Assessment of the Recreational Sport Fisheries of Florida Bay and Adjacent Waters from 1985-1998

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ABSTRACT

A stock assessment based on recreational catch and catch rate (CPUE) from 1985 - 1998 was conducted on four of the most popular gamefish in Florida Bay, Everglades National Park: snook (*Centropomus undecimalis*), gray snapper (*Lutjanus griseus*), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellatus*). The responses of catch to fishing effort and CPUE to environmental factors (rainfall, water level, and salinity) were determined.

Snook catch rates have shown a cyclical trend every four years. The peaks may reflect recruitment of juveniles that were released in prior years because of size restrictions. Recruitment may also be enhanced by increased rainfall/runoff as there was a weak correlation between water levels recorded three years before and CPUE from 1985 - 1998. Although, no statistical significance was found, this trend suggests that periods of low salinity lead to increases in abundance.

During the 1990s, gray snapper CPUE and estimated total harvest have dropped lower than anytime during the previous record and may be due to regulations imposed on the fishery in 1988 and 1990. A significant relationship was found between CPUE and mean annual salinities in northern Florida Bay suggesting that periods of high salinity may lead to increases in abundance. Mean annual rainfall and water levels were significantly inversely related to CPUE indicating that low rainfall and water levels lead to increases in abundance.

Spotted seatrout CPUE has increased recently; yet, harvest rates have been holding steady since 1990. The lack of increase in harvest associated with the increase in catch may be due to size restrictions. A significant negative correlation was found between CPUE and water levels from the previous year.

Red drum CPUE has been stable since 1989 when present bag limits were imposed. No statistically significant relationships were found between CPUE and any of the environmental variables.

For each species, annual estimated total catch was highly correlated with the estimated total effort. This suggests that current catches do not greatly impact Florida Bay stocks and that additional increases may be possible.

KEY WORDS: Everglades National Park, Florida Bay, gray snapper, recreational fisheries, red drum, snook, spotted seatrout

INTRODUCTION

Fishing activity and harvest of sportfish from Everglades National Park (ENP) have been monitored nearly continuously since 1958. This project represents one of the longest ongoing recreational fisheries monitoring programs in the world. The mainland shoreline of ENP extends from the Florida Keys to Everglades City on Florida's west coast. Tabb et al (1962) have described the animal and plant communities of the park's waters and identified distinct ecological zones which vary in their topographical, hydrological, and biotic characteristics. These zones were utilized to delineate fishing areas used in this and other ENP fishery investigations since 1960 (Figure 1). As in Tilmant (1989) and Rutherford et al. (1989bc), we refer to fishing Areas 1 - 5 as Florida Bay and adjacent waters.

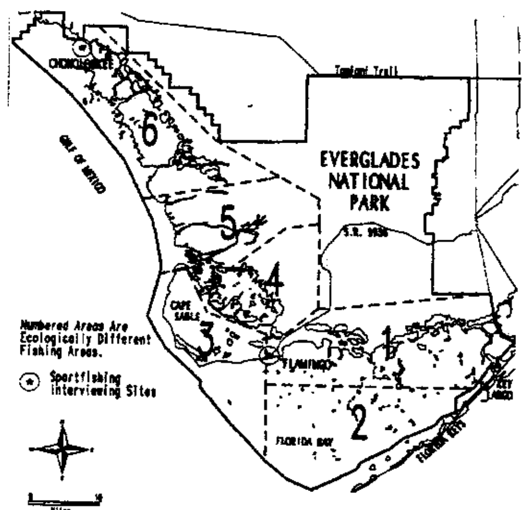

Figure 1. Ecologically different fishing areas in Everglades National Park

In the 1970s, an overall decline in the recreational harvest of gamefish was observed in the Florida Bay portion of ENP. This decline was only partially explained by a decrease in fishing effort, suggesting that population changes were reflective of long-term cyclic trends or possibly, climatic and environmental conditions. In 1985 commercial fishing was eliminated in ENP; presently only recreational guided and non-guided (sport) anglers are permitted to fish within park waters. From the mid 1980s to the early 1990s, further concerns over declining catches and catch rates (CPUE) of gamefish species in Florida Bay were noted (Boesch 1993). This prompted ENP to revisit the effects of fishing and environmental factors on the marine resources of the park. Previous studies

(Higman 1967, Davis 1980, Rutherford et al. 1989b, c) indicated that environmental factors may explain as much of the variability in fish abundance as does fishing pressure. For example, during 1989 - 1990, extreme environmental conditions (drops in water temperature and hypoxia, possibly related to seagrass die-off) resulted in a large fish kill in Florida Bay (Schmidt and Robblee 1994). Since sportfish catches are correlated with indices of freshwater runoff (ie. rainfall and water level), it was felt that the reduction of freshwater inflow to Florida Bay may have been a factor in the declining catch rates (Boesch 1993).

