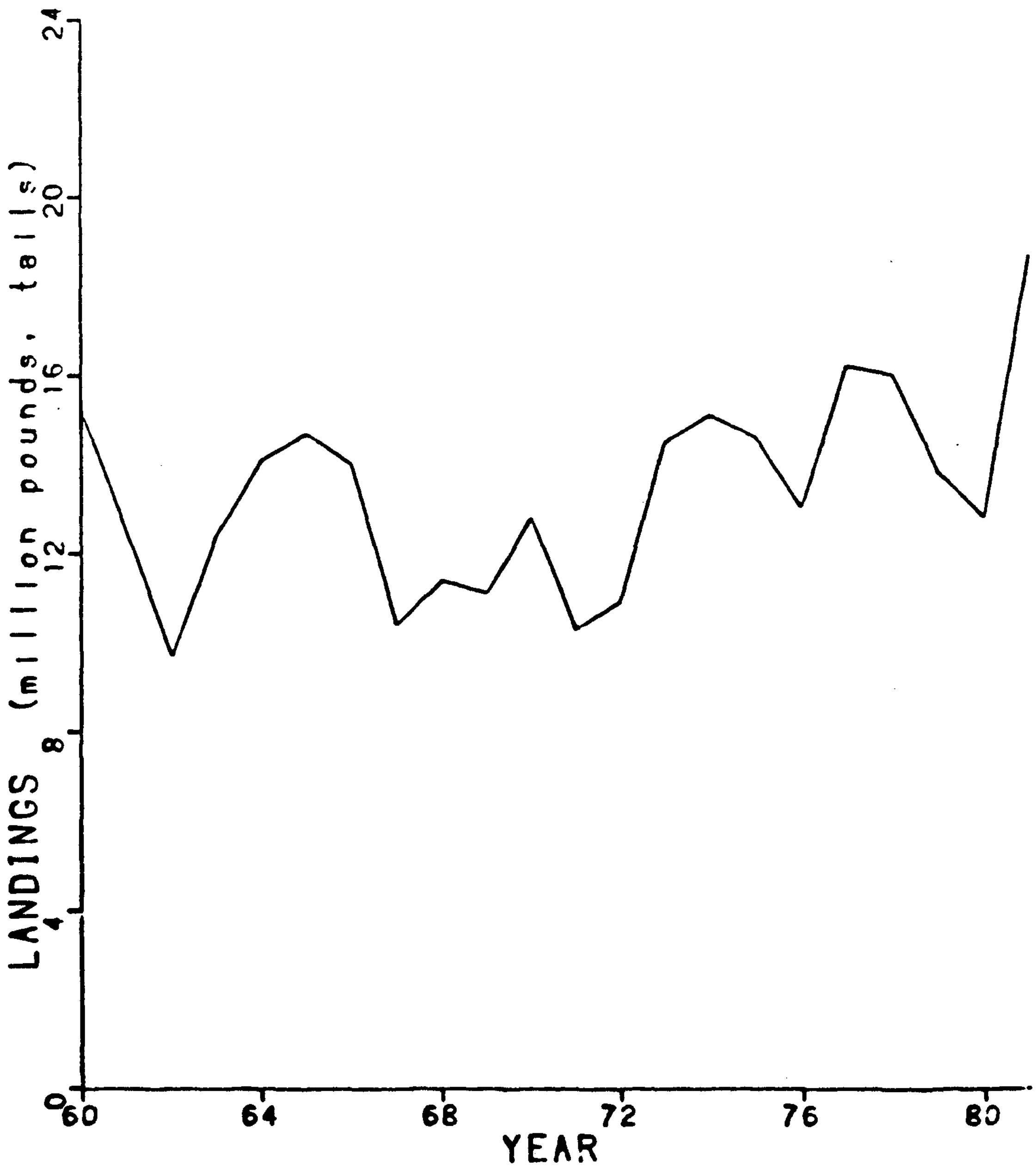


Figure SHR-6 Estimated annual directed effort for pink shrimp.

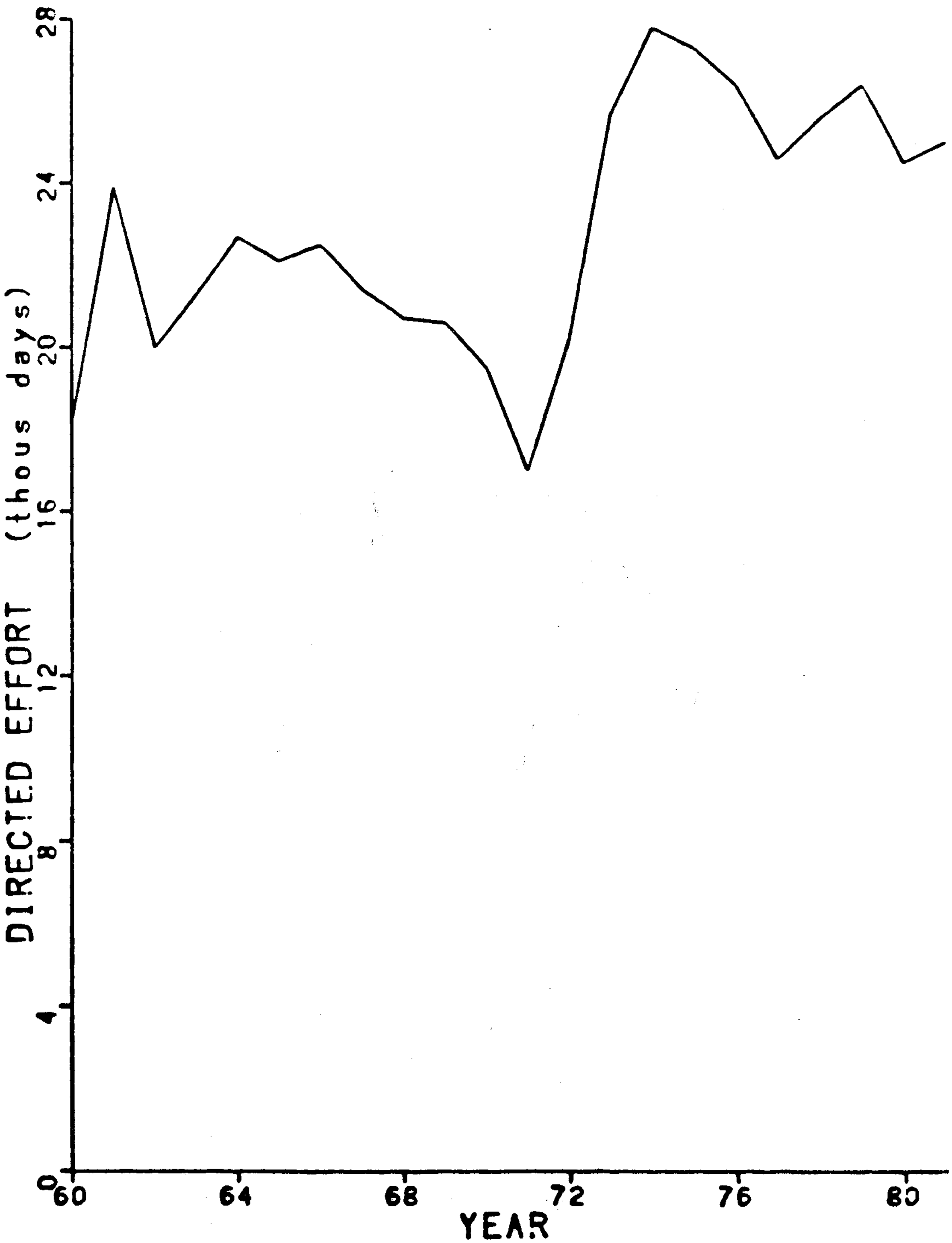


Figure SHR-7. Estimated annual average catch per unit effort for brown shrimp. (Note: CPUE is used here as a descriptive statistic only, and is not standardized for spatial, temporal, or gear changes.)

