Relationships between Catch Rates of Sport Fish and Environmental Conditions in Everglades National Park, Florida[1]

JAMES B. HIGMAN
Institute of Marine Sciences
University of Miami
Miami, Florida

Abstract

Catch rates have been determined for a period of 7 years showing the seasonal and long-term trends of availability of spotted seatrout, mangrove snapper, and redfish in Everglades National Park.

Park seasonal catch rates are apparently associated with the congregation of fish for spawning and by the response of fish to drastic changes in environmental conditions.

INTRODUCTION

THE SOUTHWESTERN SECTION of the Everglades National Park became readily accessible to sport fishermen when a highway, marina facilities and an access canal to Whitewater Bay were constructed in 1958. Greatly increased fishing pressure resulted and the National Park Service requested information to judge whether regulation of the fishery was required. A program was developed by the Institute of Marine Sciences, University of Miami, for measuring the catch of game fishes and the fishing effort as a first basis for management of these stocks.

Some biological information was available for fish found in the Park, but rates of capture of the sport fish catches were unknown. Life history studies of the spotted seatrout, *Cynoscion nebulosus,* helpful in interpreting trends in fishing effort have been conducted in Florida by Moody (1950), Klima and Tabb (1959), Tabb (1961), Moffett (1961), and Stewart (1961). The studies of Croker (1962) and Starck (1964) provided useful information on the spawning season and age of the mangrove snapper, *Lutjanus griseus.* Investigation of the life history of the redfish, *Sciaenops ocellata,* originated under this program (Yokel, 1966).

Tabb and Dubrow (1962) and Tabb, Dubrow, and Manning (1962) have described the animal and plant communities of the area and showed that distinct ecological zones exist. This information has been used to delineate the boundaries of the fishing areas used in this study. (Fig. 1).

Description of the Area

The Everglades National Park mainland shoreline extends approximately 100 miles from the Florida Keys to Everglades City on the Gulf of Mexico. Three different habitats are found in this portion of

[1]Contribution No. 817 — Institute of Marine Sciences, University of Miami, Miami, Florida.

