

The Relationship Between Spawning Season and Landings of Selected Reef Fishes on the Continental Shelf of the Southeastern United States

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ABSTRACT

To determine the relationships between spawning seasons of reef fishes and seasonality of catches of them, the records of landings by headboats and the commercial vessels operating in the Atlantic Ocean from Cape Hatteras, North Carolina to the Dry Tortugas, Florida for the years 1981-1990 were tabulated by month and by area and analyzed for seasonal trends. After adjustment for amount of fishing effort there is a strong relationship between spawning season and catch for mutton snapper, *Lutjanus analis*, gray snapper, *L. griseus*, gag *Mycteroperca microlepis*, and greater amberjack, *Seriola dumerili*, a weaker relationship for yellowtail snapper, *Ocyurus chrysurus*, and no apparent relationship for vermilion snapper, *Rhomboplites aurorubens*.

INTRODUCTION

In this paper I attempt to determine if any relationship exists between the spawning season of reef fishes and the seasonality of catches of those species. Fishing mortality (F) can then be inflicted at such a high rate that it is extremely difficult to regulate. Many reef species aggregate to spawn. Red hind, *Epinephelus guttatus*, and Nassau grouper, *E. striatus*, spawning aggregations have been documented in the Caribbean (Colin *et al.*, 1987). Some of the most intensive fishing pressure on reef fish populations occurs over spawning aggregations (Olsen and LaPlace, 1978). The goal of this investigation was to examine recreational and commercial landing records that provided clues to increased vulnerability of selected species during spawning.

METHODS

To determine if there was an apparent relationship between spawning season and landings, we studied six species: vermilion snapper, *Rhomboplites aurorubens*, yellowtail snapper, *Ocyurus chrysurus*, mutton snapper, *Lutjanus analis*, gray snapper, *L. griseus*, gag, *Mycteroperca microlepis*, and greater amberjack, *Seriola dumerili*. Records of landings by both the headboats and commercial vessels operating in the Atlantic Ocean from Cape Hatteras, North Carolina to the Dry Tortugas, Florida were tabulated by month or season, species, and by area for the period 1980-1990. I calculated monthly percentages of landings for each year and then the mean monthly percentage for each month over all years. This allowed for equal weighting of each yearly pattern. I

calculated mean monthly percentage of headboat effort (angler-days) in the same manner. I then compared the monthly pattern of landings to spawning seasons for each species as determined from the literature, as well as to seasonal headboat activity patterns, to determine possible causes for the trends.

To remove latitudinal effects in seasonality of catches I divided the overall region into subareas: North Carolina; South Carolina; northeast Florida (Nassau-Brevard County); southeast Florida (Indian River-Dade County); and the Florida Keys (including the Dry Tortugas). Only for the southeast Florida and Florida Keys regions can headboat catches be analyzed in sufficient detail (by month) to discern spawning effects. Elsewhere, headboat catches are reported by season within years. Commercial data are reported by month for all areas.

RESULTS AND DISCUSSION

Mutton Snapper

Landings averaged 20,000 kg and 30,000 kg annually for the southeast Florida and Florida Keys headboat fishery, respectively, during the years 1981-1989. Commercial landings of mutton snapper averaged near 2500 kg annually for 1982-1984, then increased to nearly 7,000 kg through 1990, with a peak in 1989 of 15,000 kg.

Mutton snapper have been observed spawning in groups (Thompson and Munro, 1974), and the spawning season has been reported as July-August in U.S. waters (Jordan and Everman, 1922). Erdman (1977) reported the capture of ripe females in March in the northeastern Caribbean. South Atlantic headboat survey personnel have observed ripe females in the southeast Florida area in late March-early April (Washnock, pers. comm.).

Headboat catches of mutton snapper in southeast Florida fluctuated greatly in both numbers and weight of fish caught by month but definite peaks occurred. Increased catches start in March and continue through July in most years, but until September in some years. Effort is highest March through July most years, with a peak in April and a second smaller or equal peak in July (Figures 1 and 2). By percentage as well annual landings for southeast Florida headboats start to increase in March, peak in July and then subside (Figure 3).

Florida Keys headboats have their greatest landings in February and March. The largest percentage of the annual catch is taken from December through March, with a peak in February (Figure 3). These four months account for almost 57 percent of the annual catch. Effort in the Florida Keys is highest January through April (Figures 1 and 2) with these four months accounting for 49 percent of annual effort. Mean percent of annual effort is highest (13 percent) in March.

Commercial landings from southeast Florida increase from March through September and peak usually during July or August (Figure 5). Commercial

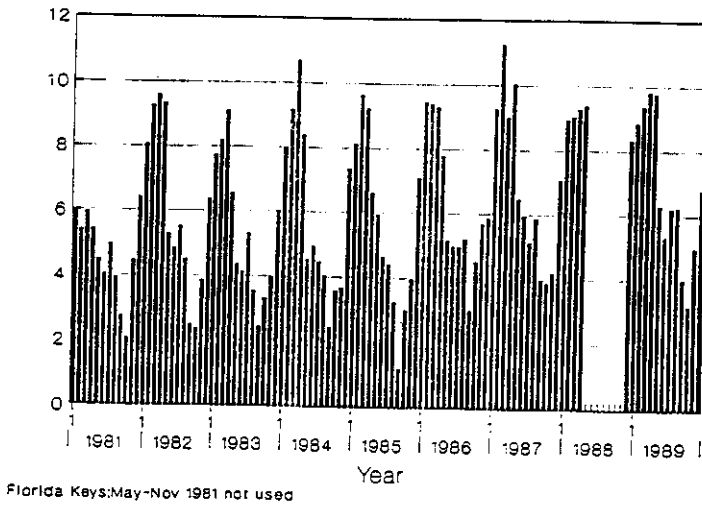
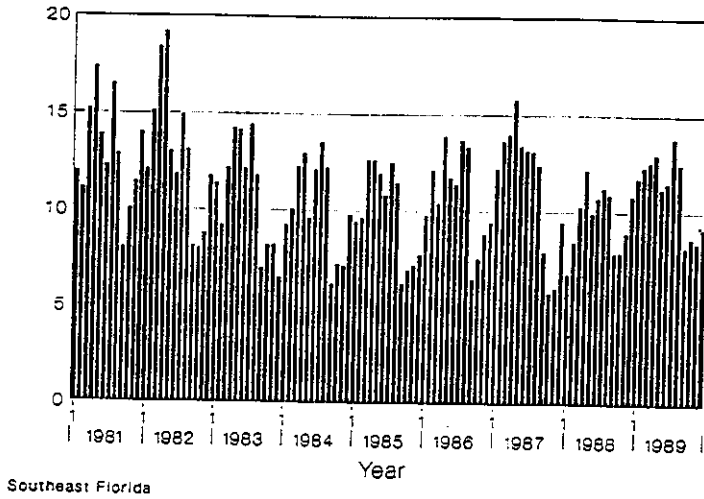
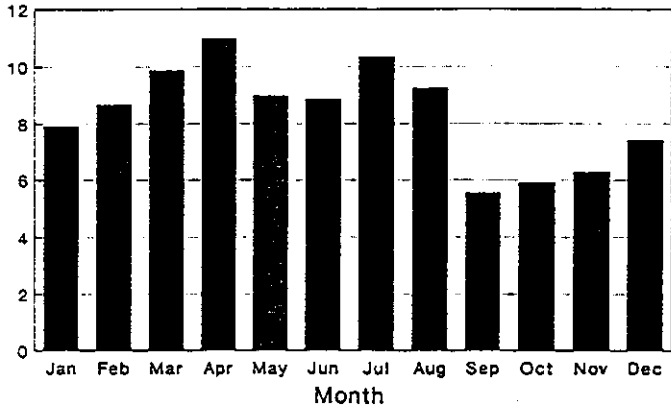
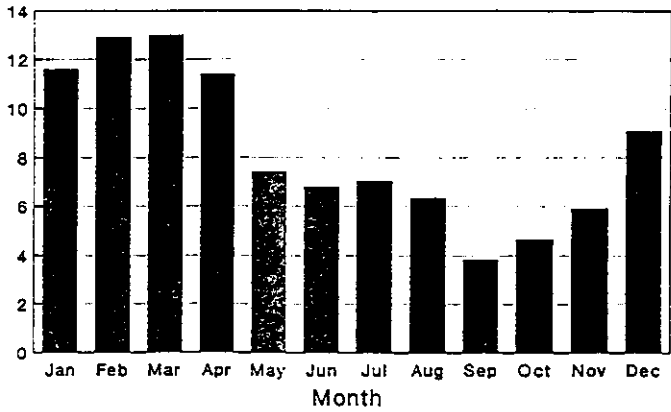


