CHARACTERISTICS OF SPORT FISHING ACTIVITY IN THREE WARM WATER DISCHARGES

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Abstract: Creel surveys were conducted at TVA's Gallatin, Kingston, and John Sevier Steam Plant discharge basins from March 1975 through May 1976. The highest period of angler use at all plants occurred between April and June. Peak harvest and pressure in the 3 discharge basins were significantly related, and high periods usually occurred later in the year than has been reported from other areas. At least 18 species were found in the combined creel from the 3 plants, and species diversity was greatest during the warm months. Three species, channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), and white bass (*Morone chrysops*), comprised over 50% of the combined creel. Angler harvest remained uncommonly high from March through August with lowest levels observed in the winter months. The overall angler catch per hour (c/h) was 0.5 fish while the highest monthly c/h recorded was 2.3 at John Sevier in May 1975. Comparisons of angler and electrofishing catches showed similar seasonal patterns. It seemed that angler c/h reflected seasonal changes in the sport fish population, and it was concluded that the fishery could sustain a significant increase in pressure and harvest at certain times of the year.

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A majority of fossil-fueled power plants and some nuclear plants discharge large volumes of thermally enriched condenser cooling water into receiving waters. Fish movement into these thermally affected areas during cold seasons and their emigration during warm months have been shown by a number of authors (Epler and Bieniarz 1973, Jensen 1974, and Storr and Schlenker 1974). As a result of this influx of fish during cool weather, angler use and fish harvest in these zones are usually significantly higher than at other times. Barkley and Perrin (1972) noted an excellent winter fishery in thermally enriched water and determined that the maximum concentrations of predators occurred in October and nonpredators in February. Hanson (1973) stated that the total catch from Thomas Hill Reservoir in Missouri would have been much less if there was not an existing thermal effluent. He determined that the largest catches came from the heated area during December through March. At a warmwater discharge into a marine environment, Landry and Strawn (1973) found the sport fishing pressure to be heaviest in the winter and early spring months while lowest usage occurred in the warmer months. The highest catch rates were recorded during October, January, and February.

Comparative studies of harvest rates and species composition of catches between thermally influenced and uninfluenced areas have been commonly reported. The general consensus of these investigations was that at certain times of the year there were considerably larger concentrations of fish in the heated discharge than in the unaffected areas, and the angler harvest rates were correspondingly greater. A comparative angling study by Gibbons et al. (1972) showed significantly more bass caught per cast in the thermal effluent. This result was complemented by underwater observations that also indicated higher concentrations of bass in the heated water area. In a similar study, Elser (1965) reported that a thermally enriched area of the Potomac River yielded more fish per trip than other areas at ambient temperatures. He found 80 percent of all the fish caught in March were from the heated water zone, and the catch in the discharge area oscillated from 40-65 percent of the total through the winter months.

At TVA's Johnsonville Steam Plant Dryer and Benson (1956) found that during the winter, large numbers of threadfin shad (*Dorosoma petenense*) congregated in the discharge basin and attracted sizable numbers of skipjack herring (*Alosa chrysochloris*) and sauger (*Stizostedion canadense*). These species reached maximum concentration in late December and early January. The authors also reported that numbers of blue (*I. furcatus*) and channel catfish began increasing in the discharge basin area in late February and reached a maximum abundance from March through June.

The purpose of this study was (1) to determine patterns of fisherman activity and harvest and (2) to obtain information on the level of utilization as compared to the availability of the fisheries resource in 3 TVA steam plant discharge basins.

LOCATION AND DESCRIPTION OF STEAM PLANT DISCHARGE BASINS

Gallatin Steam Plant is located at river mile 243 on Old Hickory Reservoir, a mainstream impoundment of the Cumberland River in Sumner County, Tennessee (Fig. 1).