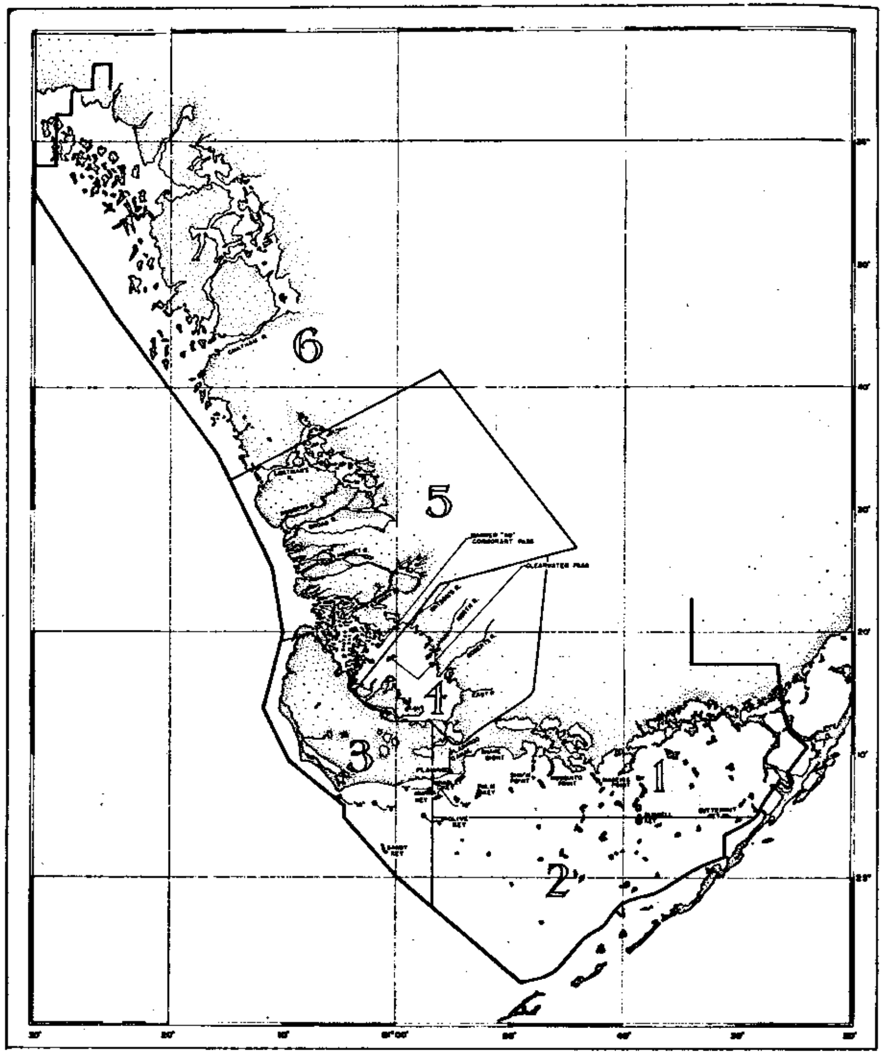

Fig. 1. Fishing areas and boundaries of the Everglades National Park, Florida.

Florida's coast. These have been classified by Price (1954) as (1) the drowned lacustrine plain of Florida Bay, (2) the great mangrove barrier ridge of the southwest coast, and (3) the irregular mangrove coastal lagoon systems between the mainland and the mangrove barrier ridge.

Florida Bay from the Florida Keys to Cape Sable is divided into a series of limestone-floored basins by irregularly shaped mud banks. Water depths in these basins rarely exceed 6 feet. The banks are commonly covered by less than 1 foot of water and are frequently exposed at low tide. The coarse material of the banks and bottom sediments is composed mainly of molluscan debris. The finer material consists of calcium carbonate marl mud and fragmented skeletons of mollusks, foraminifera, and ostracods (Ginsburg et al. 1954).

These mud flats, shallow basins, and banks of Florida Bay form the substratum for extensive beds of marine "grasses", principally *Thalassia testudinum, Diplanthera wrightii,* and *Cymodocea manatorum.* The large organisms associated with this grass community, dominated by pinfish, *Lagodon rhomboides*, and several crustaceans, including pink shrimp, *Penaeus duorarum,* are discussed by Tabb et al. (1962). They point out that these grasses stabilize the bottom and reduce turbidity caused by wind turbulence over the shallow banks.

Knowledge of the hydrography of Florida Bay is incomplete. Davis (1940) reported salinity variations of 10 ppt between wet and dry years. More comprehensive studies by Tabb et al. (1962) suggest that salinity, especially hypersalinity, and turbidity were among the factors limiting the dispersal and abundance of marine organisms in this environment. They recorded salinities as high as 70.0 ppt.

The second major habitat, the mangrove barrier ridge, extends from Cape Sable northward through the Ten Thousand Islands. Unlike Florida Bay, these coastal waters receive substantial fresh-water runoff from the Everglades. Mangrove island building is important here as the trees become established in a mixed peat-marl mud substratum that has been deposited over ancient oyster shell bars. Bottom sediments are predominantly quartz sand mixed with sand-size shell fragments. Soft muds, rich in organic material, are prevalent near river mouths. Some of these mud banks are covered with sparse growths of *Thalassia testudinum* (Davis, 1940).

The third major environmental area consists of the "back bays," brackish-water lagoons, and rivers landward of the mangrove barrier shoreline of the Park. Most prominent of these are Whitewater and Oyster Bays with their associated river drainage systems of which the Shark River is most important. Tabb et al. (1962) have described the ecological conditions of this area and the animal and plant communities in detail. Variations in salinity were believed to be chiefly responsible for changes in abundance and species composition of the communities.

Description of the Fishery

Sport fishermen at Flamingo select three main methods of reaching the fishing grounds: privately owned boats launched from a ramp; rental outboard motor powered skiffs with or without fishing guide service; or professionally guided charter boats. The fishing success of each segment of the fishery differed. The skill of private boat owners was variable and largely depended upon learning good fishing areas by repeated trips in Park waters. Rental skiffs were used mainly by tourists from out-of-state or from northern Florida counties. Unless accompanied by guides, these anglers caught the least fish. Charter boats produced the best catches because of the skill and experience of the guides. In addition, these larger boats were capable of operating in rougher waters and in more remote areas than most other craft.