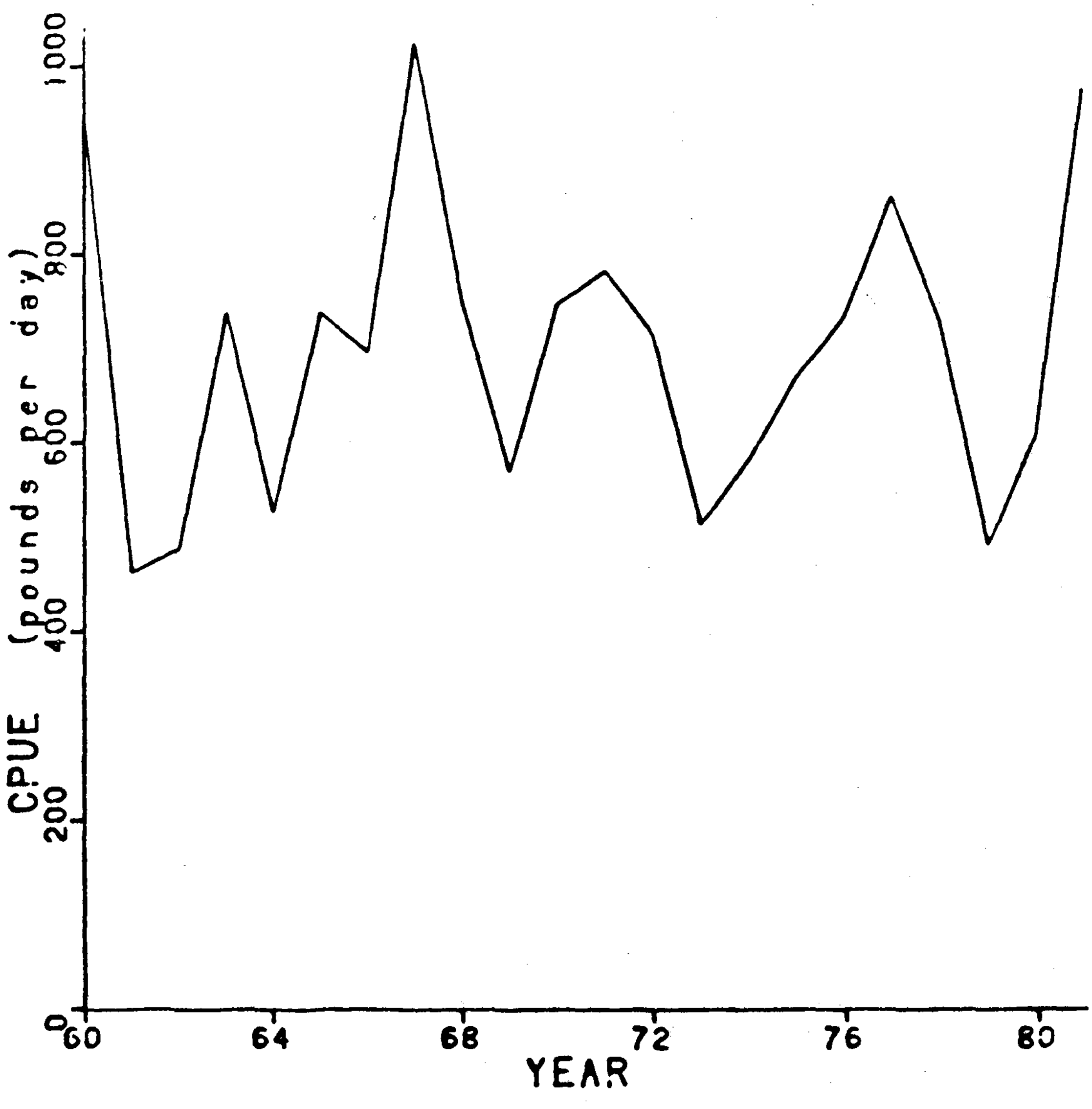


Figure SHR-8. Estimated annual average catch per unit effort for white shrimp (see note, Fig. SHR-7).

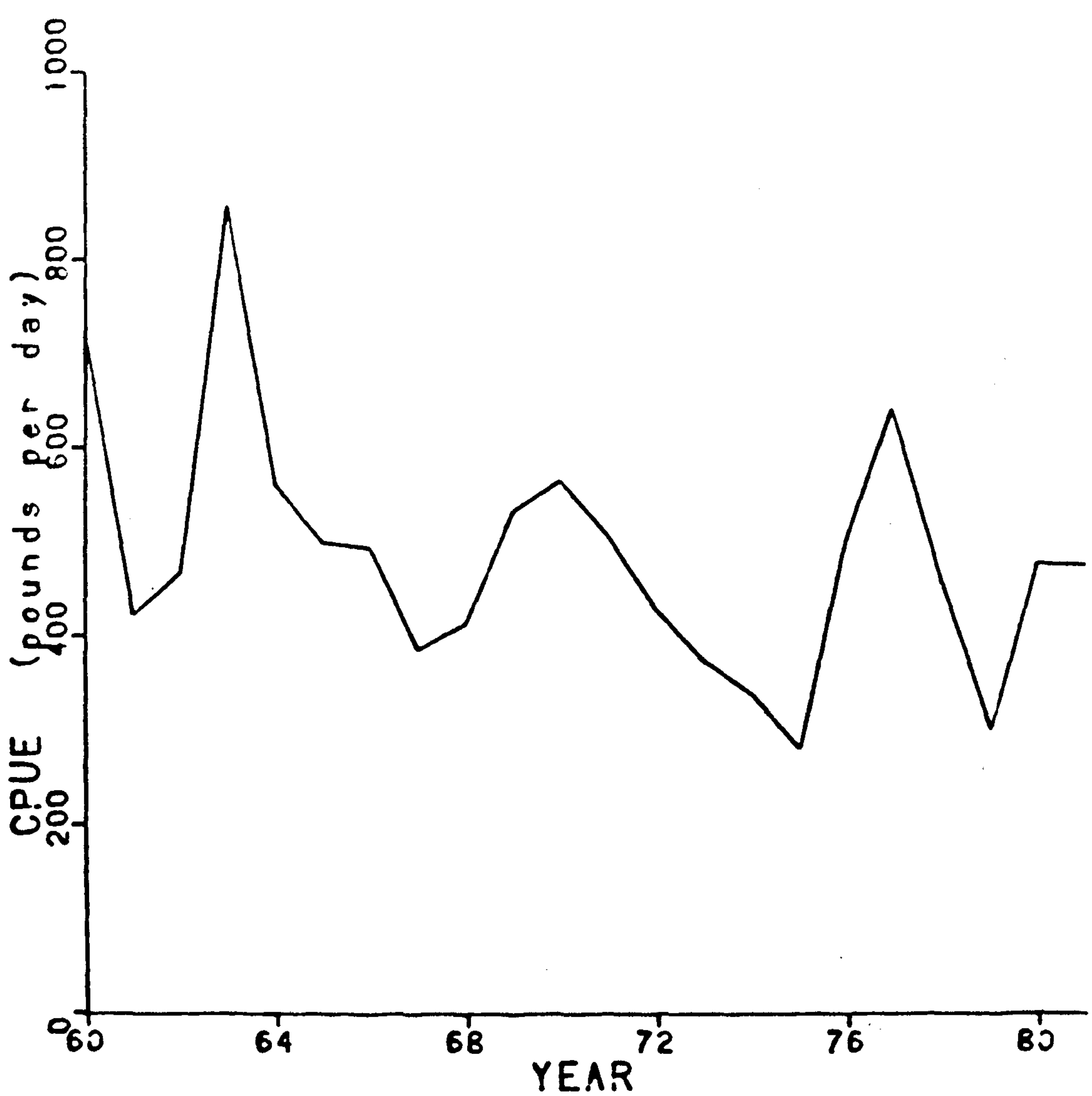


Figure SHR-9. Estimated annual average catch per unit effort for pink shrimp (see note, Fig. SHR-7)

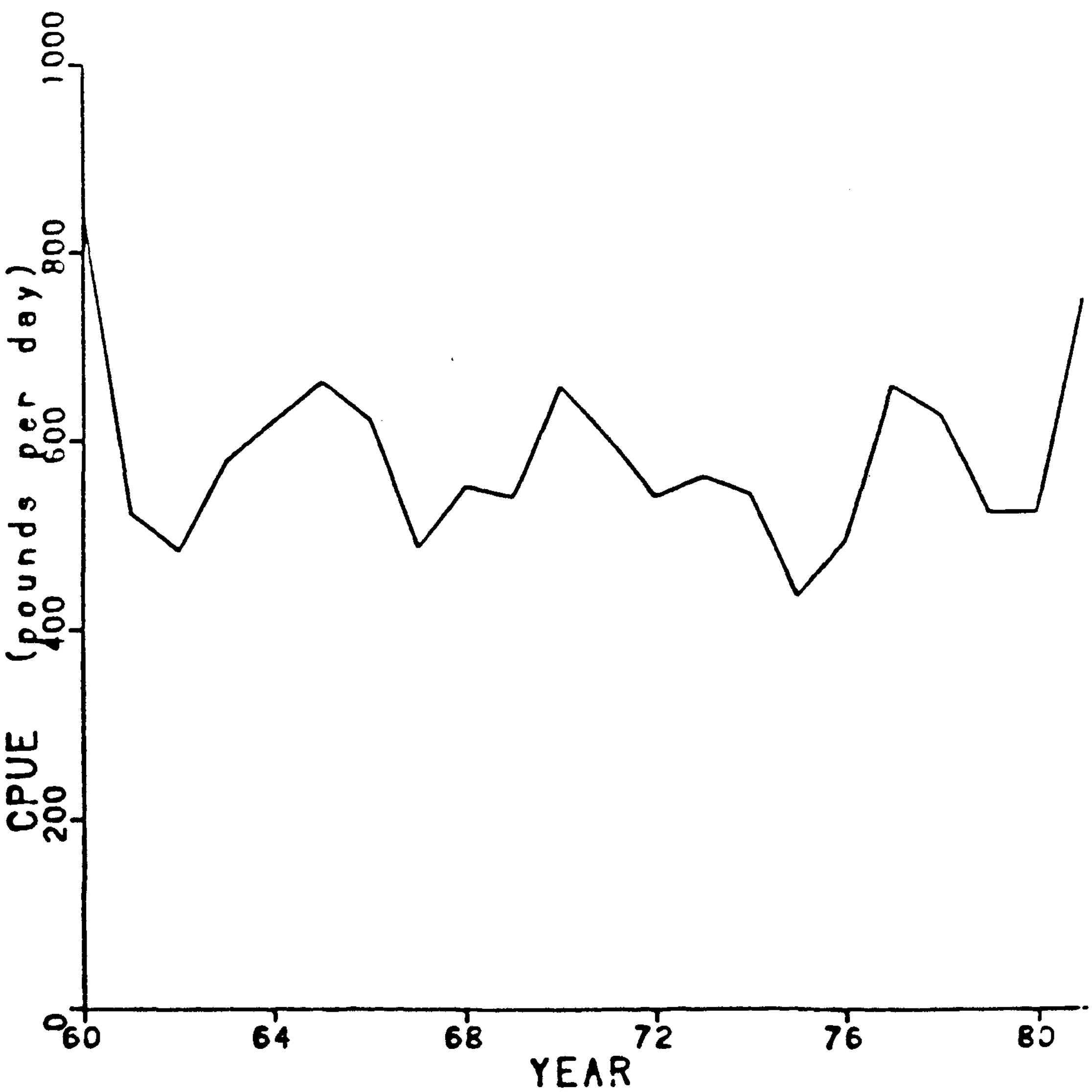


Fig. SHR-10. Estimated realized yield per recruit vs. year class for brown shrimp.