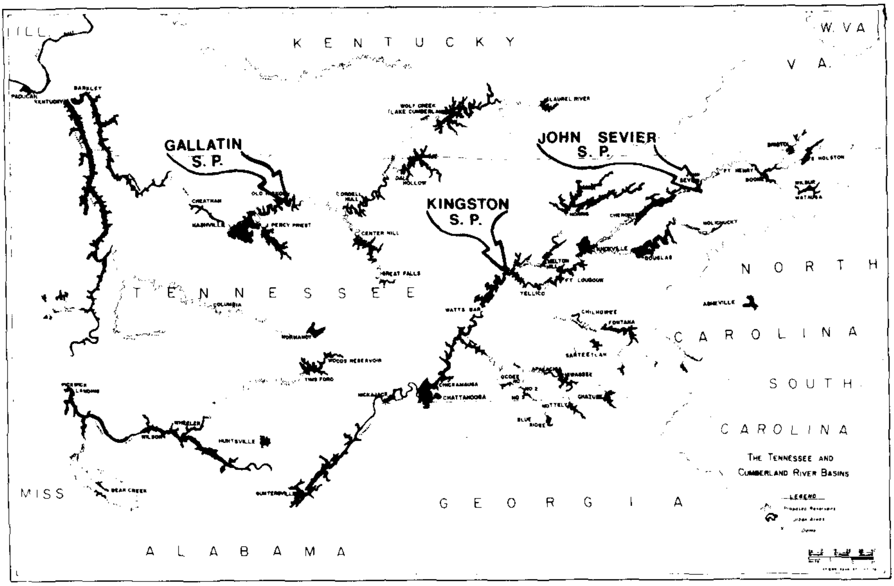

Fig. 1. The location of Gallatin, Kingston, and John Sevier Steam Plants within the Tennessee Valley.

The plant began operation in 1956 with 4 fossil-fuel units that produce a total of 1,255 megawatts. The condenser circulating water system withdraws water from Old Hickory Reservoir at a rate of 60 m^3/s and raises the temperature 8.9 C above ambient. The heated water is discharged into a 1,0006 m long, 4.5 m deep channel.

John Sevier Steam Plant is located at the headwaters of Cherokee Reservoir, a storage impoundment of the Holston River (Fig. 1). The plant began operation in 1957 with 4 coal-fired units that produce approximately 824 megawatts. Cooling water is taken from John Sevier Detention Reservoir at a rate of 31 m^3/s, heated to approximately 8.3 C above ambient, and discharged into Cherokee Reservoir. The discharge channel is 411.5 m long, 29 m wide at the head, 106.7 m wide at the mouth, and the banks are riprapped with large rocks.

Kingston Steam Plant is located on a peninsula between the Clinch and Emory River arms of Watts Bar Reservoir at Clinch River Mile 2.8. Operation began in 1955 with 9 fossil-fuel units that produce 1,700 megawatts. Circulating cooling water is supplied from the Emory and Clinch River arms and is withdrawn at a rate of approximately 61 m^3/s. The effluent is heated 8 C above ambient and is discharged into a 183 m long channel which widens into a 3.2 ha discharge basin before emptying into the Clinch River arm of Watts Bar Reservoir.

MATERIALS AND METHODS

A survey of the sport fishing creel was conducted at the discharge basins of Gallatin, Kingston, and John Sevier Steam Plants from March through April 1976. Each area was visited by a creel clerk on 2 to 6 randomly chosen days each month depending on the season. During these visits, fishermen were interviewed and all fish creeled were identified to species, weighed, and enumerated. Three counts of the number of fisherment present in the discharge areas were taken each day to obtain a daily estimate. Monthly estimates were obtained simply by totaling the daily figures.

Electrofishing samples were collected from the discharge basins of Gallatin and Kingston Steam Plants from September 1974 through September 1975. John Sevier was sampled from March 1975 through April 1976. Samples were collected from 1 to 2 days a week, biweekly. The electrofishing apparatus consisted of a portable 230 volt, 3.5 kW, AC generator and a rectifier which converted the current to pulsed (180-360 Hz) DC. The boat was operated at a constant speed, and the electrical current was applied continuously. Fish were collected along designated sections of shoreline on each bank for a 3 min period. To compare catch rates for species found in the creel with rates for the same species collected by electrofishing, the catch per 3 min sample period was expanded to a per-hour basis. Correlation coefficients between electrofishing and angler catch rates were calculated using Kendall's Tau.

RESULTS AND DISCUSSION

Angler Pressure

Generally, over the study period at the 3 steam plant discharge basins, the monthly estimated number of fishermen was the highest during the April-June period and then dropped steadily to the lowest levels from November-January (Fig. 2). These patterns largely coincided with those found in ambient water areas in the region (Chance et al. 1975) and with those observed at a nuclear power plant discharge canal on the Connecticut River (Marcy and Galvin 1973). However, as has been mentioned previously, the greatest angler activity at thermal discharges in other areas was usually recorded during the colder months when the greatest concentration of sport fishes would be expected (Barkley and Perrin 1971, Hanson 1973, and Landry and Strawn 1973).