METHODS

Measures of catch and of catch per unit of effort have been made only in the central part of Everglades National Park, from fishermen operating from Flamingo (Fig. 1). This covers the most important part of the fishery but misses data from two other significant areas, the Florida Bay side of the Florida Keys within the Park, and the western part of the Park, including Everglades City and the lower 10,000 Islands. Initial planning for this project envisioned interviewing in all three areas to determine the total fishing pressure and catch from the entire Everglades National Park, but this was impossible with the financial resources available. It may be that the condition of the fish stocks in the other parts of the Park is different from those reported here.

Sampling Procedure

Anglers were interviewed at Flamingo at the completion of their trip. Five interview days were selected in each month. The number of people fishing, the number and species of fish caught, the duration of the trip, the area in which the fish were caught, and the preference as to species sought was determined. Automatic data processing equipment was used to tabulate this interview data and to calculate the catch per unit of effort by species, by area, by month and by category of fishermen.

Calculation of Catch Per Unit of Effort

The unit of effort in this study was the "fisherman hour" which was the time away from the dock. This included time spent in traveling and in scouting for fish. Occasional overnight fishing trips were made by anglers. In these cases, time spent eating and sleeping was determined by interview and deducted from the trip length.

The number of fisherman hours each month was divided into the catch of each species to obtain the catch rate for each species of fish. These data obtained from interviewed fishermen represented only a fraction of the total catch and effort made each month. The catch per unit of effort figures obtained from the monthly sample were multiplied by the total fishing effort, derived from daily boat counts made by Park rangers. This permitted calculation of the total number of fish by species caught by all anglers for each month.

Sample Size

We have assumed the catches and catch rates of anglers interviewed during 5 days per month to be representative of the catches and catch rates made by anglers during the entire month. Numerous factors including weather and individual angling skill may have biased sample data for any given month. To test the accuracy of our sampling, cumulative geometric means were calculated from the catch per unit of effort values of increasingly larger numbers of successful anglers. From this it was possible to note where additional sampling did not improve the accuracy of the catch per unit of effort (Table 1).

TABLE 1

CUMULATIVE GEOMETRIC MEANS OF THE CATCH PER UNIT OF EFFORT OF SUCCESSFUL ANGLERS

Number Anglers	Catch/hr. Snapper	Catch/hr. Trout
10	0.3[illegible]	0.39
20	0.63	0.27
30	0.45	0.22
40	0.27	0.23
50	0.19	—
60	0.22	—
70	0.23	—

The figures in Table 1 show that reliable estimates of the catch rate for mangrove snapper could have been made after interviewing 50 to 60 successful snapper fishermen and 30 to 40 successful spotted seatrout fishermen.

To substantiate these data, sample sizes were also calculated from the variance of the geometric mean of the catch per unit of effort. The formula $N=4V/L^2$ as proposed by Snedecor (1956: 501) was used for estimating sample size. Here N is the sample size to be determined, V is the variance of the geometric mean of the catch per unit of effort, and L is the allowable error in the sample mean.

Results of the calculations are shown in Table 2 for three levels of allowable error. A sample of 50 mangrove snapper anglers and 35 trout anglers who made successful catches was selected as meeting the minimum requirements for estimating the catch rate for these species. The limits of error are ± 0.2 fish per unit of effort for samples of this size.

TABLE 2

SAMPLE SIZE ESTIMATES (S) AS CALCULATED FROM THE VARIANCE (V) FOR 3 LIMITS OF ERROR. V AND L ARE EXPRESSED IN TERMS OF THE NUMBER OF FISH CAUGHT PER HOUR

Mangrove Snapper			Spotted Seatrout		
V	L	S	V	L	S
0.4726	0.10	189	0.3131	0.10	125
0.4726	0.20	47	0.3131	0.20	35
0.4726	0.25	30	0.3131	0.25	20

The minimum sample size indicated above for spotted seatrout and mangrove snapper fishermen was obtained in each month. From 6.6 to 15.1% of the total number of anglers have been interviewed each year. Estimates of the total catch and total fishing effort projected from samples of this size remain on the side of minimal accuracy, because the variable skill of the anglers is reflected in their catch rate.