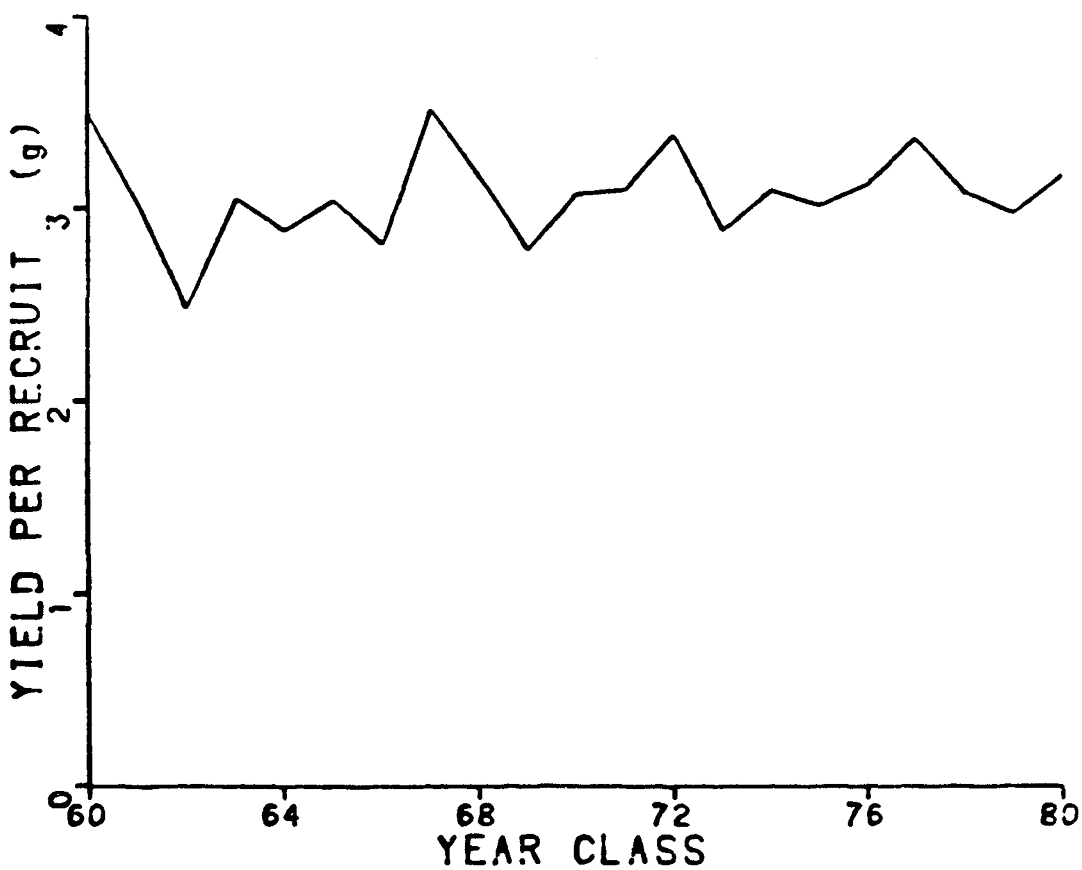


Fig. SHR-11. Estimated realized yield per recruit vs. year class for white shrimp.

Fig. SHR-12. Estimated realized yield per recruit vs. year class for pink shrimp.

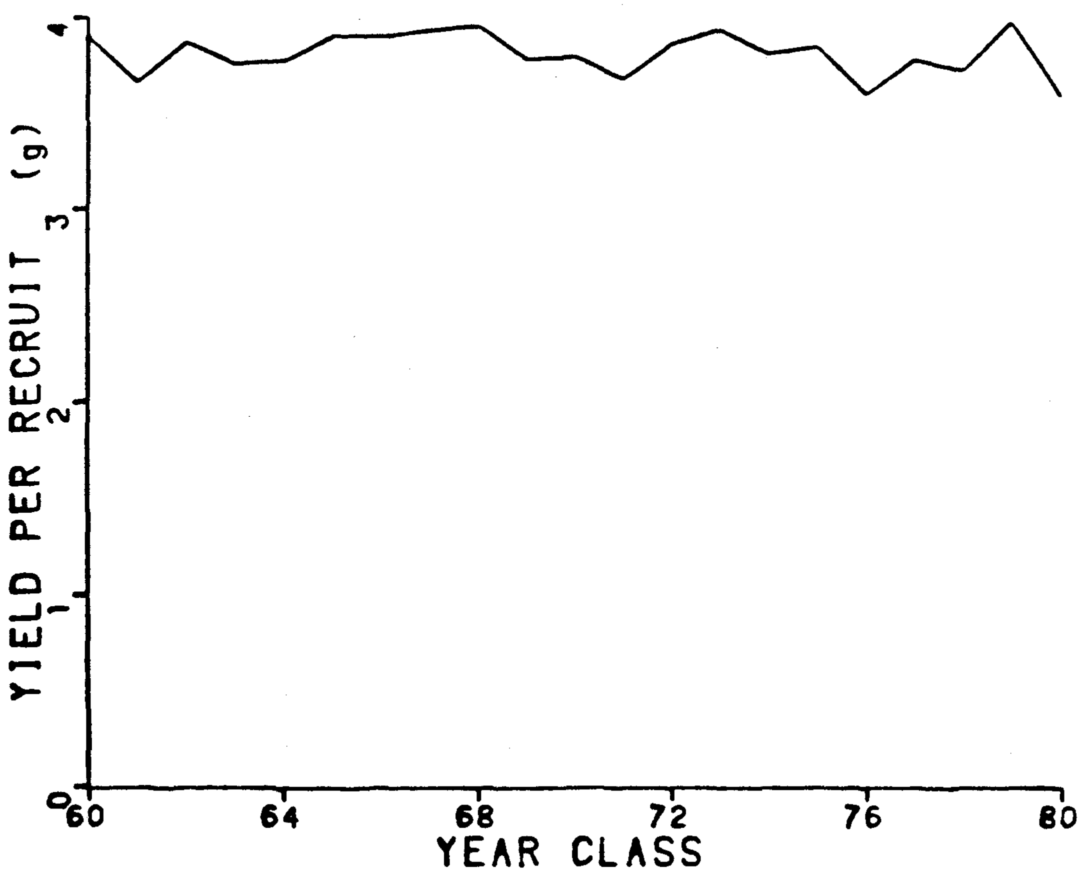


Fig. SHR-13. Estimated annual recruitment for brown shrimp.

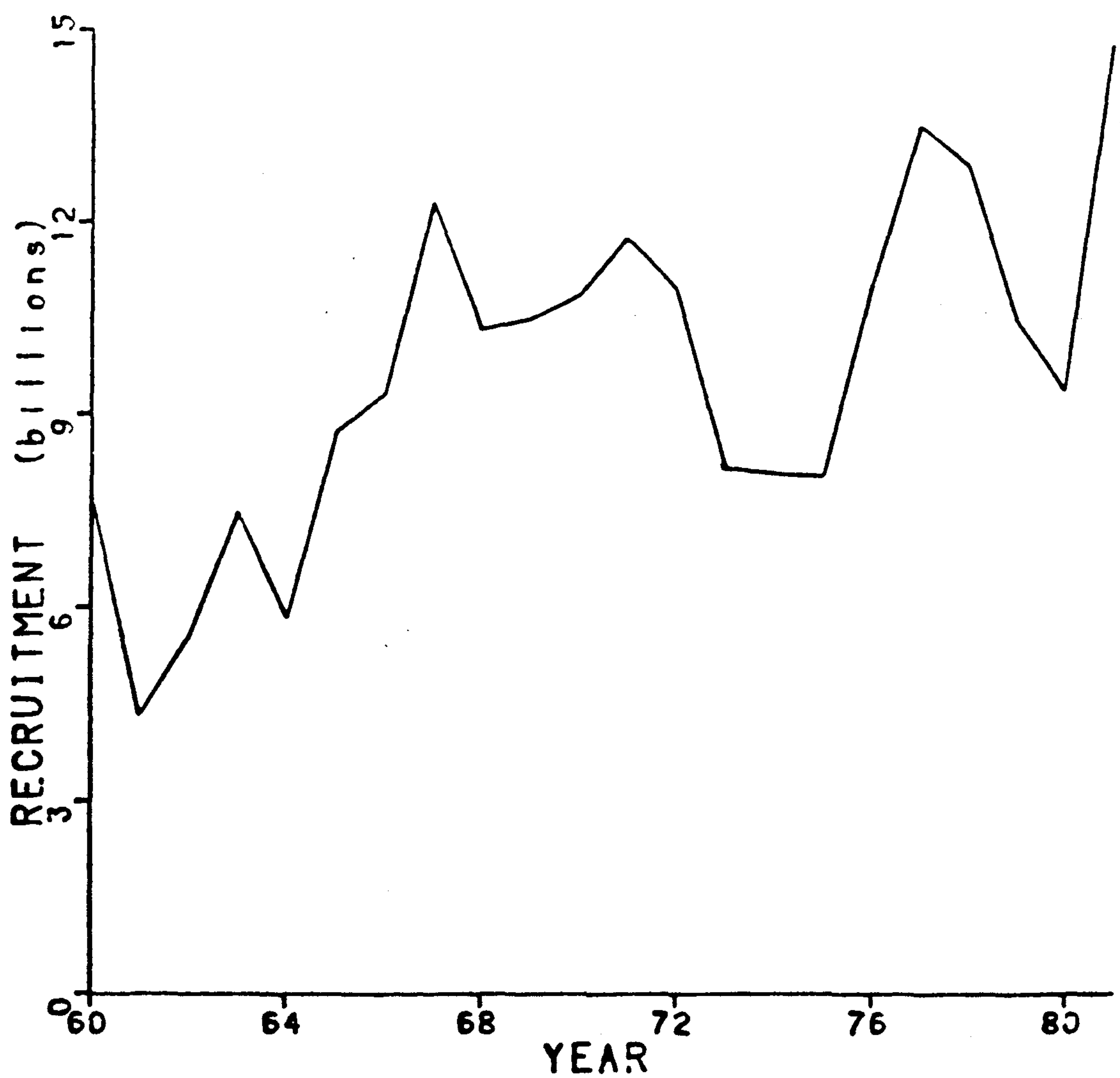


Fig. SHR-14. Brown shrimp stock recruitment relationship, between annual recruitment and October parent stock size. A: replacement line with no fishing. B: replacement line at MSR.