Figure 1. Headboat effort, 1981-1989.

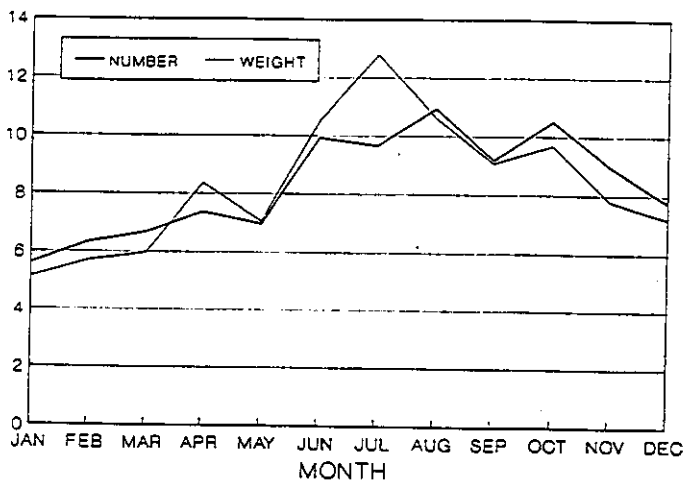


Southeast Florida

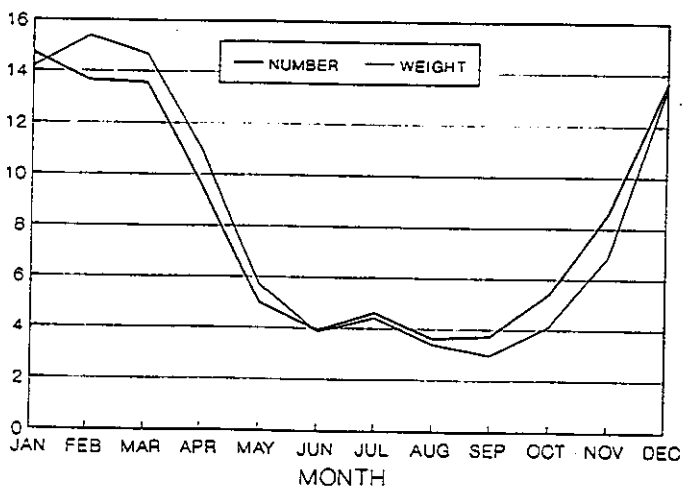


Florida Keys

Figure 2. Mean percent of annual headboat effort, 1981-1989.



Southeast Florida Headboats



Florida Keys Headboats

Figure 3. Mean percent of headboat landings of mutton snapper, 1981-1989.

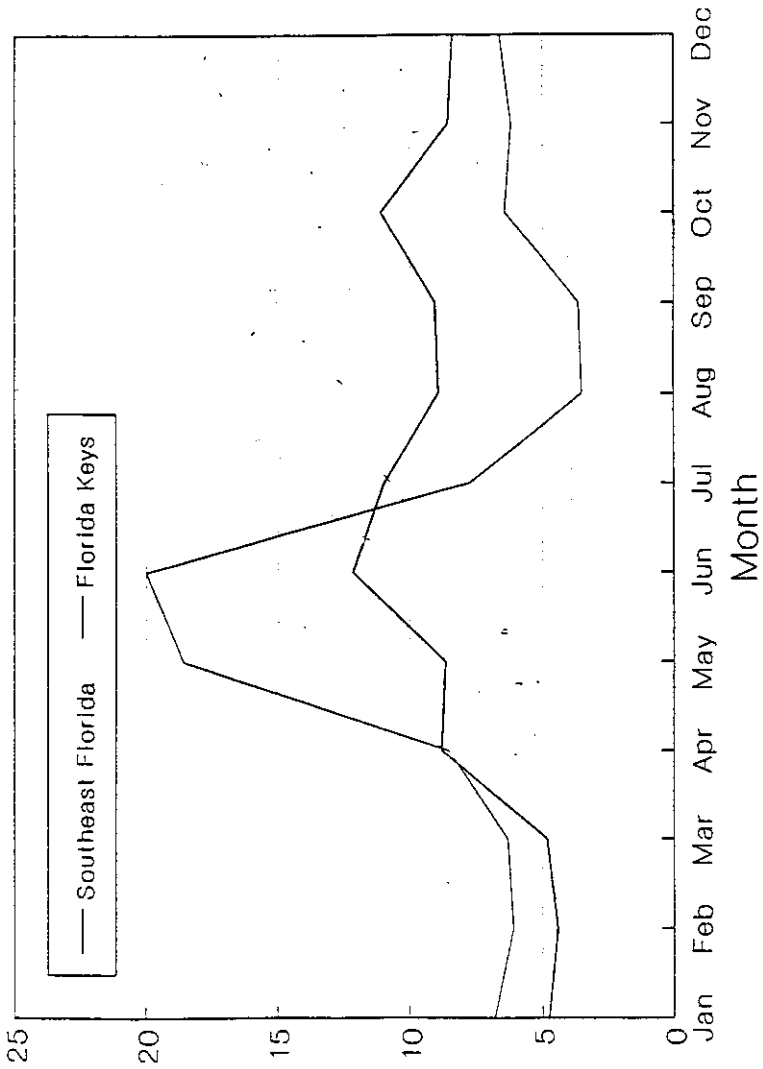
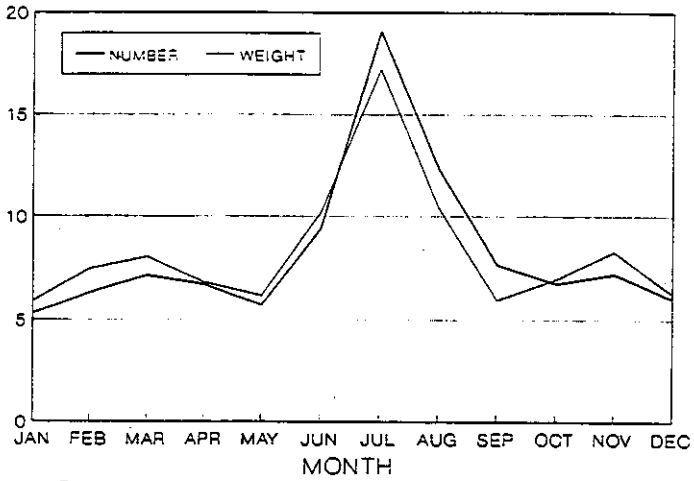
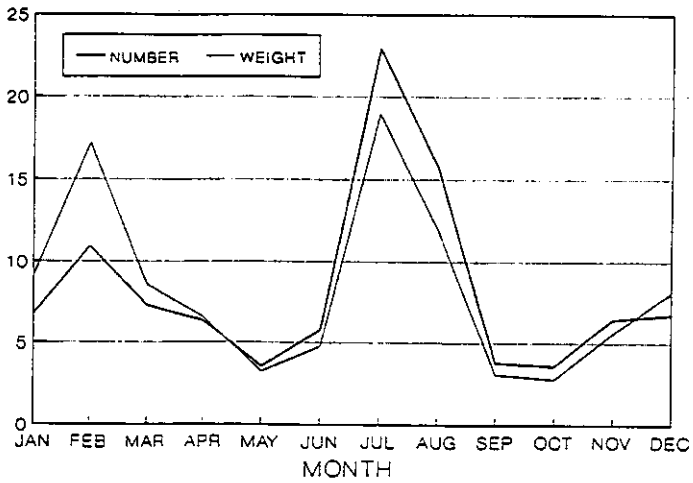