RESULTS

Most sport fish stocks apparently have not been significantly reduced despite a greater than 2-fold increase in fishing pressure from 1959 to 1965, (Table 3). An exception may be the redfish, *Sciaenops ocellata,* where a downward trend in catch per unit of fishing effort may suggest reduction in the stock.

TABLE 3

TOTAL ANGLERS AND ANGLING EFFORT, 1959-1964

Year	1959	1960	1961	1962	1963	1964	1965
Number anglers	28,000	31,000	34,500	50,200	40,700	58,000	64,300
Number angling hours	174,000	222,000	247,500	371,000	355,000	391,700	442,000

The species of the greatest importance in the sport fishery of the area are spotted seatrout, *Cynoscion nebulosus,* the mangrove snapper, *Lutjanus griseus,* and the redfish, *Sciaenops ocellata.* They rank as the top three species in numbers caught, and are also the top three in the list of species preferred by fishermen of the area. Their rank has varied during the study.

SPOTTED SEATROUT

Seasonal Availability

Winter was the most productive fishing season for spotted seatrout in 4 of the years recorded (1959-60, 1960-61, 1962-63, and 1964-65); a secondary peak of catch also occurred in late spring or summer (Fig. 2). Departures from this pattern were the peaks in spring of 1962 and summer of 1964, which overshadowed the winter peaks.

Spotted seatrout congregate in the deeper water of channels and holes in winter when the surface water temperature decreases as indicated previously by Tabb (1960 and 1961) and Moffett (1961). The relationship of air temperatures with catch rates shown in Fig. 2 seems to support this hypothesis. Mean monthly air temperatures of less than 70F appear to create this condition. The cold winters of 1959-60 and 1961-62 produced best spotted seatrout catches, while the warmer winter of 1963-64 produced poor catches by contrast. This congregating behavior is known to commercial fishermen and experienced anglers and may explain the high catch rates in winter.

The secondary peaks which occurred in both early and late summer, shown in Fig. 2, are believed to be the result of the concentration of fish during the spawning season. S'udies conducted in the Park in 1959 and 1960 demonstrated that most spawning occurred in May, with continued heavy spawning through August (Stewart, 1961). This agrees with Moffett's (1961) study of spotted seatrout at Ft. Myers, where spawning

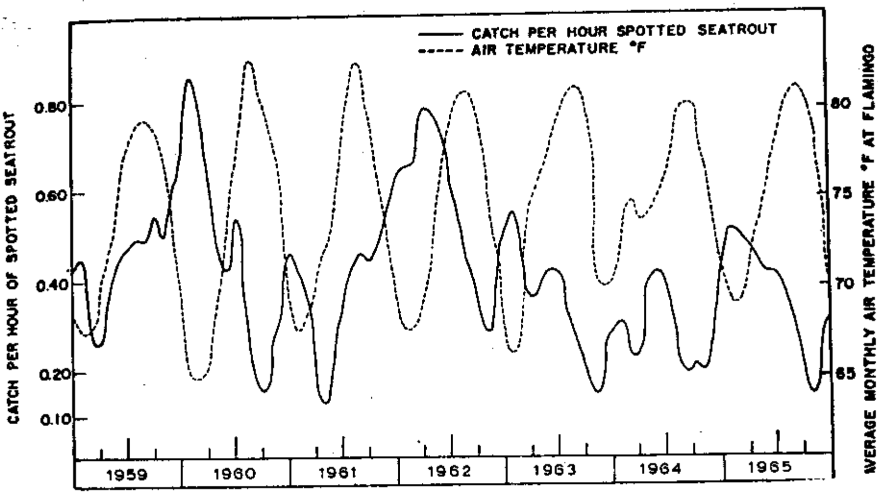

Fig. 2. Relationship between air temperature at Flamingo and the catch rate of spotted seatrout. Source of temperature data: U.S. Weather Bureau, Climatological Data, Florida, 1959-1964.

commenced in May and continued into September, and observations by Tabb (1961) in the Indian River, where spawning took place principally during April through July.