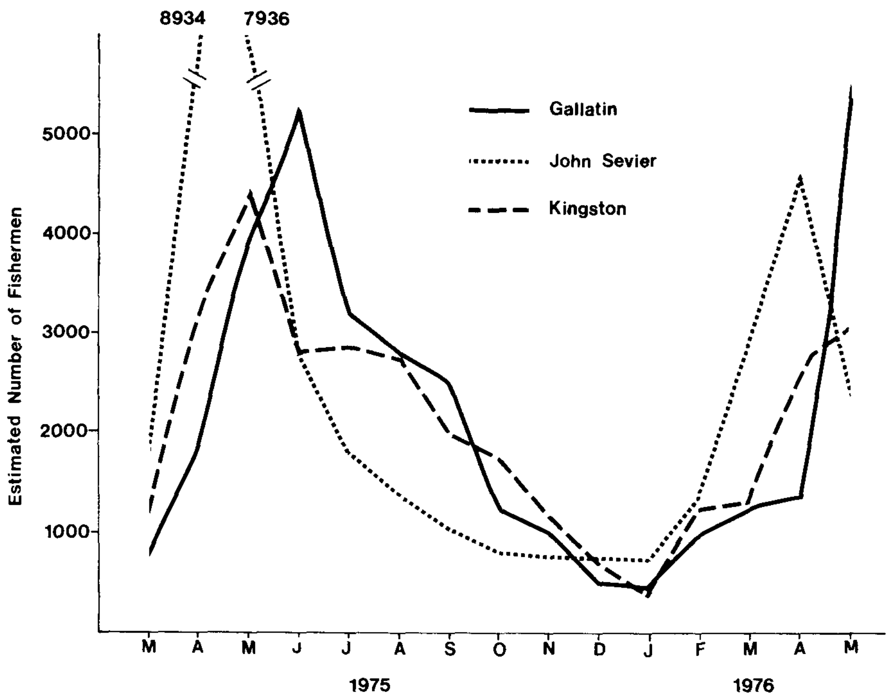

Fig. 2. Monthly estimated number of fishermen at the discharge basins of Gallatin, John Sevier, and Kingston Steam Plants (March 1975 through February 1976).

The estimated angler pressure trends were similar at each plant with the highest monthly pressure estimate occurring at John Sevier Steam Plant in April 1975 (8,934 fishermen) and the lowest at Kingston in January 1976 (349 fishermen). Seasonal high and low periods of fishing pressure at John Sevier were usually observed 1 or 2 mo earlier than at the other basins because they reflected late winter and early spring movement of white and striped bass (*M. saxatilis*) into this portion of the Holston River. These migrations are well known locally, and the sport fishermen participation at this time of the year is typically heavy. Angler pressure levels at John Sevier and Kingston were higher in the spring of 1975 than in the spring of 1976 while at Gallatin pressure was slightly higher in spring 1976. Water levels in the spring of 1975 were above normal while the following year they were lower than normal. This may explain some of the observed pressure and catch differences. The total number of anglers interviewed over the study period at Gallatin, John Sevier, and Kingston Steam Plant discharge basins was 1,139, 671, and 531, respectively, and the highest quarterly numbers were found in the spring and summer (Table 1).

Table 1. Number of hours fished, number of fishermen surveyed, and number of fish of important species caught each quarter at Gallatin, John Sevier, and Kingston Steam Plant discharge basins (March 1975-August 1976).