Figure 4. Mean percent of commercial landings of mutton snapper, 1982-1990.

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Southeast Florida Headboats



Florida Keys Headboats

Figure 5. Mean percent of headboat landings of gray snapper, 1981-1989.

landings from the Florida Keys increase beginning in March, and usually peak in April or May. The monthly percentage of commercial landings for southeast Florida (Figure 4) gradually increases from 5 percent in March to 12 percent in June, and then fluctuates at about 10 percent for the rest of the year. Florida Keys commercial catches increase in March, rise to 20 percent of annual landings in June and then subside.

Both scientific observation and anecdotal information show mutton snapper to aggregate during spawning. The literature indicates spawning occurs from March through August. A large percentage of annual landings do occur during these months of peak landings in both southeast Florida and the Florida Keys.

Gray Snapper

The gray snapper is another important component of the south Florida recreational reef fishery, contributing an average of 12,000 kg/yr and 11,000 kg/yr in the southeast Florida and Florida Keys regions respectively, for the years 1981-1989. Commercial landings average 14,000 kg from northeast Florida, 25,000 kg for southeast Florida, and 206,000 kg in the Florida Keys, for the years 1982-1990.

Gray snapper were reported to spawn during the months of July and August by Jordan and Evermann (1922). More recently, Starck and Schroeder (1970) reported spawning to occur from June to September, with peak spawning in June and July for south Florida fish. They reported peaks of occurrence of small gray snapper (10-20 mm) in July and August. Based on variations in gonad length and weight, it appears that spawning might occur on the full moon at dusk. Headboat survey personnel report that northeast Florida headboats specifically run trips at night during the full moon in summer to target gray snapper which then compose almost 90 percent of the total catch (Michael Burton, personal observation).

Landings of gray snapper fluctuate from year to year, but almost all years have a peak occurring in the months of June through August for both southeast Florida and the Florida Keys. For southeast Florida headboats the annual catch averages 6-8 percent per month January through May, then increases to 18 percent for July before falling back to 6 percent in September (Figure 5). Mean percent of annual effort for southeast Florida peaks in April, declines in May and June, and rises again in July (Figure 2). This increase in effort is of a much smaller magnitude than the threefold increase in landings (from 6 to 18 percent) that occurs from May to July. Florida Keys headboats show a similar trend (Figure 5) with a peak of 23 percent of annual landings taken in July, and a decline to below 5 percent in September. Fishing effort in July is only about one-half of March's peak of 13 percent of annual effort (Figure 2). The Florida Keys have an additional peak in February of about 17 percent of annual landings. This peak corresponds to peak effort in February and March in the

Florida Keys. However, the separation of percentage by weight caught from percentage by number caught is greatest during this month, indicating that heavier fish are being caught for some reason, perhaps related to spawning. We need further investigation to determine if gray snapper spawn in the Florida Keys during this time.

Commercial landings are similar to those of headboats for all areas. Northeast Florida and southeast Florida commercial landings have greatly exaggerated peaks during summer in almost all years. Florida Keys landings peak almost every summer, and have smaller peaks during the first three months of the year. The exception to this pattern is for the years 1984-1985, when the winter peak exceeded or was equal to the summer peak. The highest percent of annual landings occurs during the summer months in all areas, and in the Florida Keys 25 percent of annual catch is taken in July alone. (Figure 6).

Gray snapper are summer spawners. Personal observation has revealed that fishermen specifically target these fish during known spawning times and catch large numbers of gray snapper. Data presented here show that increased availability and catches of gray snapper occur during the spawning season.

Yellowtail Snapper

The yellowtail snapper is a very important component of the south Florida reef catch and accounted for an average of 29,000 kg/yr for southeast Florida headboats for 1981-1989; Florida Keys headboats landed an average of 85,000 kg/yr during the same time period. Commercial landings during the years 1982-1990 averaged 36,500 kg/yr and 522,600 kg/yr for southeast Florida and the Florida Keys, respectively.

Studies of yellowtail snapper indicate that spawning season differs by geographic area. Munro *et al.* (1973) determined that yellowtail snapper probably spawned year round off Jamaica with peak spawning in February and again in September or October. Cuban yellowtail snapper spawn March through September, with a peak in April and May (Piedra, 1969). The Florida Keys yellowtail snapper spawn serially from April to July, with peak spawning occurring in June and July. Fish with ripe ovaries were found during the months of April, June and July. Peak spawning was determined by both visual and microscopic staging of gonadal tissue and by gonosomatic indices.