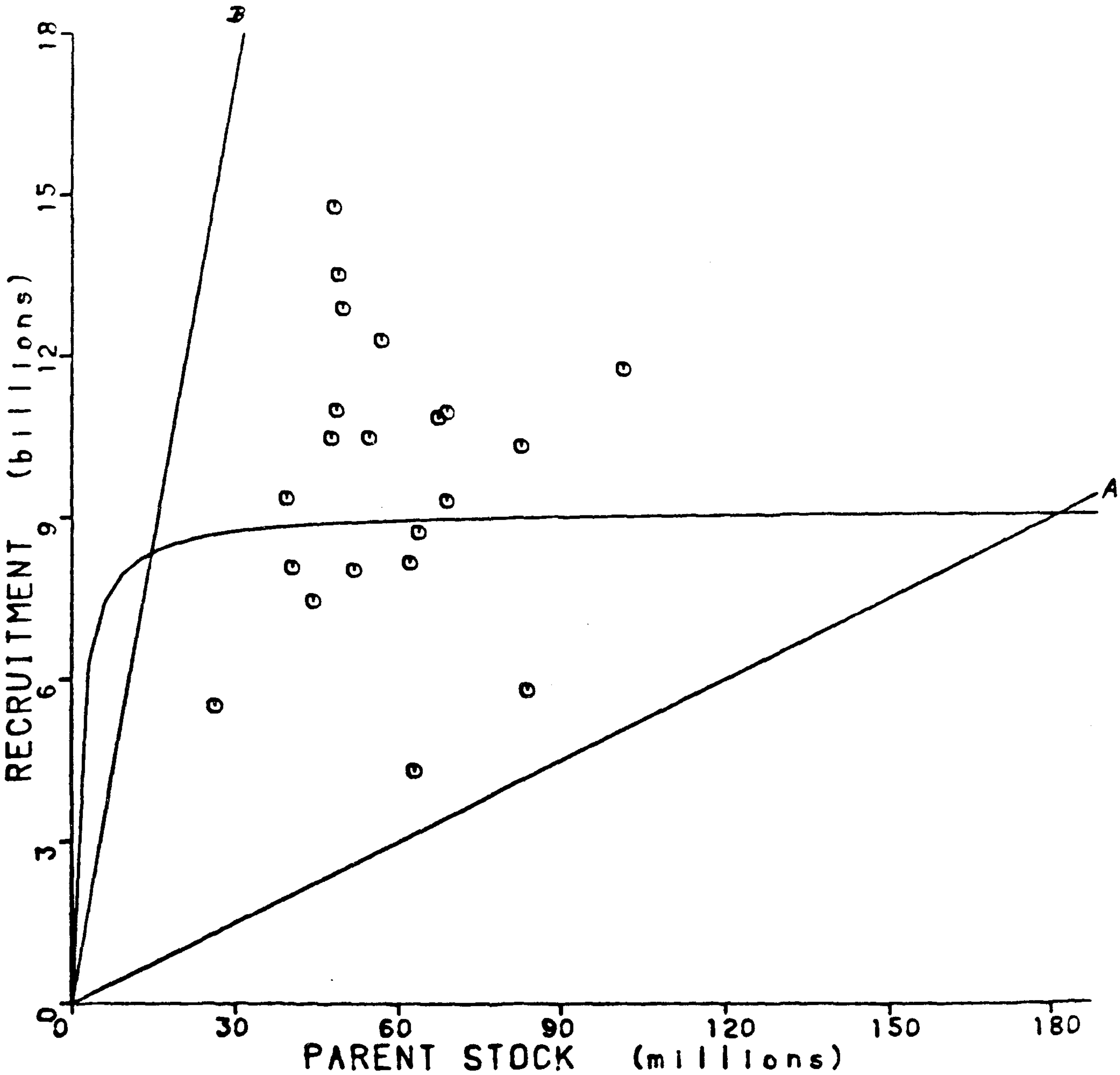


Fig. SHR-15. Brown shrimp stock recruitment relationship between annual recruitment and March parent stock size. A: replacement line with no fishing. B: replacement line at MSR.

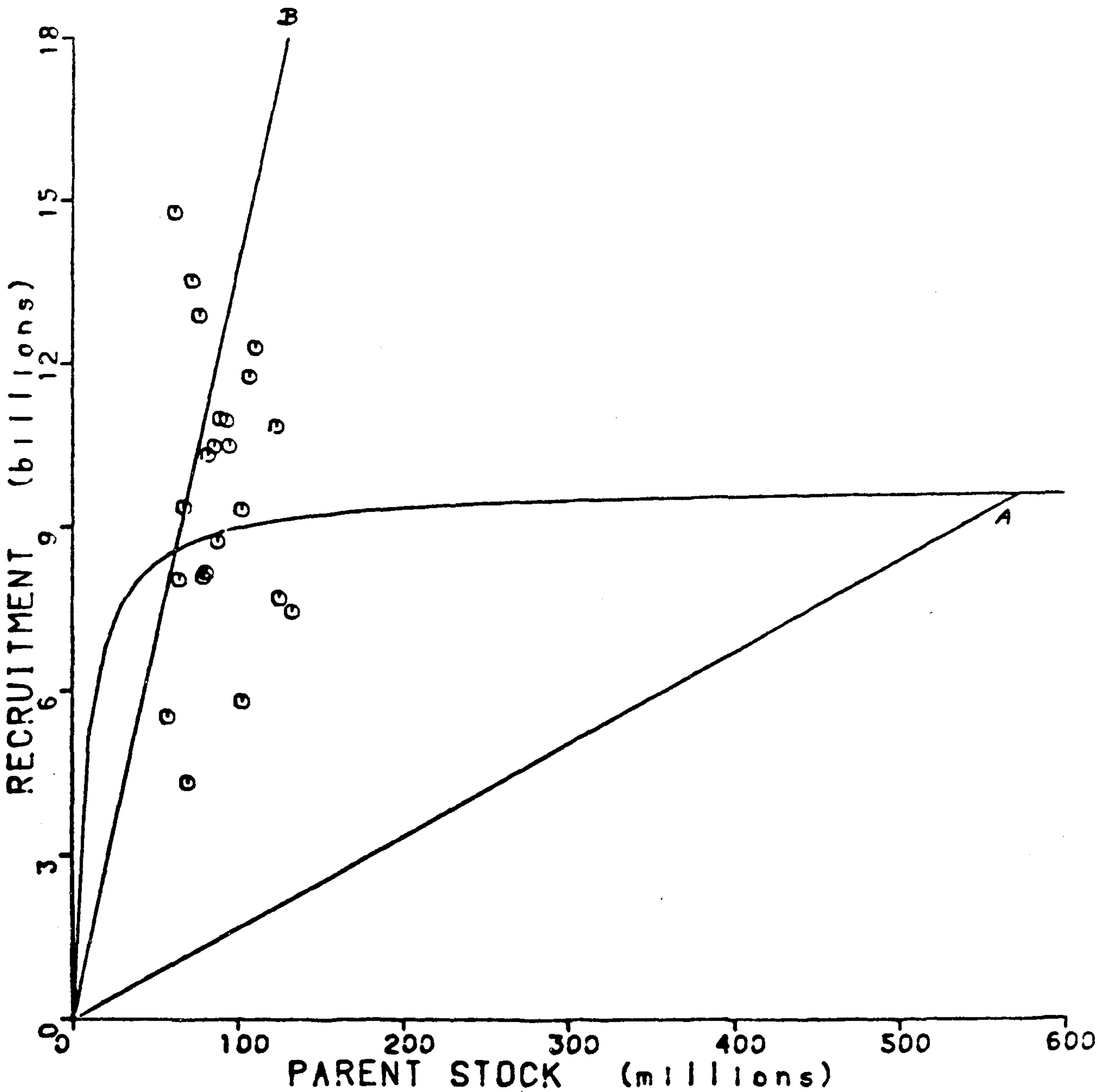


Fig. SHR-16. Estimated annual recruitment for white shrimp.