Environmental relationships and long-term population trends can only be accurately expressed on a species by species basis (Tilmant 1989). Therefore, a stock assessment based on sport fishermen (non-guided) catch and CPUE from 1985 - 1998 was conducted on four of the most popular gamefish in Florida Bay: snook (*Centropomus undecimalis*), gray snapper (*Lutjanus griseus*), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellatus*). The responses of catch to fishing effort and CPUE to environmental factors (rainfall, water level, and salinity) were determined.

METHODS

Methods employed to obtain sport fishing and boating activity in ENP have been previously documented by Higman (1967), Davis and Thue (1979), Tilmant et al. (1986), and Tilmant (1989) and are briefly discussed below as they pertain to this study. Recreational anglers are interviewed at boat launch sites (Flamingo and Chokoloskee) upon completion of their trip every weekend (Figure 1). Data recorded includes area fished, fish kept, fish released, effort (angler-hours and trip-hours), species preference, and angler residence.

Flamingo is the greatest single access point to Florida Bay, used by 50 - 65% of the anglers. Daily estimates of the number of fishing boats operating in park waters were made by regressing the daily counts of empty trailers at Flamingo against a known number of boats fishing the same day. Aerial surveys were used to determine the correlation of boat trailers at the Flamingo launch ramps to the total number and distribution of boats within the park. A highly significant linear relationship was found between the number of trailers at Flamingo and the boats observed in park waters ($r = 0.84$, $N = 243$, $p < 0.01$). The percentage of boats actually fishing was determined from angler interviews.

The catches of the interviewed anglers are only samples of the total park harvest. The estimated total catch and harvest of each species for the non-guided (sport) fishery were calculated by dividing the recorded daily catch or harvest by the total number of boats interviewed to give the mean catch or harvest per trip. This figure was then multiplied by the estimated number of fishing boats in Florida Bay to obtain the estimated total catch or harvest. In obtaining the mean catch rate (CPUE) and harvest rate (HPUE) for a species, rates of individual trips were calculated after Malvestuto (1983). Only those anglers successfully catching a species were used to calculate the CPUE to avoid bias in the possible change in effort applicable to a species each year. Only those anglers harvesting a species were used to calculate the HPUE.

For the purposes of this study, catch rates were used as an index of relative abundance. Catch rates are directly related to environmental factors such as rainfall, and are generally, not directly affected by fishing regulations while harvest rates most certainly are. The catch rates for the four major species were correlated with rainfall, water level, and salinity from 1985 - 1998. SPSS 9.0 was used to determine all correlation statistics. Total annual rainfall from 1985-98 was compiled and averaged from five stations within or near ENP (Flamingo, Royal Palm, Everglades City, Tamiami Ranger Station, and Tavernier; Butternut Key replaced Tavernier in 1997 and 1998). Water level data from 1985 - 1998 was obtained from well P-37 in western Taylor Slough. Salinity data from 1985 - 1998 was obtained from three stations in northern Florida Bay (Butternut Key, Taylor River, and Trout Cove).

It is not sufficient to know if catch rates are declining to determine if stocks are overfished. If both catch and catch rate are in decline, then there is a need to assess the amount of effort being placed on the fishery. The estimated total catch and estimated total effort of the four major species were correlated to determine if fishing effort impacted the stock.

RESULTS and DISCUSSION

Description of the Fishery

Most of the anglers fishing out of Flamingo were south Florida residents (Dade County to Ft. Lauderdale, excluding local residents from Flamingo, Florida City, and the Florida Keys). Most of the anglers interviewed did not try to catch any particular kind of fish. Over 80 species of fish and shellfish have been reported in the recreational catches of ENP since 1972; however, snook and red drum were the most sought after fish, followed by spotted seatrout, gray snapper, and tarpon.

The contribution of individual species has experienced considerable variation over the years. The biggest changes in catch composition appeared to be a noticeable decline in the proportion of spotted seatrout catches during recent years, the erratic year to year variation in the frequency of gray snapper catches, and the increase (1989 - 1998) in the proportion of snook and red drum catches (Figure 2).