In most years catches of yellowtail snapper from the southeast Florida headboat fishery have two monthly peaks, one in early summer and another in late fall. There is only one peak in 1985, in September. The highest percentage (Figure 7) of annual landings of southeast Florida headboats is taken during August (13 percent). The percentage stays high from August through October, then declines. Effort is highest April through July (Figures 1 and 2). There are two months when the percentage of total weight substantially exceeds

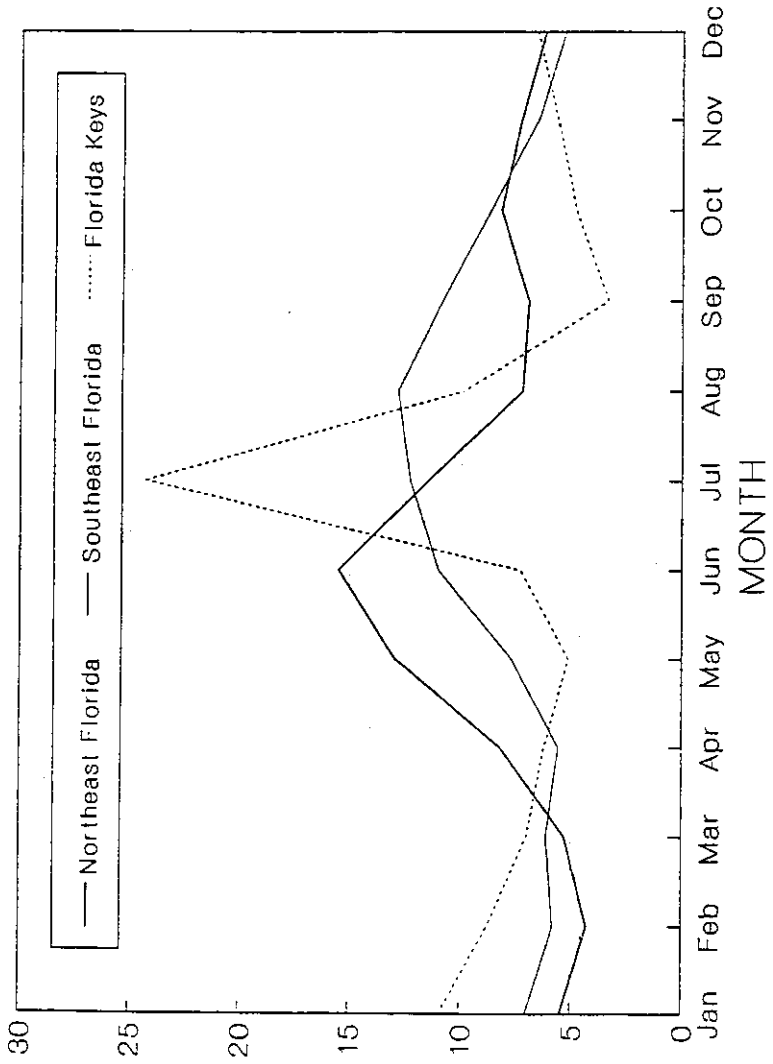
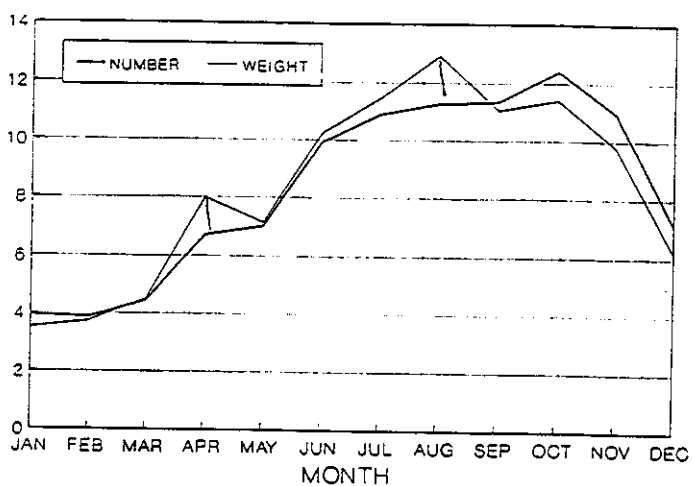
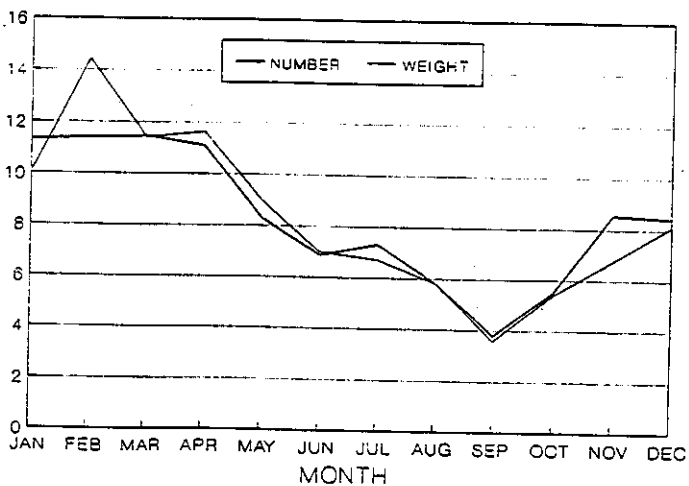


Figure 6. Mean percent of commercial landings of gray snapper, 1982-1990.

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Southeast Florida Headboats



Florida Keys Headboats

Figure 7. Mean percent of headboat landings of yellowtail snapper, 1981-1989.

percentage of total number of fish caught, April and August. Perhaps the fish are heavier then because they are in spawning condition.

Headboat catches from the Florida Keys are more erratic. Some years have only one peak and other years have three almost equal peaks. By mean percentage, Florida Keys headboat landings (Figure 7) show a single peak (14 percent) of total weight caught in February, the month where weight exceeds the number by the largest amount. Effort is highest in the Florida Keys in February and March (Figures 1 and 2).

Commercial landings from the southeast Florida show a relatively regular pattern of increases in about April subsequent substantial rises to a peak, usually in July, and then subside. Florida Keys landings are similar with a peak occurring almost always in June or July, that is often preceded by a lesser peak in April. By percentage the two areas are remarkably similar, with June accounting for 15 percent of annual catch for both (Figure 8). Both the commercial catches and the headboat landings from southeastern Florida peak in the summer, but in the Keys headboat catches are largest at a different time, January through March. This could be attributable to winter being the season of peak fishing effort in the Keys, but the increased size of the fish (Figure 7) implies a phenomenon related to spawning. Yellowtail snapper spawning season is most likely April through July, primarily June and July. Landings definitely increase during the summer in most fisheries and areas.

Vermilion Snapper

Vermilion snapper provide large landings to the headboat fishery of the southeast U.S. Average catches for the years 1981-1989 were 29,000 kg/yr, 39,000 kg/yr, and 56,000 kg/yr for North Carolina, South Carolina and northeast Florida respectively. Although vermilion snapper are less abundant in south Florida, landings still averaged almost 19,000 kg/yr in southeast Florida and 10,000 kg/yr in the Florida Keys. Commercial landings averaged 150,000 kg/yr for North Carolina, 127,000 kg/yr for South Carolina and 60,000 kg/yr for northeast Florida.