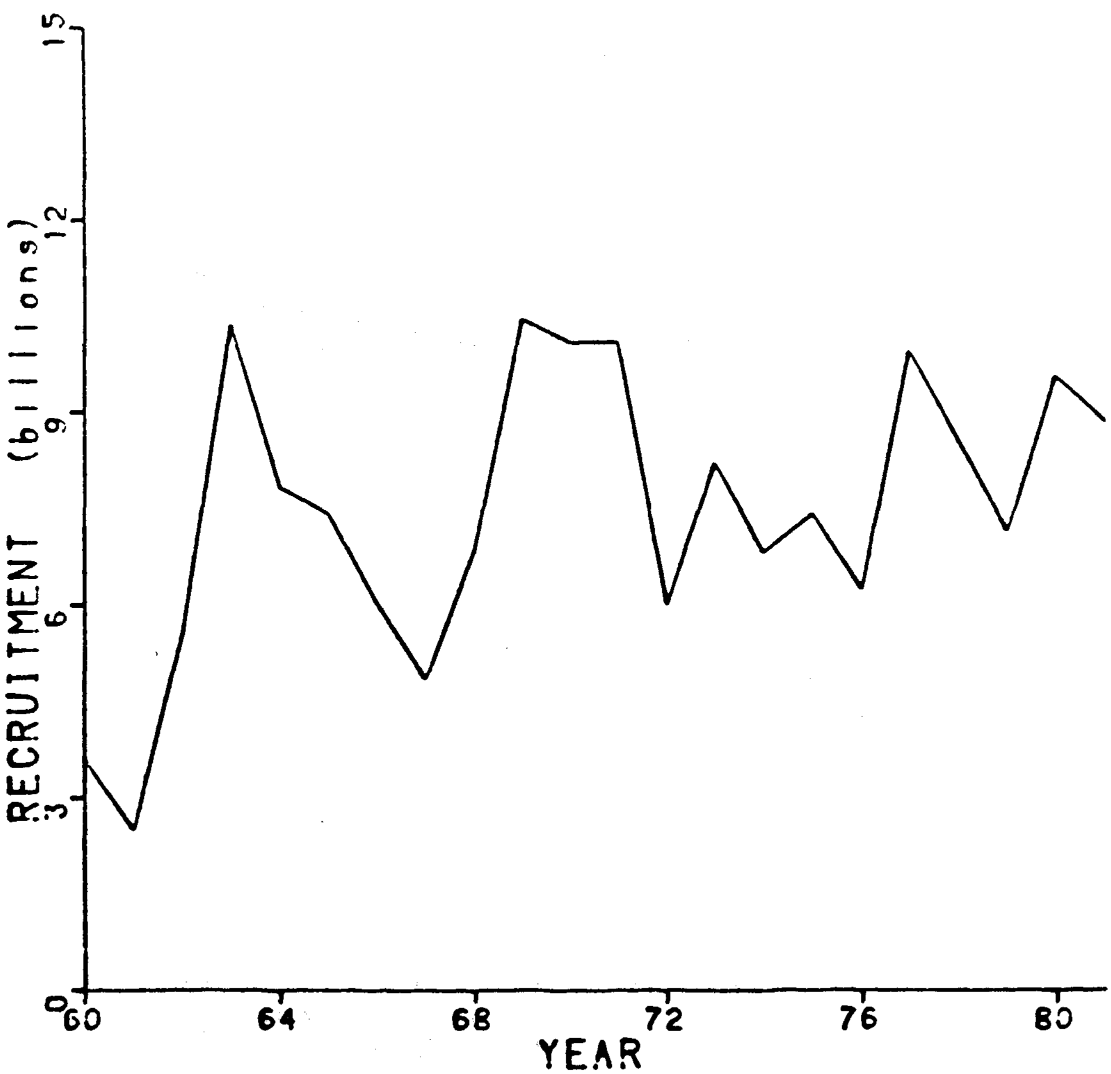


Fig. SHR-17. White shrimp stock recruitment relationship between annual recruitment and May parent stock size. A: replacement line with no fishing. B: replacement line at MSR.

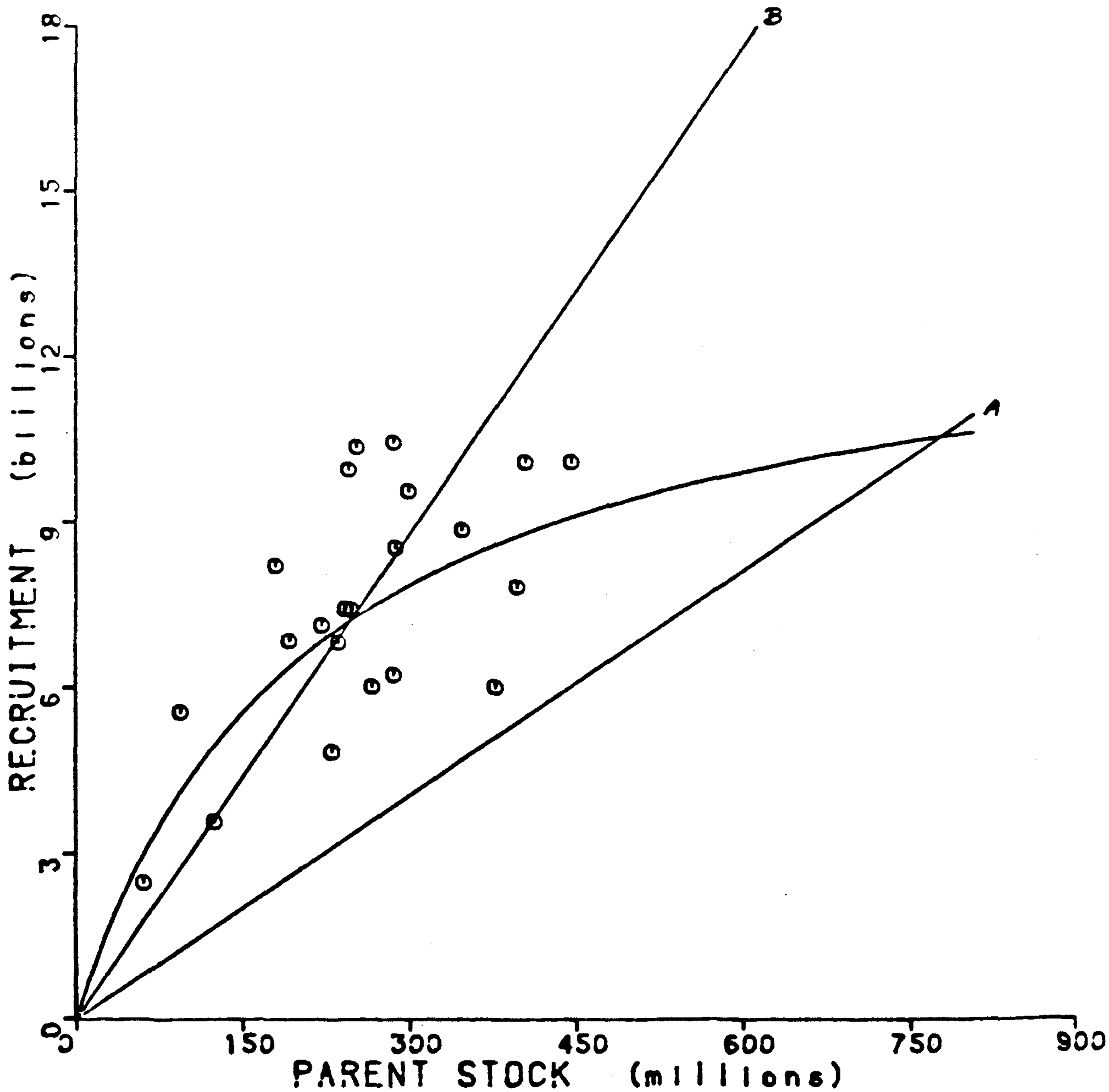


Fig. SHR-18. White shrimp stock recruitment relationship between annual recruitment and August parent stock size. A: replacement line with no fishing. B: replacement line at MSR.

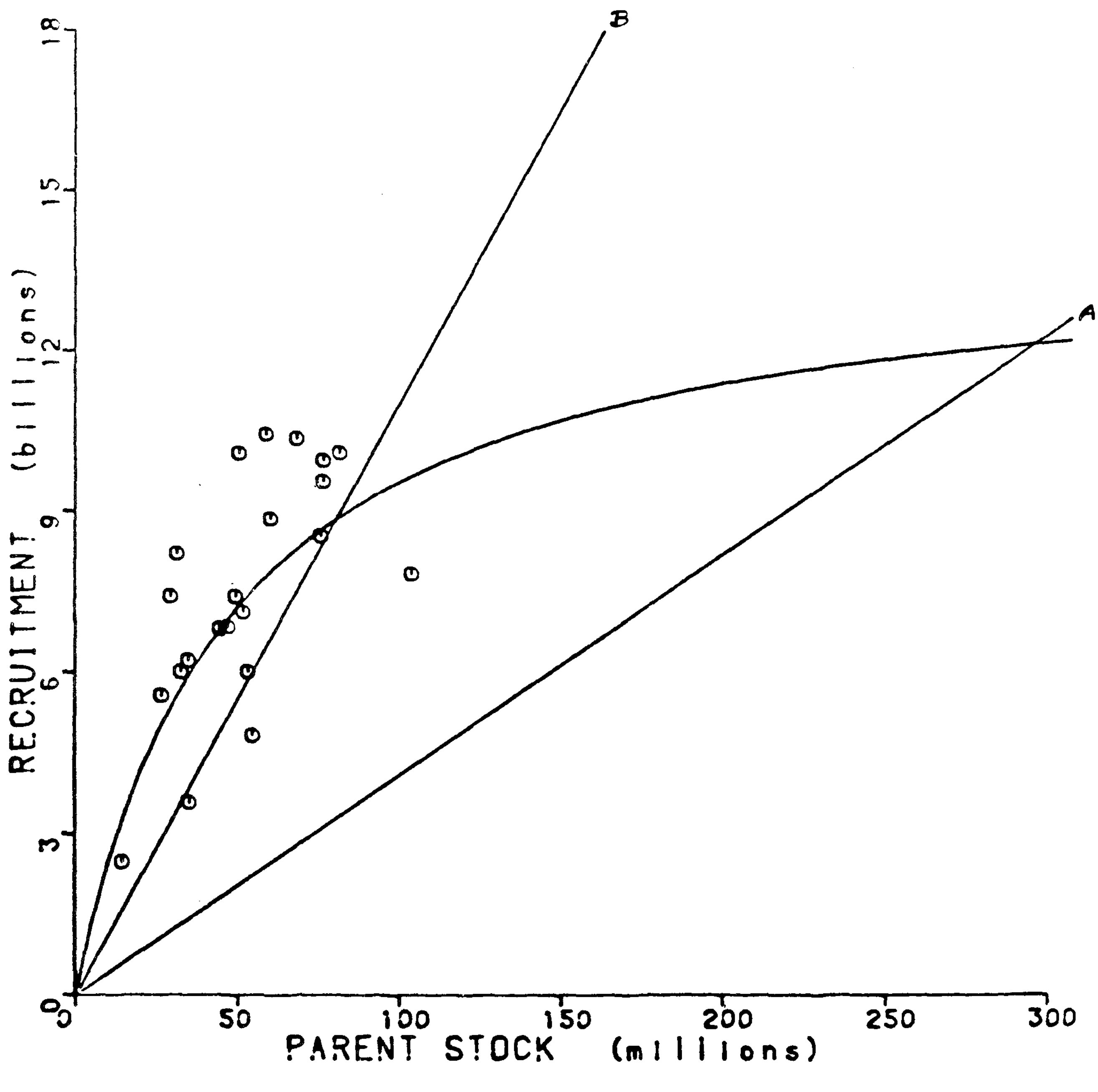


Fig. SHR-19. Estimated annual recruitment for pink shrimp.