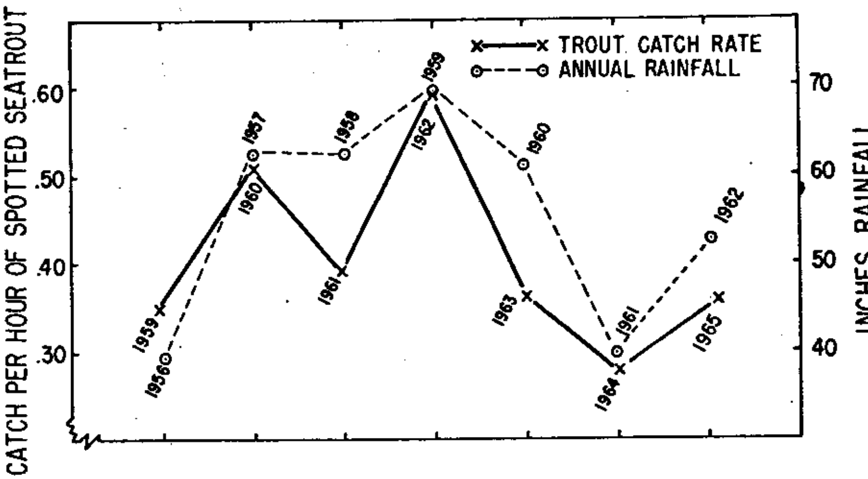

Fig. 3. Catch rates of spotted seatrout and the annual rainfall of the Everglades district for 3 years previous. Source of rainfall data: U.S. Weather Bureau, Climatological Data, Florida, 1956-1962.

Abundance

The annual catch rate of spotted seatrout is plotted with the annual rainfall of the Everglades District for 3 years earlier in Fig. 3. This time interval was suggested by studies which showed that 2- and 3-year old spotted seatrout dominated the catch during 1959 and 1960 (Stewart, 1961). The similarity of the curves suggests that rainfall influences the survival of larval and juvenile trout which live in the estuary and which enter the fishery 3 years later. The value of the correlation coefficient is low, indicating that any existing relationship is loosely coupled and that other environmental parameters were of greater importance.

MANGROVE SNAPPER

Seasonal Availability

The most productive season for mangrove snapper was late summer, with secondary peaks occurring in June 1959 and 1964 (Fig. 4). The high catch rates in late summer generally coincided with highest water temperatures and falling salinities. These peak catches also occurred during the spawning season (Starck, 1964), but Croker (1962) has shown that mangrove snapper never become sexually mature in the Park. Therefore availability is not affected by concentration for spawning.

The phenomenon described as "bad water" by Tabb and Jones (1962) — an oxygen deficiency created by local heavy runoff flushing decomposed organic material from mangrove swamps — may drive these fish from their mangrove habitat into areas more accessible to fishermen. This condition occurs near the end of the rainy season and coincides with the late summer peak catch rates (Fig. 4).