Spotted seatrout are the most frequently caught sportfish in Florida Bay. Seatrout are estuarine dependent and spend their entire life cycle within ENP (Rutherford et al. 1982). Tagging studies indicated little inter-estuary movement

(Iversen and Moffett 1962, Beaumarige 1969, Rago and Goodyear 1985). This suggests that there are two unit stocks of spotted seatrout in park waters, one in the Florida Bay-Whitewater Bay area (Areas 1 - 5) and one in the 10,000 Islands area (Area 6) (Tilmant 1989, Schirripa and Goodyear 1994).

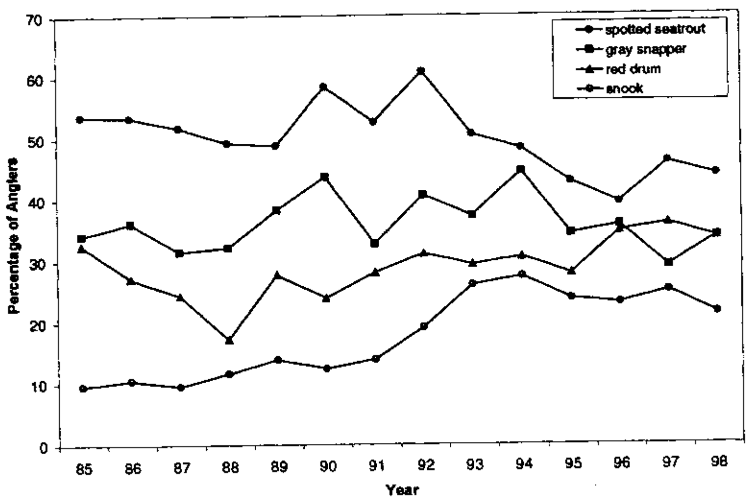

Figure 2. Percentage of anglers interviewed at Flamingo (Areas 1-5) catching spotted seatrout, gray snapper, red drum, and snook from 1985 - 1998

The second most commonly caught sportfish in Florida Bay is gray snapper. Snapper enter ENP as small juveniles using the area as a nursery, recruit to the fishery at age one, and grow up in park waters to age 3 - 4 (Rutherford et al. 1989a). Rutherford et al. (1989a) found that 3 - 4 year olds comprised as much as 87% of the fish harvested, with some up to age seven harvested, but few over age four. Snapper then start leaving the estuary to spawn and live on offshore reefs (Rutherford et al. 1983). Emigration is further supported by Schmidt et al. (1999); they found that harvested fish were larger in the outer regions of Florida Bay.

Red drum are a typical euryhaline species that use estuaries as nursery areas before migrating offshore to the more open waters of the Gulf between ages 3 - 5 (Yokel 1966). Therefore, the red drum fishery in ENP is directed towards late stage juvenile and early adult fish remaining in the park's estuaries (Tilmant et al. 1989). Tagging studies have shown little inter-bay movement of immature red drum in Florida (Ingle et al. 1962, Topp 1963).

Snook are a relatively non-migratory, estuarine dependent species. Snook will make localized movements between estuaries as juveniles and move to nearby offshore areas as adults for spawning. The fishery consists of snook aged 3 - 5 years old (Thue et al 1982, Muller and Murphy 1997). Two unit stocks have been identified in south Florida, one population on the Gulf coast and the other on the Atlantic coast with differences in size and age based on genetic properties (Tringali and Bert 1996). Florida Bay snook may comprise an immigrant adult population derived from one or both populations.

The overall trend in recreational fishing boats since 1973 shows high values in 1973 - 1975, with lows in 1979 - 1980, and a rebound in the mid-1980s (Figure 3). The decline during the late 1970s occurred because of increased gasoline costs and decreased fish abundance/catch rates; this combination of factors may have deterred anglers from visiting ENP (Tilmant et al. 1986). The decline in 1992 is attributed to the impacts of Hurricane Andrew; ENP was closed from September through December. There has been an increasing trend since 1992 with the highest number of fishing boats recorded during 1997 (28,927 fishing boats) followed by a slight decline in 1998 (Figure 3). The recreational fishing effort (angler-hours) has mirrored this trend as well (Figure 3).