Vermilion snapper possibly spawn year round in the Caribbean, with peak spawning occurring when the sea surface temperature is 26.5°C (Munro *et al.*, 1973). Grimes and Huntsman (1980) determined that vermilion snapper spawn April through September off North Carolina, and ripe fish were found when the surface temperature was between 26°C and 27°C.

Headboat catches in southeast Florida fluctuate erratically with peaks in the winter. Some years (1982, 1983, 1984) have a midsummer peak as well, but the January peaks are greatest. The highest percentage of annual landings occurs in January (Figure 9) with January and February alone accounting for 25 percent of the annual catch for southeast Florida headboats. The months March through July have the lowest mean percentage of annual landings and the highest mean

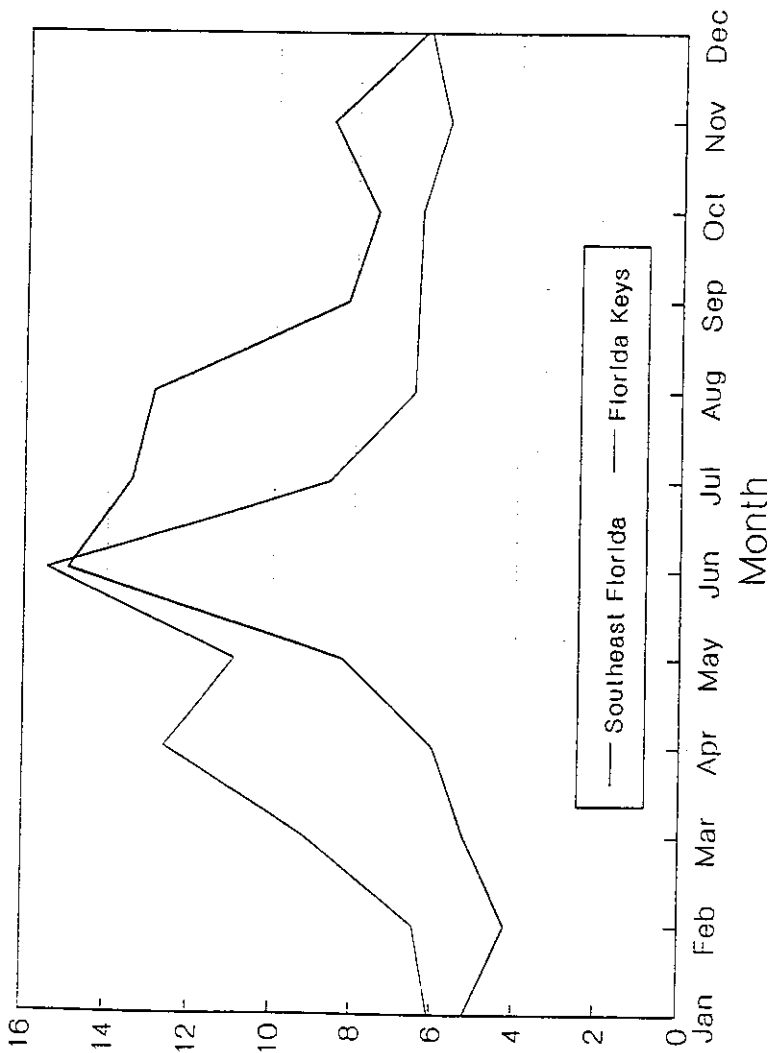


Figure 8. Mean percent of commercial landings of yellowtail snapper, 1982-1990.

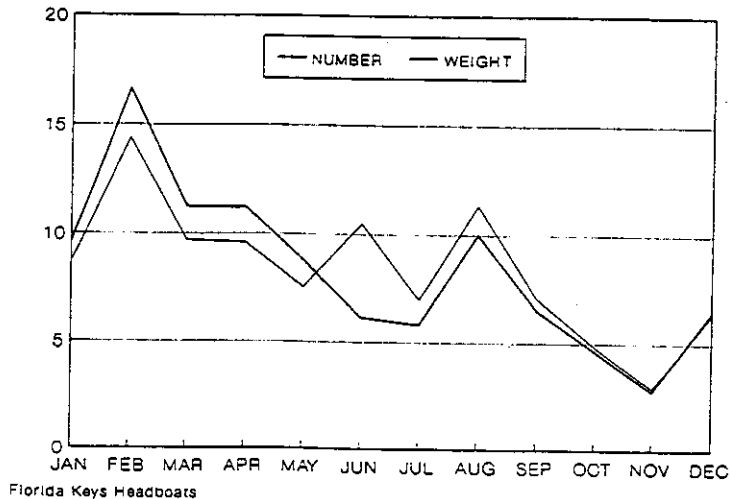
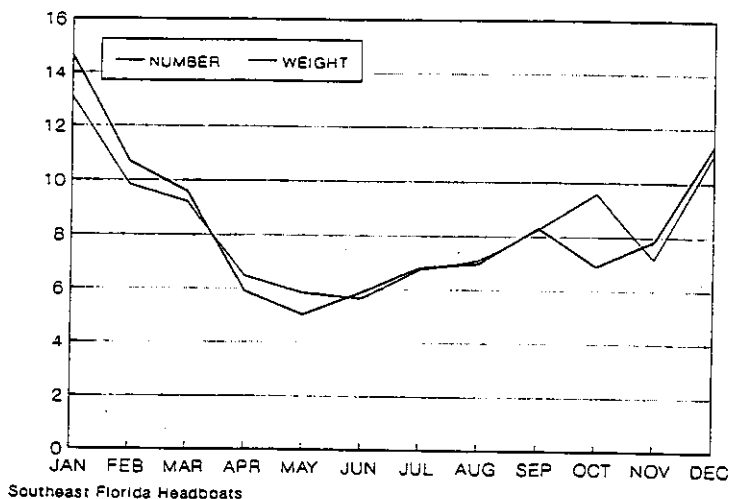


Figure 9. Mean percent of headboat landings of vermillion snapper, 1982-1990.

percentage of annual effort (Figure 1b). Florida Keys landings peak a month later (February and March) most years. Florida Keys headboat catches also show the greatest percentage of the annual total in February, 17 percent (Figure 9). Mean percentage of annual effort is highest in the Florida Keys in February and March (Figure 9).

The greatest commercial landings in North Carolina occur in the summer in most years, probably because inclement weather during the winter inhibits fishing. South Carolina peak commercial landings occur in February and March most years, and in northeast Florida landings fluctuate greatly, but overall are dispersed evenly through the months. In North Carolina the months with the highest percentage of the annual catch of vermilion snapper are in the summer (Figure 10), but it is likely that increased landings in summer are as much a result of improving weather as of aggregated or more active fish. In South Carolina the percentage of annual landings caught each month varies little, ranging from 7 to 11 percent. No peaks are evident. In northeast Florida catches are about equal at 8 percent for the first six months of the year, then decline sharply in July and gradually increase through October. This pattern appears to be indicative of the annual slow period in fishing attributable to reduced effort due to hot weather.