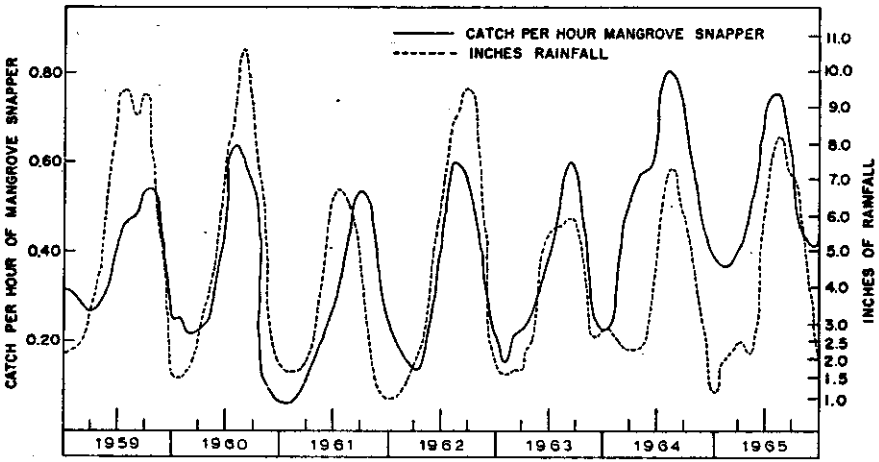

Fig. 4. Relationship between rainfall over the Everglades District and the catch rate of mangrove snapper. Source of rainfall data: U.S. Weather Bureau, Climatological Data, Florida, 1959-1965.

Catch rates of mangrove snapper tend to show an inverse relationship with annual rainfall of the previous year (Fig. 5). This lag was used because studies have demonstrated that snapper caught in the Park were predominantly 1-year-old fish. Years with less than 50 inches of rainfall appear to contribute to conditions which favor survival and growth of juvenile snapper. The correlation coefficient for this relationship was also low indicating that the relationship, if any, is of less importance than factors which were not measured.

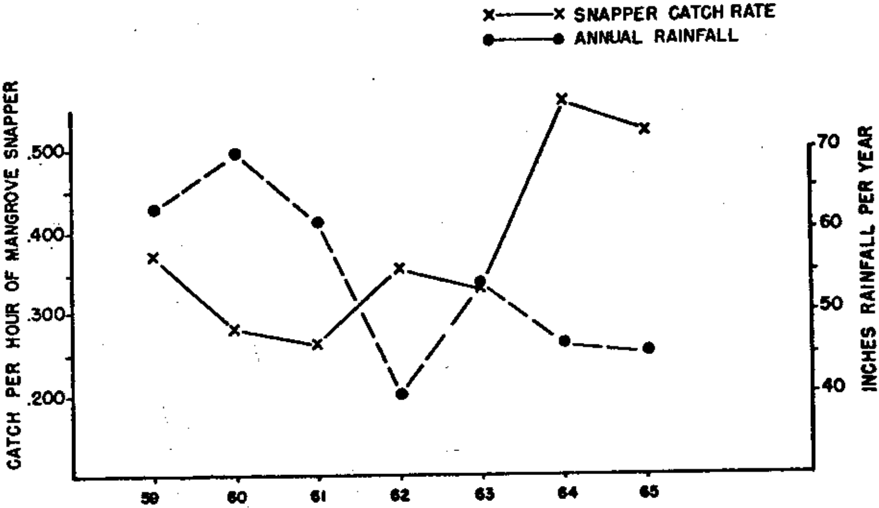

Fig. 5. Catch rates of mangrove snapper and the annual rainfall of the Everglades District for the previous year. Source of rainfall data: U.S. Weather Bureau, Climatological Data, Florida, 1958-1964.

Our effort data reflect only abundance of immature mangrove snapper since Croker (1962) has demonstrated that Park anglers caught only immature fish. Starck (1964) has shown that extensive concentrations of mature fish inhabit the reef areas offshore from the Florida Keys, and the present study does not include this habitat.

REDFISH

Seasonal Availability

Redfish were most available during the months of November, December, and January. The peak catch rates occurred during periods of lowest annual salinity, but highest catch rates occurred during the winter of 1961-62 when salinities also were at record heights. Salinities at this time averaged from 30 to 32 ppt in contrast to 15 to 25 ppt occurring in winter of the two previous years (Fig. 6).

Air temperatures, which are closely related to water temperature, did not appear to be related to catches of redfish. Monthly average air temperatures at Flamingo were 72.8F and 68.8F for November and December 1961 respectively. Temperatures during winter months for other years when catches were highest ranged from 62.6F in December 1963 to 75.0F in November 1960.