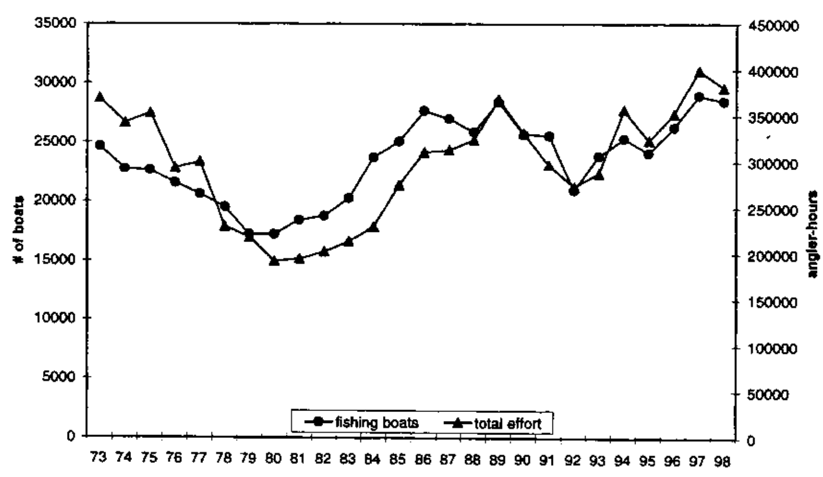

Figure 3. Estimated number of fishing boats and estimated total effort in Florida Bay (Areas 1 - 5), 1973 - 1998

Snook

Snook popularity has risen dramatically from 1985 - 1994. The percentage of boats catching snook in Florida Bay increased from 9% in 1985 to nearly 27% in 1994, but suffered a slight decline in recent years (Figure 2).

Harvest rates have been quite stable since 1985; however, catch rates have shown a cyclical trend every four years (Figure 4). Catch rate decreased from 1985-88, reaching a low of 0.1674 fish/angler-hour in 1988, only to increase to a high of 0.326 fish/angler-hour in 1992. Another low was reached in 1997 (0.217 fish/angler-hour); catch rate started to increase yet again in 1998 with a value of 0.229 fish/angler-hour. Muller and Murphy (1997) reported catch rates of similar magnitude and trends as those found in this study. The increases may reflect stock recruitment of small, juvenile snook, which were released in prior years because of size restrictions. The timing of the cycle seen in catch rate is probably partly due to the four years needed for juveniles to recruit to the fishery (Thue et al. 1982).

The declines in snook stock size from 1985 - 1988 may have been due to low rainfall and water levels in the upper marsh regions. There was a weak correlation between water levels recorded three years before and catch rates from 1985 - 1998 ($r = 0.591$, $N = 11$, $p > 0.05$). Although no statistically significant correlation was found, this suggests that a period of high rainfall/water level leads to an increase in the abundance of snook. Field studies on snook habitat have shown that the greatest number of juvenile snook are consistently found in shallow, well protected, back-water areas of estuaries that are influenced by freshwater runoff (Fore and Schmidt 1974, McMichael et al. 1987). Van Os et al. (1981) found that snook catch rate within the St. Lucie River estuary, was positively correlated with the length of river control discharges. They concluded that snook move into the freshwater discharges to take advantage of the augmented food supply.

The total estimated catch of snook from the sport fishery in Florida Bay increased from a low of 6,538 fish in 1986 to a high of 22,581 fish in 1994. However, snook catches have declined since 1994; 14,641 fish were caught in 1998. Despite the two fish per person bag limit and closed seasons during January, June, July, August, and December, sport fishermen harvest had not been reduced until 1998 (Figure 5). During 1985 - 1994, there was a 148% increase in catch, while harvest increased only 40%, suggesting that increased catches were due to young fish that were released in prior years. The increase in catch during 1991 - 1994 has been credited to the quick recovery of the stocks because of the regulations mentioned above; although, it should be noted that fishing effort doubled from 1991 - 1994.