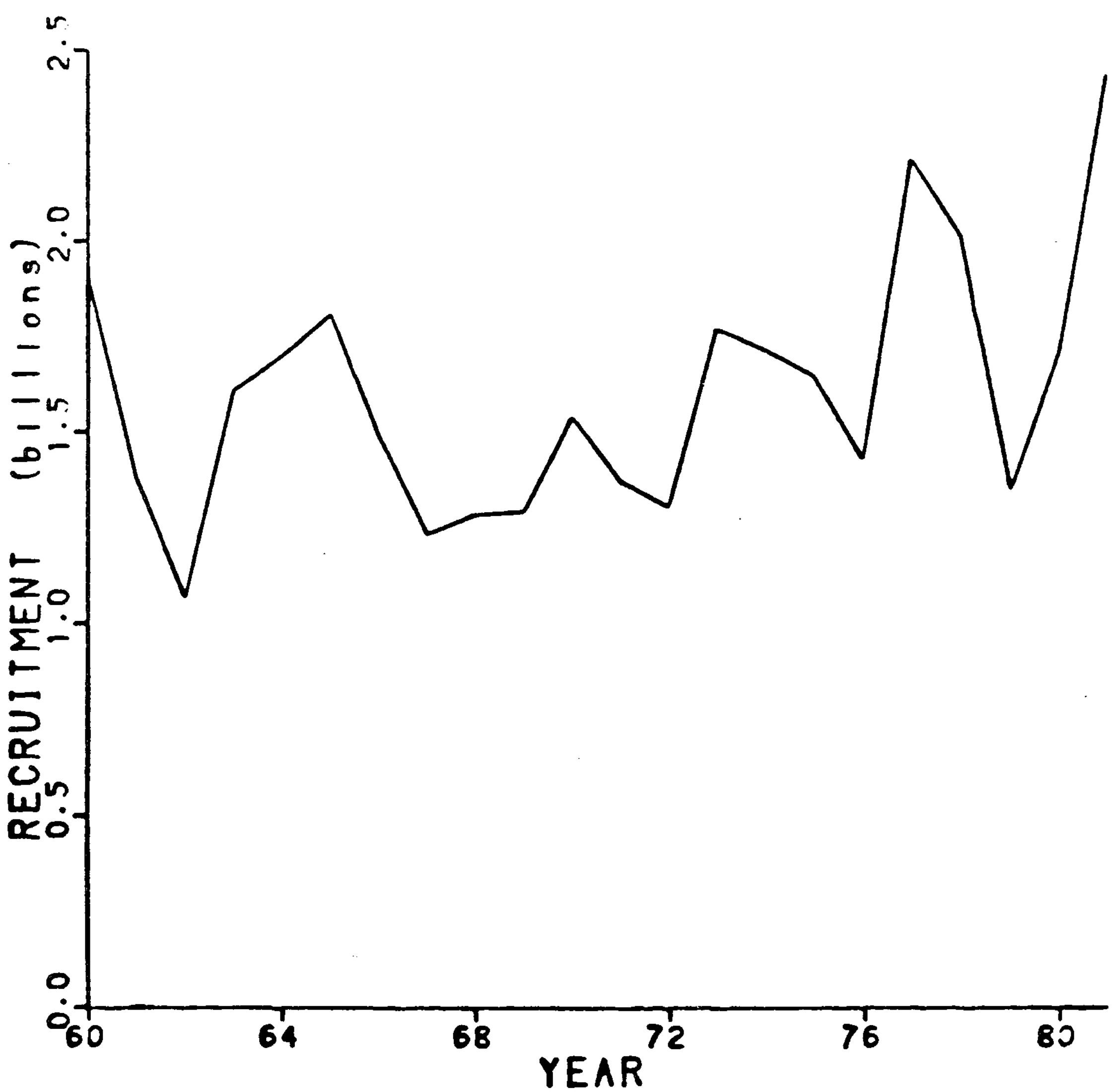


Fig. SHR-20. Pink shrimp stock/recruitment relationship between January through June recruitment and February parent stock size.

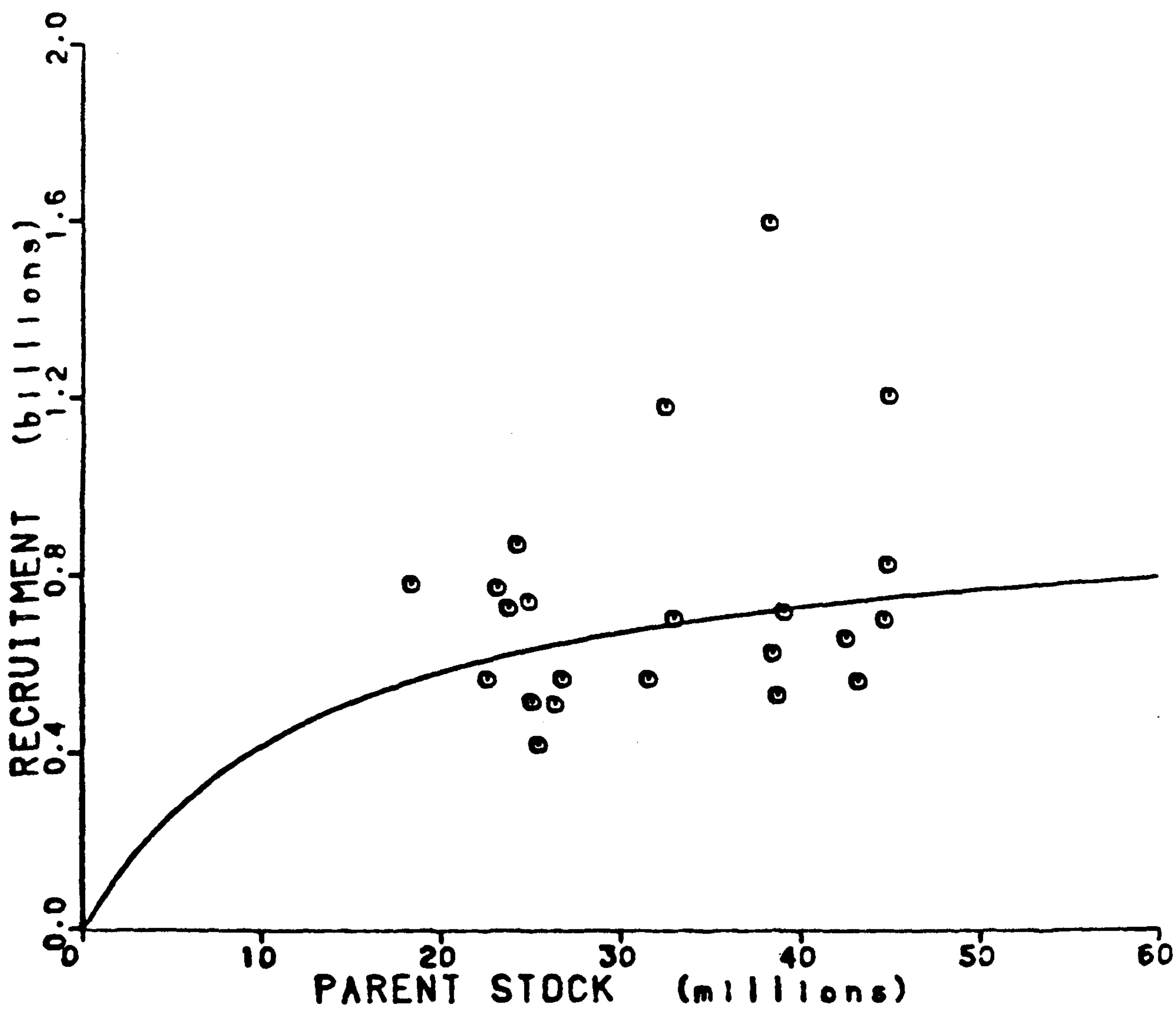


Fig. SHR-21. Pink shrimp stock/recruitment relationship between July through December and August parent stock size.