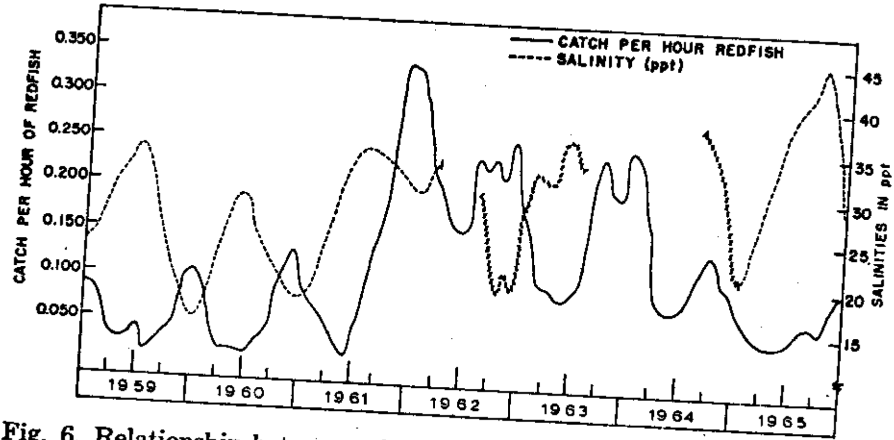

Fig. 6. Relationship between salinity and the catch rate of redfish.

Secondary peaks in redfish catch occurred in most years in August, September, and October (Fig. 6). These were preponderantly 12- to 16-inch, 1-year old fish, which were entering the fishery for the first time (Yokel, 1966).

Annual redfish catch rates are shown in Fig. 7. An inverse correlation between catch rates and rainfall in the previous year was suggested by the graph. Statistical testing shows there is no correlation. The 1 year lag period was used because Yokel (1966) found that 60% of the catch in 1960 and 1961 was comprised of 12- to 18-month old fish. The cause of the 1962 peak catch rate is unknown.

Catch rate data for redfish only reflect the relative abundance of immature redfish as studies by Yokel (1966) indicate.

DISCUSSION

Fishing Pressure

Information is not available on the fishing effort for the eastern area of the Park (the Florida Keys) or the western area (Everglades City). From limited studies in 1958, it was estimated that one-half as much fishing effort originated from the Florida Keys as from Flamingo, and information from these areas is urgently required for full understanding of fish populations in the Everglades National Park.

In 1964 it was estimated from records of fisherman-days reported in the Everglades National Park Narrative Annual Fisheries Report for 1964 (unpublished) that approximately 50% of the total fishing effort originated from Flamingo, 22% from the Keys, and 28% from Everglades City. The total sport fishing effort for the entire Everglades National Park is probably about double that of the Flamingo area, but it is not possible to extrapolate the present data to the whole Park.

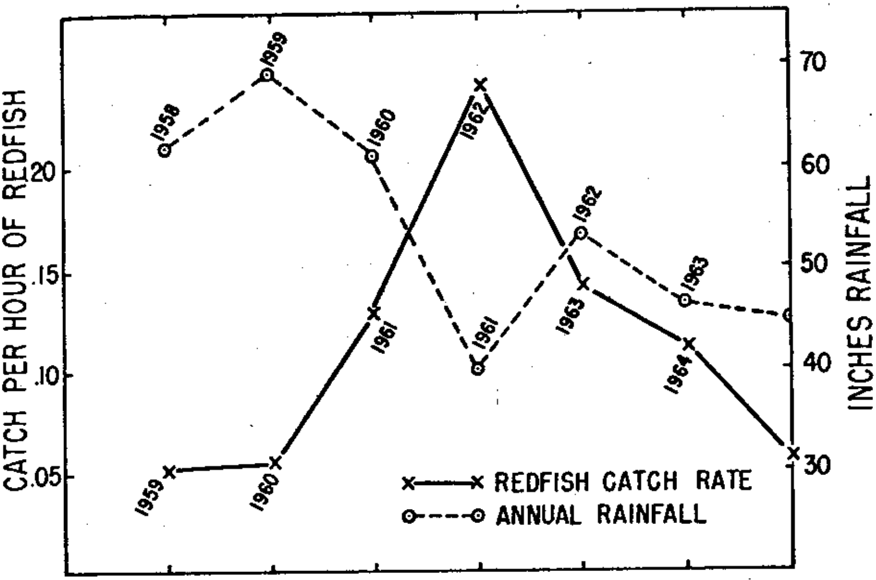

Fig. 7. Catch rates of redfish and the annual rainfall of the Everglades District for the previous year. Source of rainfall data: U.S. Weather Bureau Climatological Data, Florida, 1958-1964.