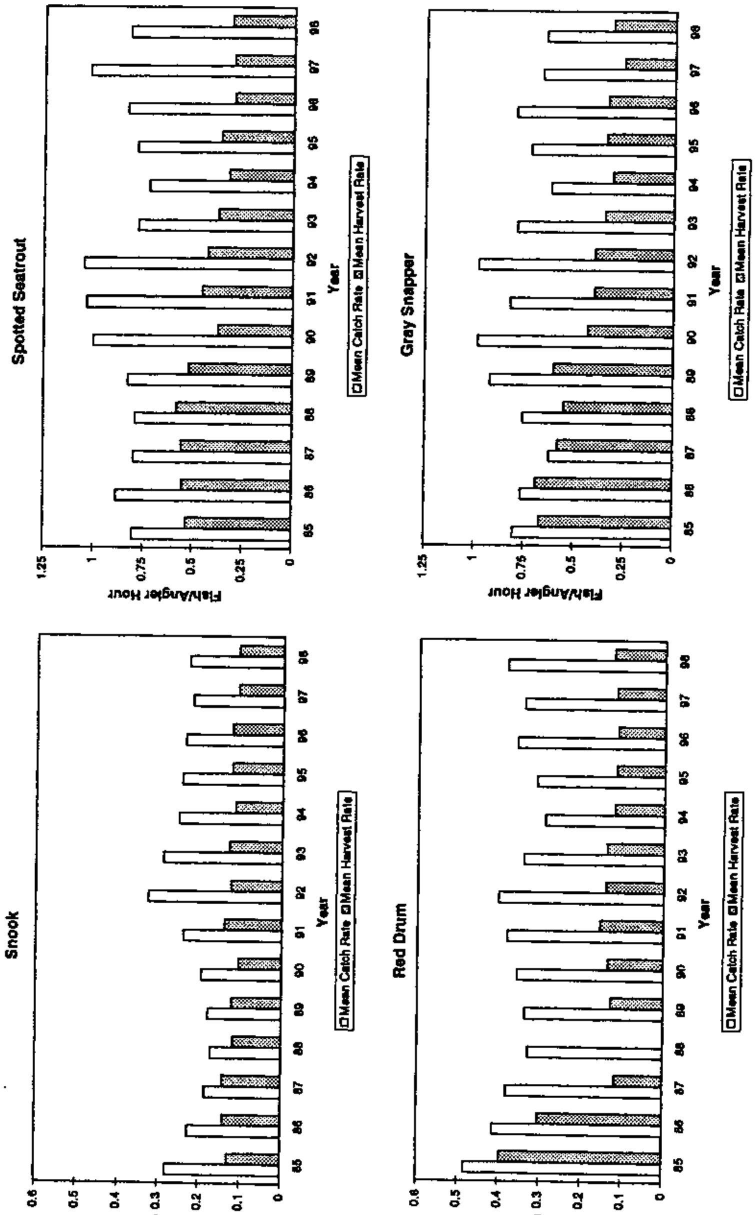

Figure 4. Recreational non-guided (sport) catch and harvest rates for the four major species of gamefish in Everglades National Park (Areas 1 - 5), 1985 - 1998

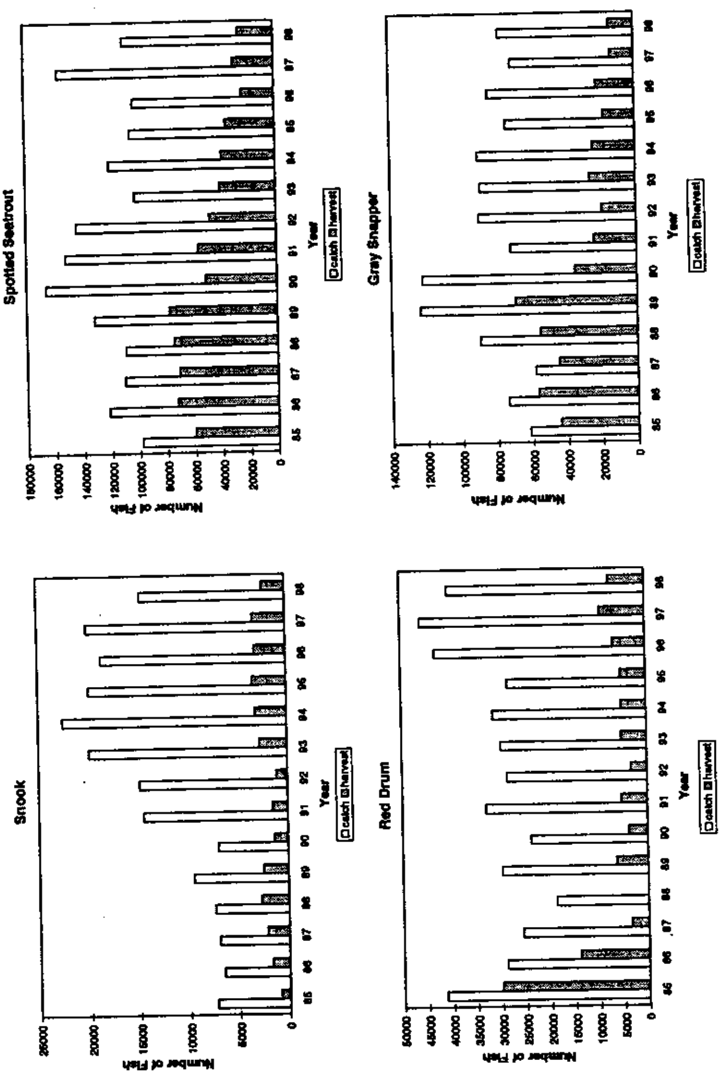

Figure 5. Estimated total catch and estimated total harvest of the four major species of gamefish by non-guided (sport) anglers in Everglades National Park (Areas 1 - 5), 1985 - 1998