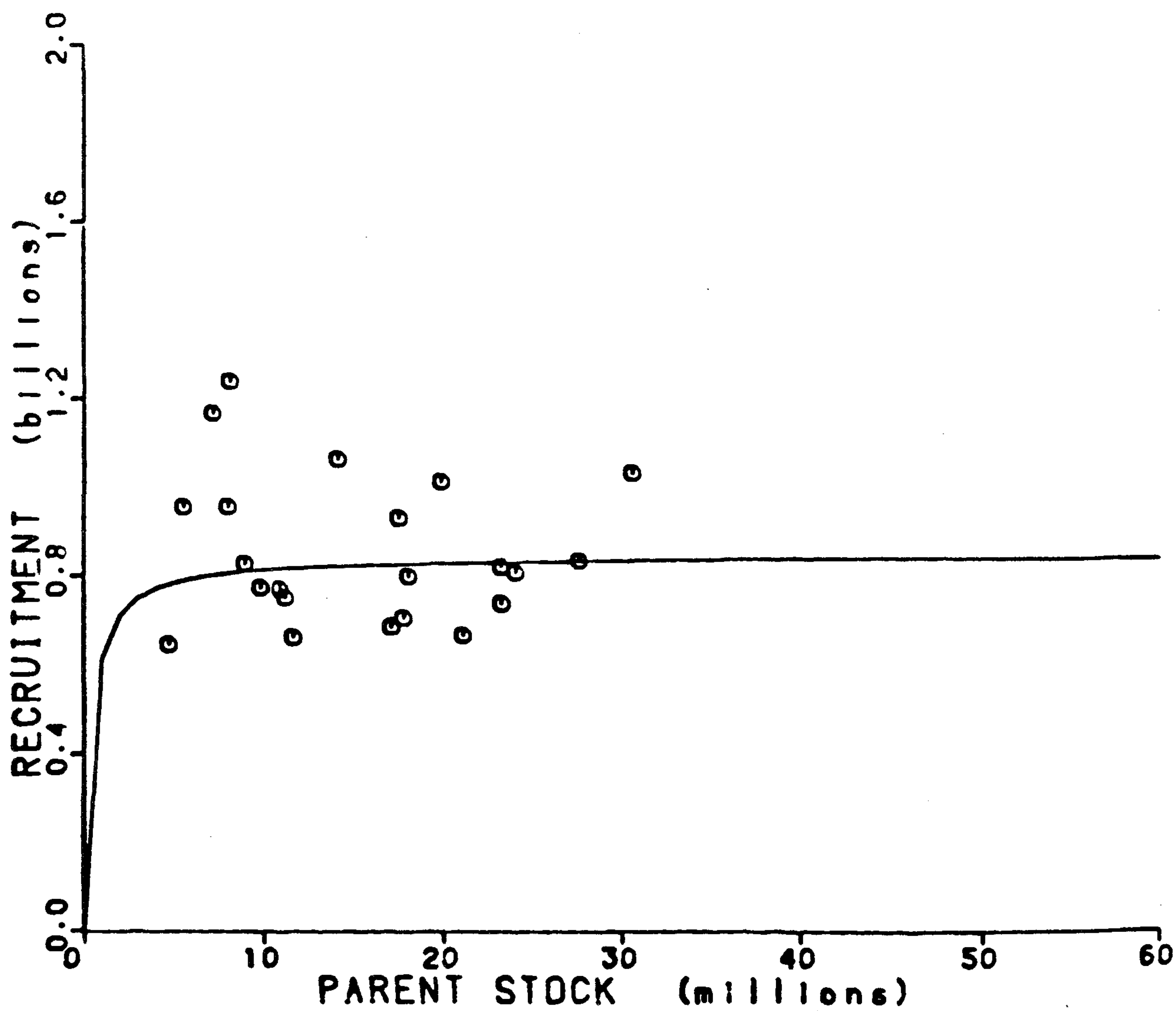


Fig. SHR-22. Annual average size of brown shrimp landed. Numbers at right give equivalent size as tails per pound. (Note: average size calculations assumed landings by weight are spread uniformly between the size boundaries of the commercial market categories. For the >68 category, an arbitrary boundary of 200 tails per pound was assumed.)

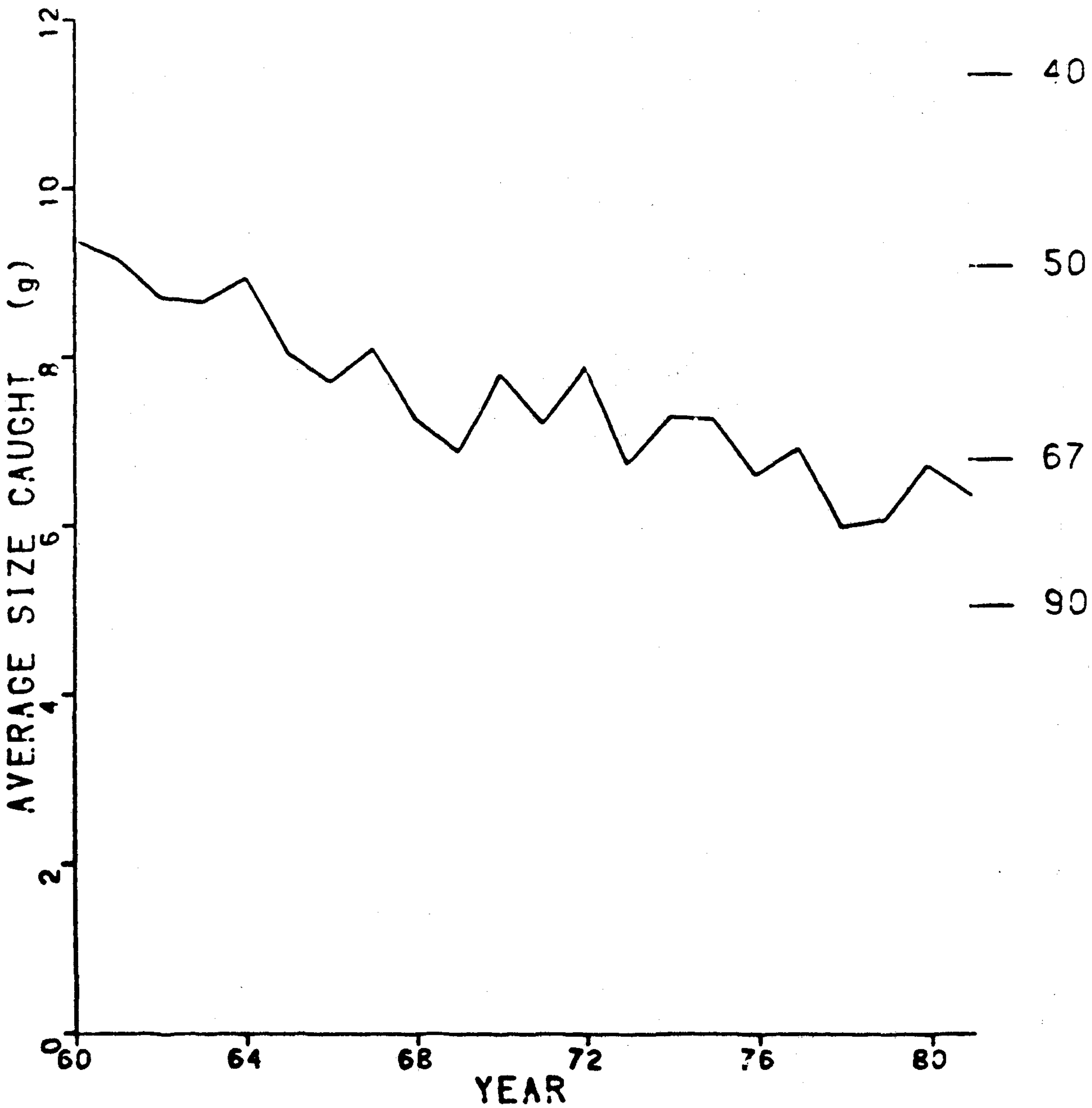


Fig. SHR-23. Annual average size of white shrimp landed. Numbers at right give equivalent size as tails per pound (see note, Fig. SHR-22).