	March-May			*June-August*			*Sept.-Nov.*			*Dec.-Feb.*			*March-May*			*June-August*	*Total*		
Discharge Basin	G	JS	K	G	JS	K	G	JS	K	G	JS	K	G	JS	K	G	G	JS	K
No. Hours Fished	471	302	194	660	257	313	387	123	89	150	238	67	173	105	124	330	2171	1025	787
No. Fishermen	332	226	152	256	161	164	192	68	65	119	143	49	81	73	101	159	1139	671	531
No. Fish of Each Species Caught																			
Carp (*Cyprinus carpio*)	20	16	8	49	6	9	1	6	—	2	6	—	6	1	—	17	95	35	17
Smallmouth Buffalo (*Ictiobus bubalus*)	13	—	—	52	—	—	2	—	—	—	—	—	4	—	—	23	94	—	—
Blue Catfish (*Ictalurus furcatus*)	34	—	18	28	—	37	12	—	17	1	—	—	3	—	1	—	78	—	73
Channel Catfish (*Ictalurus punctatus*)	49	16	4	17	24	37	15	3	4	6	1	—	8	6	1	39	134	50	46
White Bass (*Morone chrysops*)	56	201	62	—	8	5	2	1	2	13	86	—	26	28	53	9	106	324	122
Striped Bass (*Morone saxatilis*)	—	49	35	—	4	—	4	2	—	—	6	—	2	—	—	—	6	61	35
White striped Hybrid Bass	—	63	19	—	5	—	—	—	—	—	3	—	—	2	—	—	—	73	19
Bluegill (*Lepomis macrochirus*)	3	16	4	32	56	37	32	17	4	5	10	—	6	1	12	22	100	100	57
Lepomis sp.[a]	12	3	9	23	30	12	24	—	4	7	—	—	2	1	1	14	82	34	26
Largemouth Bass (*Micropterus salmoides*)	5	2	—	1	5	—	6	22	—	1	6	—	2	—	—	7	22	35	—
White Crappie (*Pomoxis annularis*)	2	—	—	—	3	—	9	14	—	1	16	—	—	2	—	—	12	35	—
Freshwater Drum (*Aplodinotus grunniens*)	37	—	13	11	—	17	1	—	—	1	—	—	4	—	1	19	73	—	31
TOTAL	231	366	172	213	141	154	110	65	31	37	134	0	66	41	69	150	802	747	426

[a]Usually composed of one or more of the following species: Orange spotted (*Lepomis humilis*), longear (*Lepomis megalotis*), and green sunfish (*Lepomis cyanellus*)

Angler Harvest

The quarterly angler harvest data from each of the steam plants showed a significant relationship (Kendall's Tau = 0.70, $P = .0002$) between the hourly fishing pressure and the size of the creel. The greatest number of fish were usually caught in the March to August period with a much lower number during December to February. An exception was the John Sevier area where numbers in the winter quarter were also high. A majority of the species at each plant showed distinctly higher numbers during the warm months. However, a few species were fairly well represented in the creel in the colder months.

The species composition of the total catch from all basins showed 3 species (channel catfish, bluegill, and white bass) contributed significantly (more than 10%) to the total number harvested, and together they comprised over 50 percent of the entire creel. The latter species was represented by greater numbers than the other 2 combined (Table 1). Three additional species (blue catfish, carp, and smallmouth buffalo) made significant contributions to the harvest at one or more of the basins.

Bluegill and white bass were the only species to have numbers in excess of 10 percent of the total catch from each area. Channel catfish was a significant component of the harvests at Gallatin and Kingston (15.6 and 10.3%, respectively). Blue catfish also was important in the catches from these two plants with 9.1 and 16.3 percent, respectively. Two other species, carp and smallmouth buffalo, were significant contributors to the creel at the Gallatin basin. Both largemouth and smallmouth bass (*M. dolomieui*) were poorly represented at Gallatin and Kingston, but largemouth bass did comprise 4.6 percent of the creel at John Sevier.

At least 18 species were found in the combined creel survey from the 3 areas. The greatest number of species was generally collected during the months March through June, and this period was followed by a gradual decrease to low points during January, February, and March (Fig. 3). Most important taxa occurred more frequently in the warmer months although some, such as white bass and white crappie, were prevalent