There is little evidence for a spawning season-catch relationship. Headboat landings are highest in the winter in south Florida, headboat effort is highest in the spring and summer, and commercial landings in the three northern areas do not increase during the accepted spawning season.

Gag

The gag is one of the fishes most sought by headboat anglers. Average annual headboat landings for the years 1981-1989 were 7,500 kg/yr for North Carolina, 2,000 kg/yr for South Carolina and 6,800 kg/yr for northeast Florida. Gag are less abundant in south Florida, where they are replaced to some degree by the red grouper, *Epinephelus morio*. Still, headboat landings in southeast Florida averaged 1,500 kg/yr. Commercial landings of gag averaged 122,000 kg/yr for 1986-1990 in North Carolina. South Carolina averaged 145,000 kg/yr for the years 1982-1990. Northeast Florida commercial landings averaged 65,000 kg/yr from 1986-1990. Southeast Florida averaged just under 20,000 kg/yr of gag landed from 1986-1990.

Gag appear to be a winter spawner. Peak spawning occurred in February off the Carolinas (Manooch and Haimovici, 1978) and in the Gulf of Mexico gag spawned from January through March (McErlean, 1963). I have observed gag in northeast Florida in spawning condition (running milt) from December through February. South Florida fishermen have reported gag school off the coast from Hobe Sound to Boynton Beach from Christmas through April, and they have

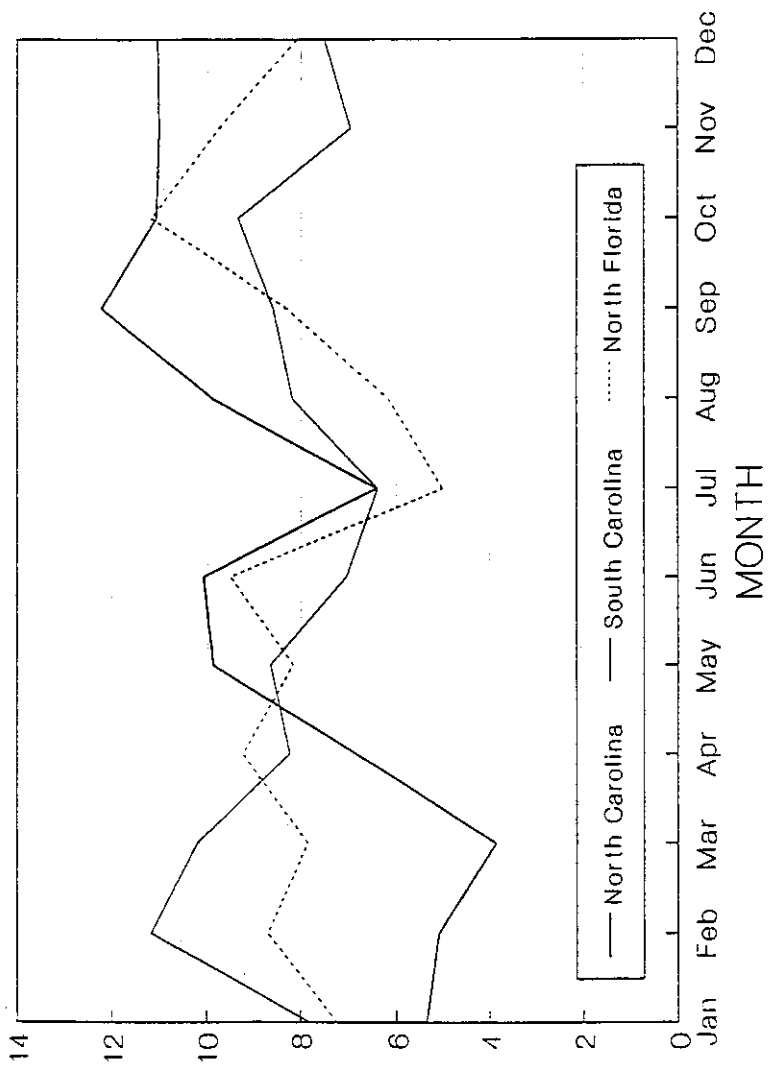


Figure 10. Mean percent of commercial landings of vermilion snapper, 1982-1990.

reported ripe gag (running milt, loose eggs) from the area off Jupiter Inlet (Charles Schaefer, NMFS port agent Tequesta, FL., personal communication).

In southeast Florida headboat landings increased during the winter with a peak usually occurring in January. The highest monthly percentage (17 percent) of the annual catch is taken in January (Figure 11) with December landings a close second (13 percent). Mean percentage of annual headboat effort rises in January but does not peak until April (Figure 2). The months of January through April account for 56 percent of the total annual catch.

Trends in commercial landings for North Carolina, South Carolina and northeast Florida are difficult to discern. There are some peaks during the winter months, but there are also many equal peaks during other months that indicate that weather and the ability to get to the fishing grounds are perhaps more important in determining catches than reproductive behavior. The highest percentage of the annual catch occurs April through June in these areas (Figure 12). In southeast Florida commercial landings consistently increase in November every year, and peak in January or February. The highest percentage of the annual catch is taken in January and February, about 34 percent (Figure 12). The percentage diminishes until November, when it starts to quickly rise again.

Data from southeast suggest that substantial increases in landings of gag occur during the spawning months rather than in months of highest headboat effort. The species is protected in its northern range by inclement weather that greatly reduces fishing pressure, at least recreationally, during the spawning season. There is also some preliminary evidence that gag from northern areas may participate in a spawning migration to waters off South Florida (Van Sant *et al.*, 1990).

Greater Amberjack

Greater amberjack are popular sport fish and are well known for their fighting ability. Relatively little attention was paid to amberjack by commercial fishermen until blackened amberjack dishes were popularized by Louisiana chefs in the mid-1980s. Soon after, amberjack became popular as a smoked fish delicacy, often packaged in individual bite-size portions and sold in restaurants and bars nationwide. North Carolina commercial landings averaged almost 24,000 kg/yr from 1986-1990. South Carolina landings averaged 20,000 kg/yr for the period 1982-1990. Average landings were higher in Florida, almost 98,000 kg/yr in southeast Florida and 78,000 kg/yr in the Florida Keys. Northeast Florida landings averaged 72,000 kg/yr. The development of the market for amberjack in 1986 significantly increased landings, especially in Florida. The pre-1986 commercial average was 13,000 kg/yr in north Florida, compared with a post-1986 average of 120,000 kg/yr. Southeast Florida produced 18,000 kg/yr