Annual fishing effort of sport anglers catching snook in Florida Bay ranged from a low of 26,775 angler-hours in 1985 to a high of 107,825 angler-hours in 1997. The estimated total catch of snook for the sport fishery was highly correlated with the estimated total effort placed on the stock from 1985 - 1998 ($r = 0.901$, $N = 14$, $p < 0.0001$) (Figure 6). This suggests that current catches do not greatly impact the Florida Bay stock and that additional increases may be possible. Muller and Murphy (1997) also concluded that snook stocks in south Florida are in good condition. However, snook catches decreased dramatically in 1998 after five years (1993 - 1997) of good catches and all time high in effort in 1997. CPUE from 1993 - 1997 was decreasing, but catch remained very high because of the high fishing effort. During 1998, state regulations were revised to sustain a 40% spawning potential ratio (SPR) by increasing the minimum size to 26," while maintaining a maximum size of 34" and a two fish bag limit. The increase in minimum size may also be responsible for the decline in harvest in 1998.

Gray Snapper

The percentage of anglers reporting catches of gray snapper has fluctuated from year to year from 1985 - 1998 (Figure 2). The large decline seen in 1991 was probably due to new regulations imposed in 1990, which increased the minimum size to 10" with a bag limit of five fish per person. Snapper catch rate has shown no definitive trend; although, catch rates were highest during 1989 - 1990 (Figure 4). Snapper catch rate has declined the last two years, while harvest rates have shown steady declines since 1985 (Figure 4). During 1988 - 1990, the increase in catch rate, but not harvest rate was reflective of the new regulations.

A significant, positive relationship ($r = 0.601$, $N = 14$, $p < 0.03$) was found between catch rate and mean annual salinities found in northern Florida Bay, suggesting that periods of high salinity may lead to increased abundance of gray snapper. Average annual water levels recorded at P-37 were significantly inversely related to gray snapper catch rates during the same year ($r = 0.712$, $N = 14$, $p = 0.004$), indicating that during periods of reduced water levels in upper Taylor Slough, abundance of gray snapper increased. Rainfall was also inversely correlated with gray snapper catch rates ($r = 0.506$, $N = 14$, $p > 0.06$). Which leads to the theory that increases in gray snapper abundance during the period of 1988-90 may have been related to low yearly rainfall in the ENP area and periods of high salinities in Florida Bay. A series of low rainfall years from 1985 - 1990 resulted in hypersaline conditions in Florida Bay. Rutherford et al. (1983) reported larger fish in areas of higher salinity. Thus, if during low rainfall years (which cause high salinity conditions), sub-adult fish remain in Florida Bay longer, then gray snapper abundance should increase and the fish would become increasingly available to the angler (higher catch rates). During 1992 - 1995, water levels/rainfall increased, especially from Tropical Storm Gordon in November 1994, resulting in salinity reductions in northern Florida Bay with a notable decrease in gray snapper CPUE.

There was also a significant inverse relationship between catch rates and mean annual water level recorded one year before ($r = 0.574$, $N = 13$, $p = 0.04$), and between catch rates and mean annual rainfall recorded three years before ($r = 0.778$, $N = 11$, $p = 0.005$). These relationships are explained by the fact that higher salinities enhance the growth and survival of juvenile snapper which would recruit to the fishery in future years (Higman 1967, Rutherford et al. 1989c).

The estimated total catch and CPUE of gray snapper follow the same general trend; although, CPUE fluctuates a little more. The estimated catch in Florida Bay had been increasing from 1985, reaching highs in 1989 - 1990 following new size restrictions and highs in effort as well (Figure 5). The catch then dropped in 1991 and has remained relatively stable since (Figure 5). During the 1990s, the estimated total harvest for gray snapper has dropped lower than anytime during the previous record (Figure 5). This is probably due to the state regulations imposed on the fishery in 1990 when the minimum size was increased from 8" to 10" with a bag limit of five fish per person. These regulations may have prevented increases in snapper harvest because anglers shifted their efforts to red drum and seatrout instead; however, reduced stock size also limited harvest (Rutherford et al, 1989c).