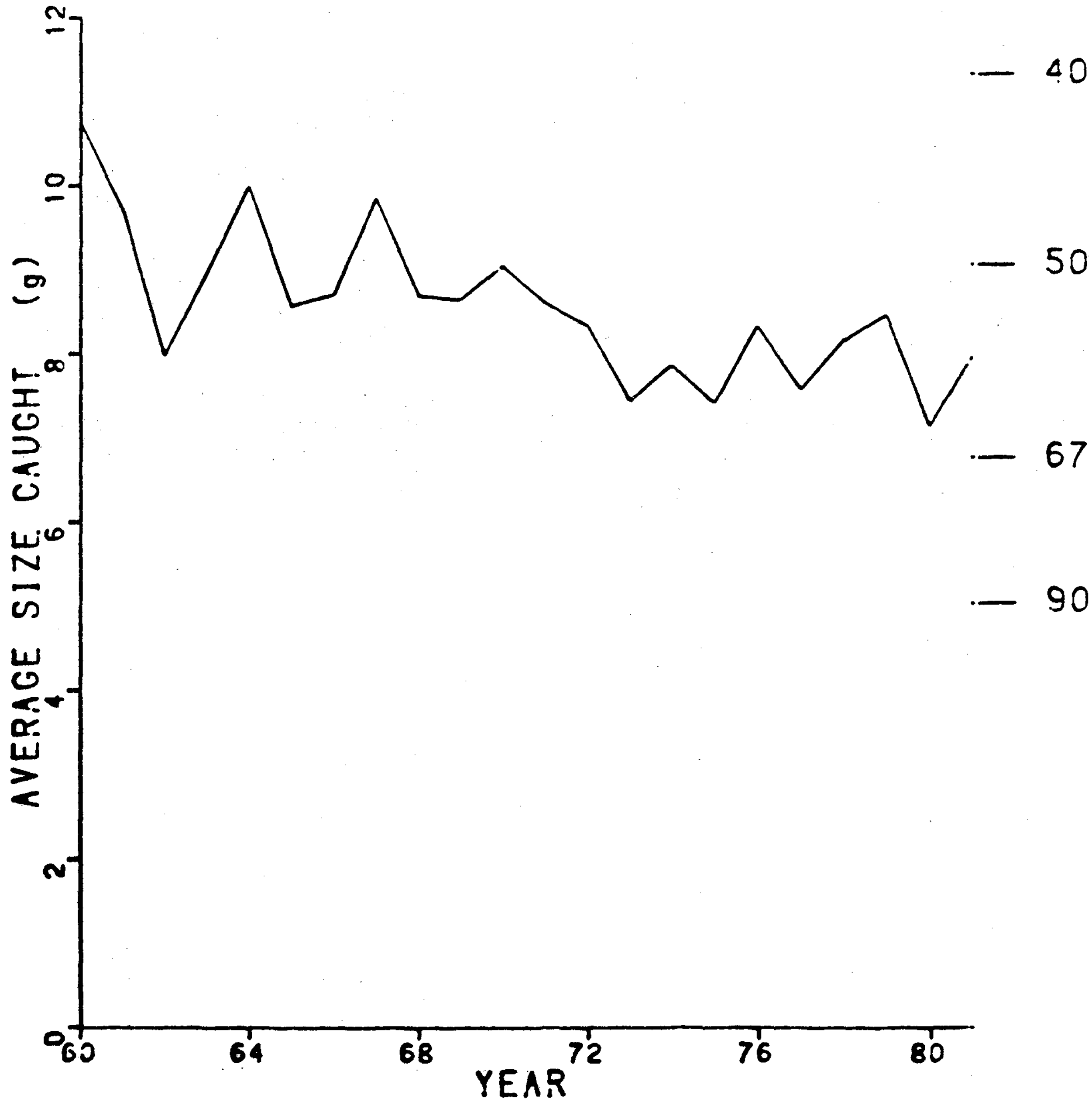
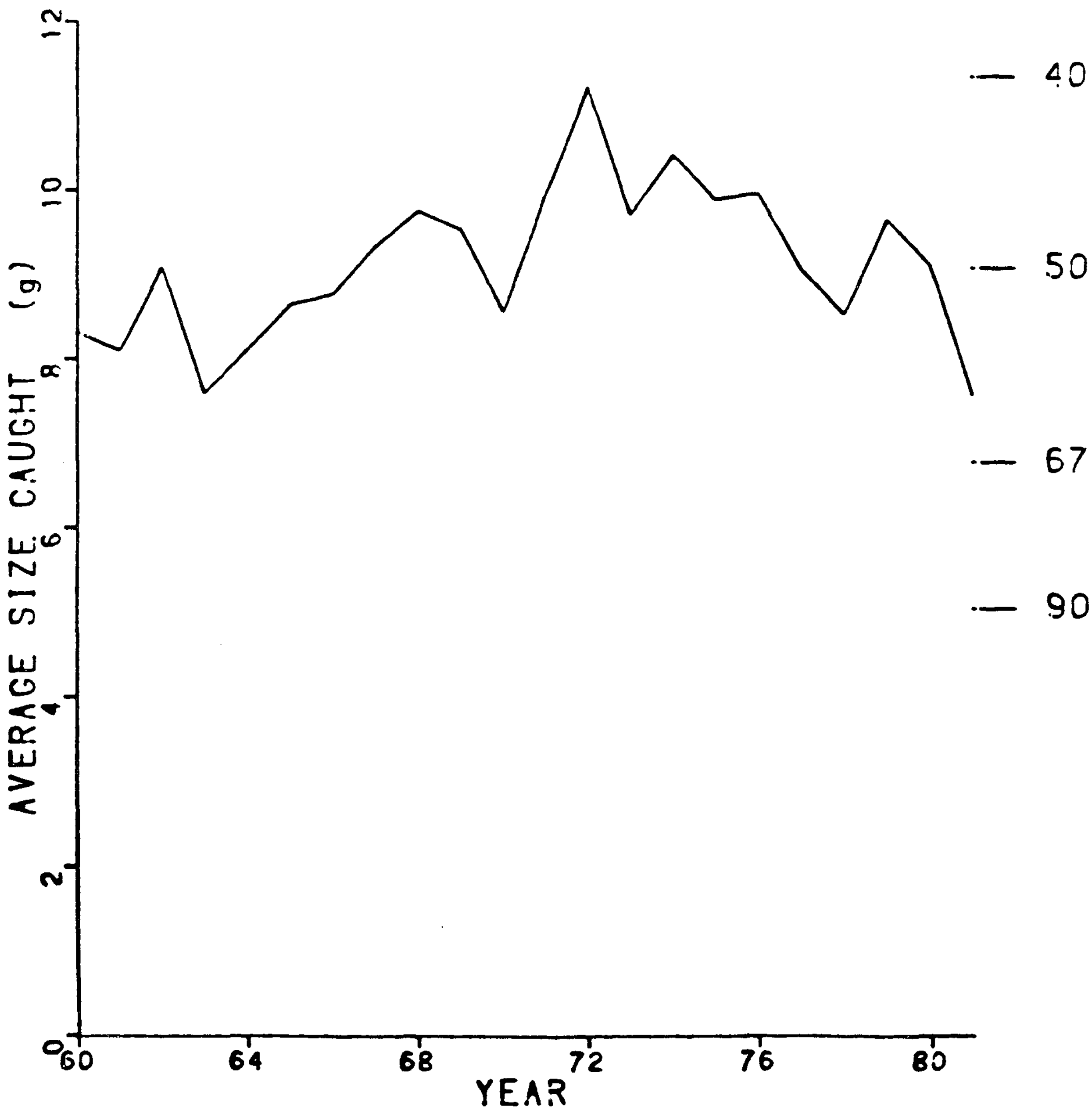


Fig. SHR-24. Annual average size of pink shrimp landed. Numbers at right give equivalent size as tails per pound (see note, Fig. SHR-22).



GENERAL RESEARCH RECOMMENDATIONS

The reports of the working groups given in the previous sections specify research and data needs for improving accuracy and precision of the stock assessment analyses on that particular stock. However, there are some generic themes which are common to most, if not all, of the working groups' research recommendations. The following is an outline of the general areas of research which are critical to improvement of our management advice.

(1) Stock Identification - Much of the present assessment work on southeast resources was based upon assumptions and hypotheses of the definition of the unit of stock. In many cases it was not clear what amount of interchange the hypothesized population had with other populations of the same species, or alternatively if there were significant sub-units of the population which should be managed separately. Examples of the resources for which stock identifications are unclear or unknown are billfish and swordfish, king mackerel, groundfish, reef fish, lobsters, bottlenosed dolphin, loggerhead turtles, coastal herrings, and sharks. The definition of the unit stock requires research into both the reproductive and recruitment processes. What are the migratory patterns of these populations as they relate to spawning or mating of adults? How are the larval fish distributed through the ocean by currents? These questions should be explored using a cadre of research techniques: biochemical and genetic analyses, trace element constituencies, comparison of vital rate parameters, and oceanographic and laboratory experiments. The basic management question is: "is the stock changing in abundance?" Often this question cannot be answered with precision without more research on the definition of the unit stock.

(2) Statistical Data - A major limiting factor in the stock assessment analyses is a lack of data. In particular, usable time series of effort data are often not available. These data are important for developing indices of abundance, defining the relative state of the fishery, fitting production models, estimating mortality rates, and refining virtual population assessment techniques. Collection of effort data is very important to the assessment research.

Another area of data collection which is lacking is size frequencies from the catch. One of the most sophisticated assessment techniques available is virtual population assessment which requires a time series of catch at size and sex (if appropriate) to back generate population abundance. In the previously discussed analyses, this could only be done for Atlantic menhaden and brown, white and pink shrimp. The ability to do virtual population assessments needs to be expanded to other species groups. This will require the collation of available historical size/sex frequency information and regular and continuous collection of these data in the future.

(3) Recruitment Indices - The virtual population assessment technique may be used to generate recruitment indices, for past years. Additionally, catch per unit effort of young size groups can also be used. However, other indices should be explored. Fishery independent surveys were suggested in this Workshop as useful for reef fish and possibly groundfish recruitment indices. These need to be examined, as well as research into other methods.

In addition, the above methods are generally <u>not</u> being used to predict accurately recruitment levels in future years. The recruitment indices show remarkable changes for menhaden and shrimp which are largely unexplained. Variation in recruitment is caused by a combination of environmental factors, stock size and fishing patterns. These factors should be examined in conjunction with statistically precise prediction models, so that more accurate forecasts can be made.

(4) Multi-Stock Assessment - Most of the assessment work presented in the Workshop dealt with single-stocks with no analysis of inter-stock or inter-species interaction. In some instances production models have been fitted to catch data from aggregated assemblages (reef fish, groundfish). There are some severe theoretical limitations to the usefulness of this approach. A research effort is needed to develop: (1) models to depict this interaction if it is significant, (2) models which can be used with limited data sets on species-assemblages, and (3) models which explore criteria and theory of fisheries exploitation of communities of fish such as reef fish, groundfish, coastal herrings, coastal pelagics and others.

In general the above the research directions should be addressed by long-term research programs. However, these needs must be if quantum improvements in the predictability and utility of the applied stock assessment models are to be made.

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APPENDIX 2
List of Workshop Documents

BILLFISH, SWORDFISH, AND SHARKS (BSS)

SAW/82/BSS/1	Beardsley, G.L. (ed.) 1978. Report of the Billfish Stock Assessment Workshop - Atlantic Session. NOAA/NMFS, Southeast Fisheries Center, Miami, Florida 33149. 47 p.
SAW/82/BSS/2	ICCAT. 1981. Report of the ICCAT intersessional workshop on billfish. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, Volume 16. p. 1-31 only.
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SAW/82/BSS/4	Berkeley, S.A., and E.D. Houde. 1981. Population parameter estimates and catch-effort statistics in the broadbill swordfish (<u>Xiphius gladius</u>) fishery of the Florida Straits. Inter. Council. Explor. Sea, C.M. 1981/H:35. 13 p.
SAW/82/BSS/5	Farber, M.I., and R.J. Conser. 1982. Swordfish indices of abundance from the Japanese longline fishery data for various areas of the Atlantic Ocean.
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MARINE MAMMALS AND TURTLES

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