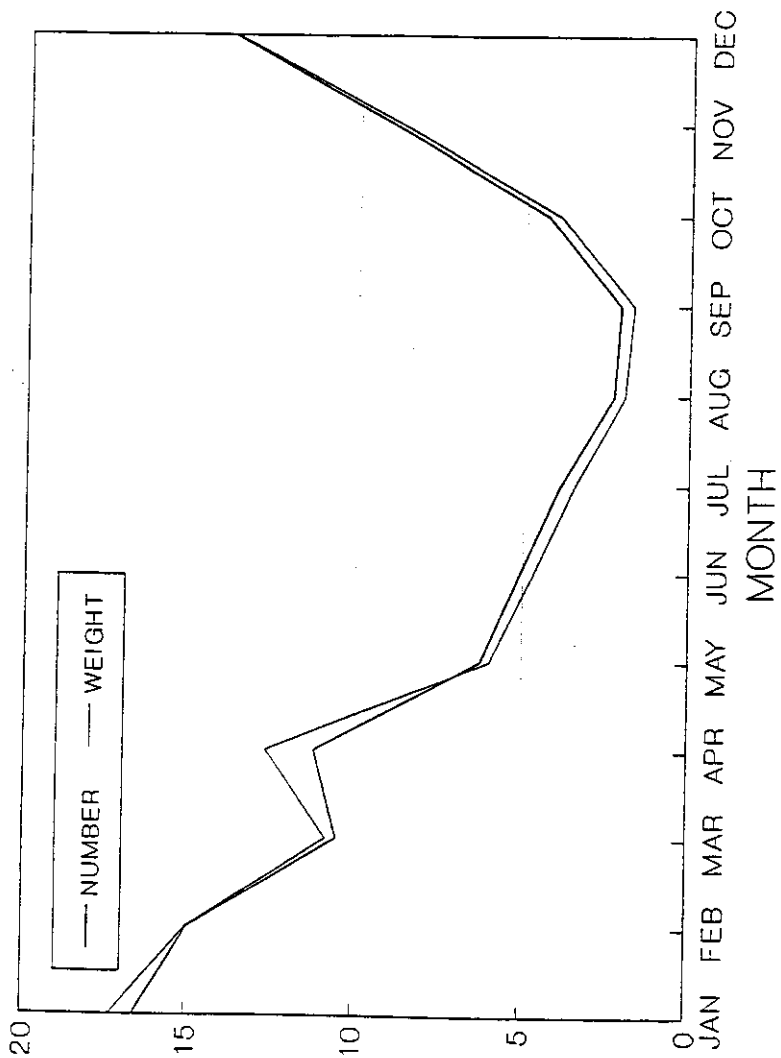


Figure 11. Mean percent of headboat landings of gag, 1981-1989.

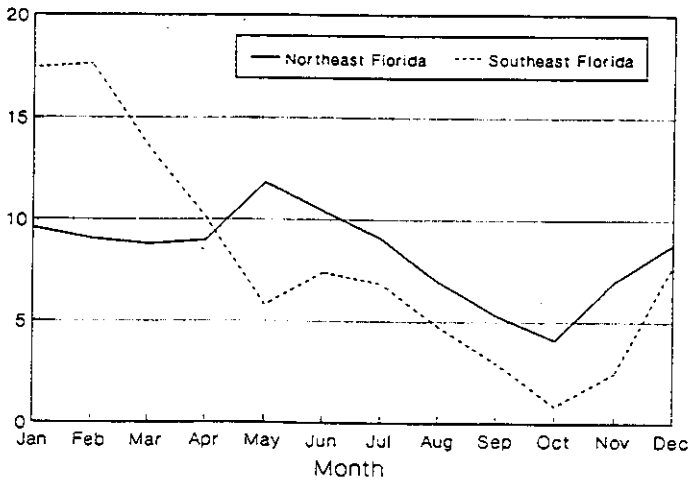
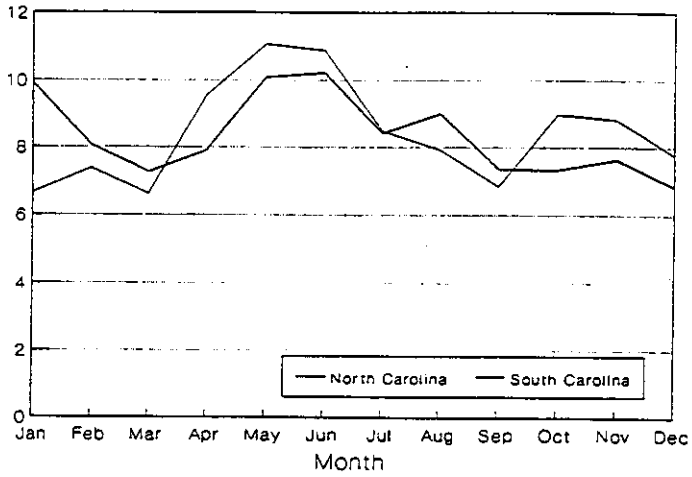


Figure 12. Mean percent of commercial landings of gag, 1986-1990.

for 1982-1985 compared to 161,000 kg/yr after 1985. The Florida Keys produced 35,000 kg/yr from 1982-1985 and 113,000 kg/yr after 1985.

Greater amberjack were thought to be summer spawners off North Carolina (Hildebrand and Cable, 1930) due to the capture of small (young) fish (4-12 mm) in August and September. Spawning season was determined to be March-June off south Florida, with a peak in April and May (Burch, 1979). Ripe females were found in all seasons in the Florida Keys, however, suggesting some year round spawning. Leak (1981), after finding larvae in all seasons in the eastern Gulf of Mexico and the Straits of Florida, suggested amberjack spawn year round. Erdman (1977) found ripe *S. dumerili* in all seasons in the Caribbean.

Headboat landings for southeast Florida peak in April and May of every year. Several years have a second smaller peak, usually in September or October. Effort peaks in April of most years (Figures 1 and 2). Florida Keys landings do not exhibit as many peaks, but when present, they occur in April. February through April is the time of highest effort for Florida Keys headboats (Figures 1 and 2). The largest percentage of the annual catch is taken in April and May (total 45 percent in southeast Florida, 43 percent in Keys) (Figure 13). April is also the month in both areas when the percentage of weight caught exceeds the percentage of number caught by the greatest amount, perhaps indicating fish that are heavier due to spawning condition or that the older spawners become differentially more vulnerable than younger fish.

Commercial landings of greater amberjack in North Carolina, South Carolina and northeast Florida are highest during the summer months, and decrease in the winter. Southeast Florida landings increase in March and peak in April or May every year (Figure 14). Similarly in the Florida Keys landings peak in April-June (Figure 15). A large percentage of South Carolina amberjack landings occur in March, but there seems to be no pattern for landings in North Carolina or northeast Florida. But in southeast Florida and the Florida Keys the highest percentage of annual landings are in April, with April-May accounting for 49 percent of annual catch in southeast Florida and 38 percent in the Keys (Figures 14 and 15). There is evidence of at least limited spawning year round in the south Florida area, but the primary spawning time seems to be March-June, with a peak of spawning activity occurring in April and May. Both headboat and commercial landings from southeast Florida and the Florida Keys are greatest during these two months.