Annual estimated effort for the gray snapper fishery ranged from a low of 96,311 angler-hours in 1985 to a high of 168,239 angler-hours in 1994. The yearly catches were lowest in 1985 (61,859) and 1987 (58,401) and highest in 1989 (123,707) and 1990 (122,327). Increased size limits in 1988 and 1990 and the imposition of new bag limits in 1990 may account for the high number of gray snapper caught and released during those years. The estimated total catch was linearly correlated with the estimated total effort from 1985-98 ($r=0.705$, $N=14$, $p<0.005$) suggesting that the maximum potential catch of the fishery in Florida Bay has not been reached (Figure 6).

Spotted Seatrout

The percentage of boats catching seatrout declined steadily from 1985-89, but increased sharply to a 14 year high of almost 65% in 1992 (Figure 2). Since then, the percentage of anglers catching seatrout declined to a low in 1996 of 39% (Figure 2). Seatrout were caught by 44% of the anglers in 1998. Fishing regulations may have affected angler strategy as the declining trend in seatrout is associated with increases in snook and red drum; fishermen may have switched their targeting preference to the latter two species when their stocks recovered.

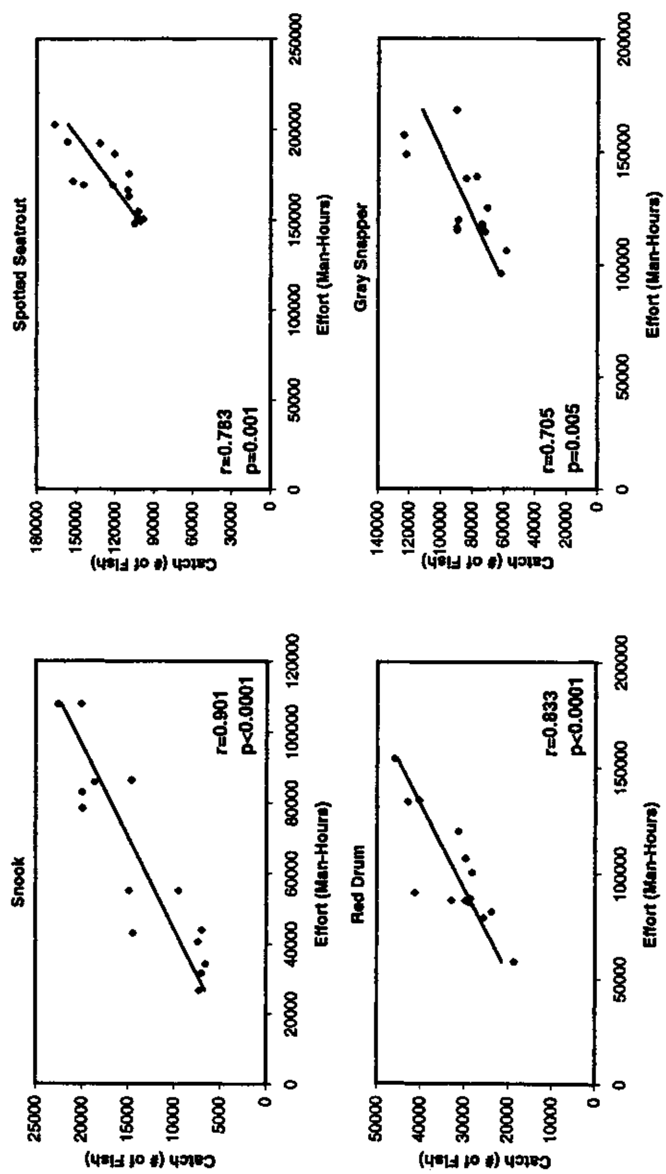

Figure 6. Correlation of total estimated catch and total estimated effort for the for major species of gamefish in Everglades National Park (Areas 1 - 5), 1985 - 1998

Seatrout catch rate had been holding steady from 1985-88, then increased from 1989 - 1992, but dropped in the two ensuing years (Figure 4). Since 1994, seatrout catch rate has been increasing in Florida Bay; however, there was a slight drop in 1998 to 0.8231 fish/angler-hour (Figure 4). Harvest rates have been decreasing slowly, but steadily over the period of record (Figure 4). The lack of increase in harvest rate associated with the increase in catch rate may be due to state regulations imposed on the fishery in 1989 which raised the minimum size from 12" to 14," and then for south Florida populations to 15" in 1996. These regulations were meant to reduce harvest to achieve a 35% SPR set by the Florida Marine Fisheries Commission (FMFC).