Length-frequencies of fishes caught and material for studies of age, growth and food habits of the principal species should be collected simultaneously with interviewing.

Life history studies have helped in the interpretation of seasonal changes in catch rates. Ecological information is not available for the larval and juvenile stages and it is felt that the hydrography and meteorology of the area affect these immature stages. Studies of their abundance, survival, responses, and tolerances to environmental conditions should be conducted in order to understand long-term catch rate fluctuations.

REFERENCES

CROKER, ROBERT A.
1962. Growth and food of the gray snapper, *Lutjanus griseus,* in Everglades National Park. Trans. Amer. Fish. Soc. *91* (4): 379-383.

DAVIS, J. H.
1940. The ecology and geologic role of mangroves in Florida. Carnegie Inst. Wash. Pub. No. 517, p. 203-412.

GINSBURG, R. N., L. B. ISHAM, S. J. BEIN, and J. KUPERBERG
1954. Laminated algal sediments of south Florida and their recognition in the fossil record. Mar. Lab., U. of Miami, mimeo, rpt. No. 54-20, p. 1-33.

KLIMA, E. F. and D. C. TABB
1959. A contribution to the biology of the spotted weakfish, *Cynoscion nebulosus,* (Cuvier) from northwest Florida with a description of the fishery. Fla. St. Bd. Consv. Tech. Ser. 30, p. 1-25.

Moffett, A. W.
1961. Movements and growth of spotted seatrout, *Cynoscion nebulosus,* (Cuvier) in West Florida. Fla. St. Bd. Consv. Tech. Ser. 36, p. 1-33.

Moody, W. D.
1950. A study of the natural history of the spotted seatrout, *Cynoscion nebulosus,* in the Cedar Key, Florida area. Quart. Jour. Fla. Acad. Sci. *12* (3): 147-171.

Price, W. A.
1954. Shorelines and coasts of the Gulf of Mexico. In Gulf of Mexico its origin, waters and marine life. U.S. Fish. Wildl. Serv. Fish. Bull., No. 89, p. 39-86.

Snedecor, George W.
1956. Statistical methods, Fifth Edition. Iowa State College Press. p. 501.

Starck, Walter A., II
1964. A contribution to the biology of the gray snapper, *Lutjanus griseus* (Linnaeus), in the vicinity of Lower Matecumbe Key, Florida. (Unpublished doctoral dissertation, Institute of Marine Science, University of Miami.)

Stewart, K. W.
1961. Contributions to the biology of the spotted seatrout, *Cynoscion nebulosus,* in the Everglades National Park, Florida (Unpublished masters thesis. Institute of Marine Science, University of Miami.)

Tabb, D. C.
1960. The spotted seatrout fishery of the Indian River area, Florida. Fla. St. Bd. Consv. Tech. Ser. 33 p. 1-18.
1961. A contribution to the biology of the spotted seatrout, *Cynoscion nebulosus,* (Cuvier) of east-central Florida. Fla. St. Bd. Consv. Tech. Ser. 35, p. 1-22.

———and D. L. Dubrow
1962. Hydrographic data, supplement I, from the inshore bays and estuaries of Everglades National Park, Florida, 1959-62. Institute of Marine Science, University of Miami, mimeo. rept. No. 62-9, p. 1-22.

———and D. L. Dubrow, and R. B. Manning
1962. The ecology of northern Florida Bay and adjacent estuaries. Fla. St. Bd. Consv., Tech. Ser. 39, p. 1-79.

———and A. C. Jones
1962. Effect of Hurricane Donna on the aquatic fauna of North Florida Bay. Trans. Amer. Fish. Soc. *91* (4): 375-378.

Yokel, B. J.
1966. A contribution to the biology and distribution of the red drum, *Sciaenops ocellata.* (Unpublished masters thesis. Institute of Marince Science, University of Miami).