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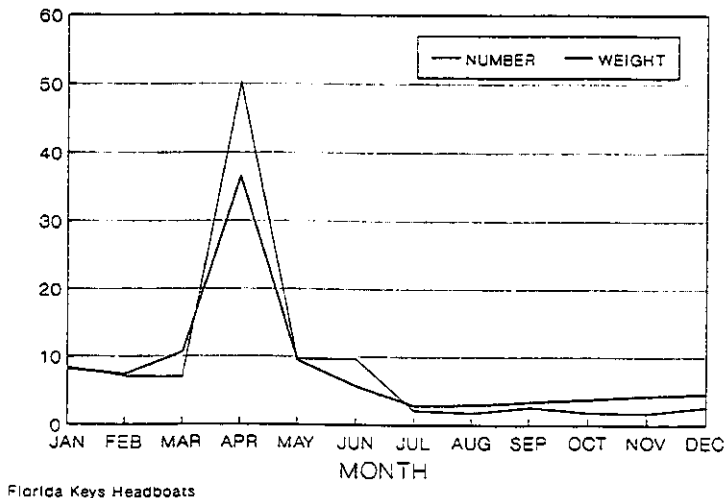
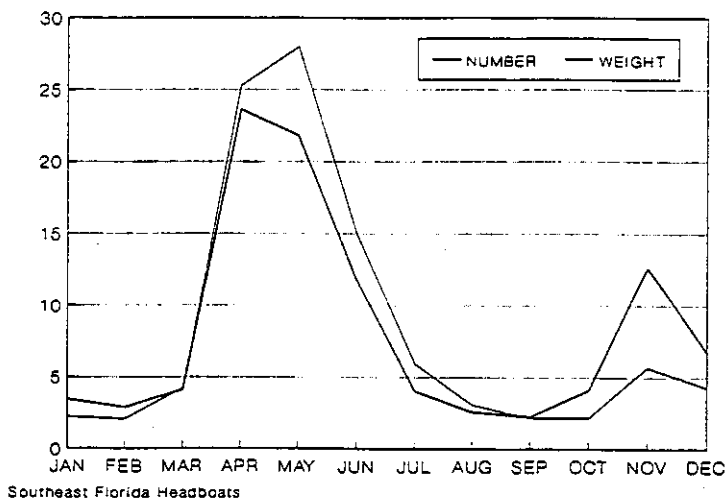


Figure 13. Mean percent of headboat landings of greater amberjack, 1981-1989.

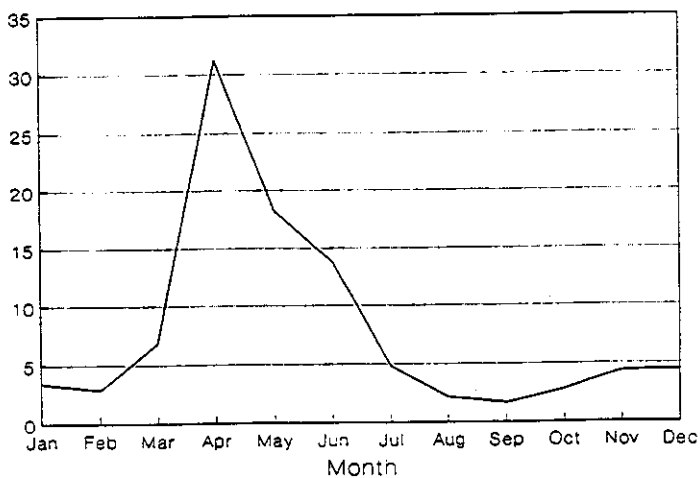
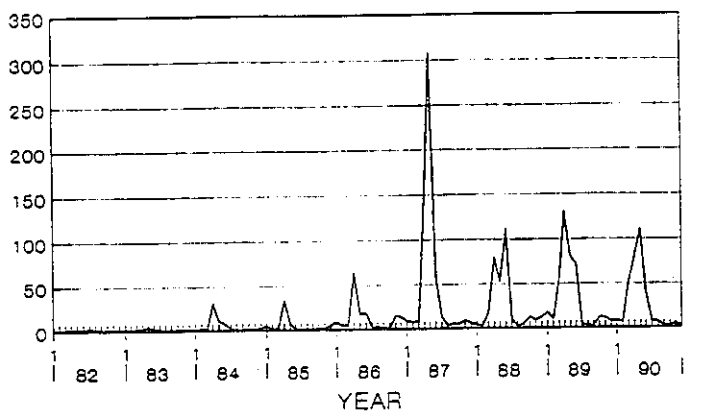


Figure 14. Commercial landings and mean percent of annual catch, greater amberjack, 1982-1990.

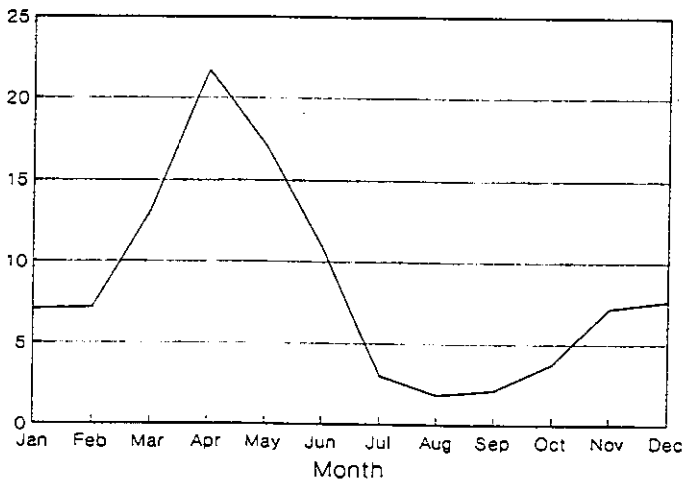
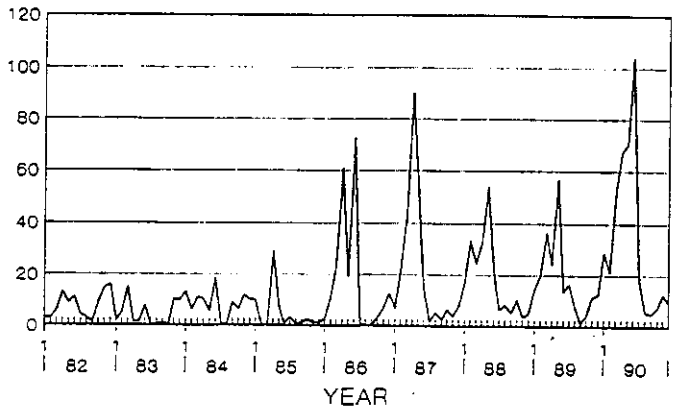


Figure 15. Commercial landings and mean percent of annual catch, greater amberjack, 1982-1990.

A. Manooch reviewed the manuscript. B. Harvey contributed countless manuscript retypes.

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