Seatrout catch rate and salinity seem to follow the same trend. As salinity increased to a high in 1990, seatrout catch rates increased and as salinities dropped in the proceeding years, catch rates also decreased; however, there was no statistically significant relationship between the two variables from 1985-98. When catch rates were correlated with annual water levels recorded at P-37 from the previous year, a significant inverse relationship was found ($r = 0.552$, $N = 13$, $p = 0.05$). In contrast, Thayer et al. (1998) reported increases in the abundance of larval and small juvenile seatrout in northern Florida Bay, suggesting that lowered salinities in this area may increase the survival of young-of-the-year fish. In laboratory studies, Taniguchi (1980) and Wakeman and Wolschlag (1977) found that survival and growth for larval and juvenile seatrout was greatest at 28ppt.

The estimated total catch and CPUE of seatrout follow the same general trend. Catch increased to a high in 1990 (effort also reached its peak in 1990), then declined till 1996 (Figure 5). There was a large spike in fish caught in 1997 due to increased effort (Figure 5), but may have also been due to the increase in minimum size to 15" in 1996. The estimated total harvest decreased dramatically from highs in 1988 - 1989 to a low in 1996 with a slight rebound during 1997-98 (Figure 5).

Total estimated effort for seatrout ranged from a high of 202,383 angler-hours in 1990 to a low of 147,882 angler-hours in 1995. The correlation of yearly effort with catch was linear and significant ($r = 0.783$, $N = 14$, $p < 0.001$) (Figure 6). There was no decrease in total catch with increasing effort, indicating that yearly fishing effort did not severely impact the fishery.

Red Drum

The percentage of boats catching red drum decreased dramatically from 33% in 1985 to 17% in 1988 when the fishery was closed due to overfishing (Figure 2). When harvest was reopened, the percentage of anglers catching the species increased steadily to a 14 year high in 1997 of 36% (Figure 2).

Our analysis indicates that red drum in Florida Bay have recovered since

1988. However, abundances remain considerably lower than during the period of 1979-85 (Tilmant et al. 1989). Catch rates have been increasing steadily since an all time low in 1994 to 0.3842 fish/angler-hour in 1998 (Figure 4). Since the fishery recovered faster than anticipated, the FMFC allowed year-round fishing in 1996, which may explain the higher catch rates in the late 1990s. Meanwhile, harvest rates in Florida Bay have remained quite stable since 1989 when bag limits of 1 fish per person were imposed (Figure 4). Increased size limits (12" to 18") and a closed season imposed on the fishery in 1985 accounted for the large declines in harvest rate after 1985 (Figure 4); however, the sharp decline during the early 1980s suggests overfishing and/or poor recruitment. If red drum populations were overexploited resulting in reduced recruitment during the late 1980s, the restrictive regulations mentioned above may have allowed the offshore stocks to rebuild, resulting in increased recruitment to the fishery beginning in 1989.

It is unknown if any environmental factors aided in the recovery as no statistically significant relationships were found between catch rate and any of the environmental variables (rainfall, water level, and salinity). However, Tilmant et al. (1989) found a positive correlation between the number of age 1 fish and rainfall from the previous year suggesting that below average rainfall in 1984 - 1985 may have been responsible for the poor recruitment during those years. In laboratory studies, Holt et al (1981) found that survival and growth for larval and juvenile red drum was greatest at 30‰.

The total estimated catch of red drum decreased steadily from 1985 - 1988, when the fishery was closed, following the same trend seen in CPUE (Figure 5). The total estimated catch has been recovering since, with a large jump in 1996 when year-round harvest was permitted, increasing the fishing effort (Figure 5). There was a 14-year high in 1997 with 45,979 fish caught. The estimated total harvest of red drum had been steadily increasing after 1992 until a slight drop in 1998 (Figure 5). The 9,227 fish kept in 1997 represents the highest value since the mid-1980s when the fishery collapsed (Figure 5).

The total estimated recreational fishing effort for red drum in Florida Bay ranged from a low of 58,093 angler-hours in 1988 to a high of 154,227 angler-hours in 1997, which represents about 2.5 times the fishing effort in 1988. A statistically significant linear relationship ($r = 0.833$, $N = 14$, $p < 0.0001$) was found between yearly effort from 1985-98 and the resultant catch, suggesting that the increase in fishing effort did not greatly impact the red drum stock (Figure 6).

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