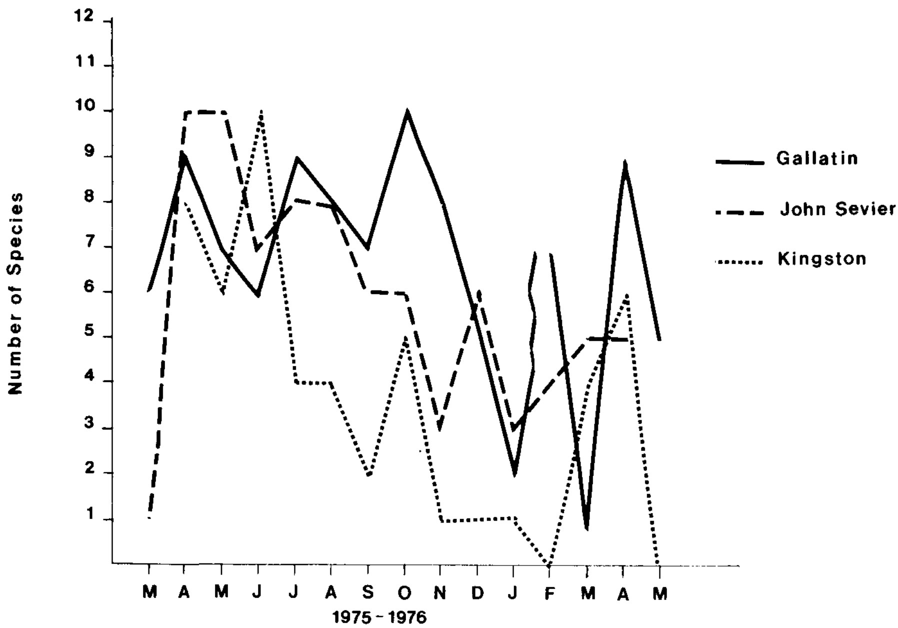

Fig. 3. The number of species found monthly in the creel at Gallatin, John Sevier, and Kingston Steam Plants discharge basins (March 1975 through May 1976).

during the colder months (Fig. 4). The most often recurring taxa caught in the 3 discharge basins were channel catfish, carp, white bass, bluegill, *Lepomis* sp., and largemouth bass. Over the study period channel catfish were found every month through the spring and summer at each area and then occurred less often from December to March. This species was the most frequently occurring fish in the total sample (only absent from all sites in January) at Gallatin and John Sevier. They were absent from all areas during November and December 1975 and reappeared in the creel from January to April 1976. At Kingston, creel data showed that carp did not occur after June 1975.

White bass usually were found from December to June, but at Kingston they did not appear in the harvest until March (Fig. 4). At all sample sites they occurred infrequently from June through November. The months of July and November were the only ones in which white bass were not found in the creel at any discharge basin. This species, along with bluegill, was the second most frequently occurring fish.

Bluegill, ranking high among the most common species creeled, was only missing from all areas in the month of January (Fig. 4). They were usually represented in the harvest at 2 or more sites from April through November. Other sunfish (*Lepomis* sp.) were not found in the catch from any area during December and January and usually showed only scattered occurrence at other times of the year. Largemouth bass were absent from the creel at all discharge basins during January, February, and April (1975 only). They occurred most consistently at John Sevier (July to December) and were only found occasionally throughout the year at the other 2 plants.

In summary, the frequent absence from the creel by most of the important species occurred from 1 or more of the areas during the colder months. However, channel cat-

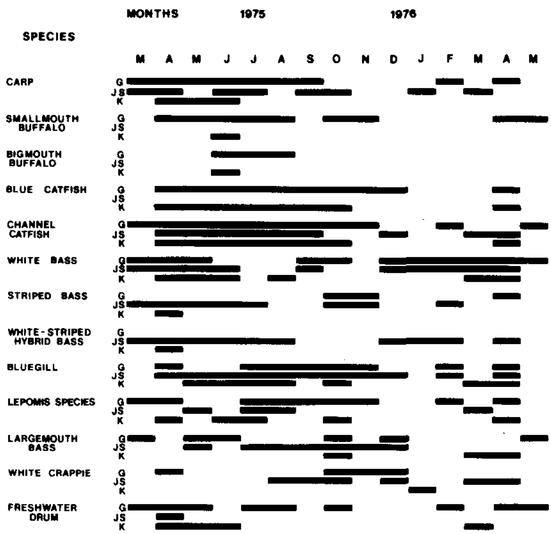

Fig. 4 Monthly species occurrence in the creel at Gallatin, John Sevier, and Kingston Steam Plants (March 1975 through May 1976).

fish, white bass, and bluegill were commonly found throughout the duration of this study, and they comprised a significant portion of the harvest from each area. Large influxes of white, striped, and white-striped hybrid basses in early spring contributed heavily to the creel, but bluegill and channel catfish, being more eurythermal and sedentary, apparently helped sustain angler pressure and harvest beyond the typical winter-early spring heated discharge fishing season.

Angler and Electrofishing Catch Per Unit Effort

The mean seasonal angler c/h for all 3 areas combined was highest in the spring 1975 (0.89) and lowest in the fall and winter quarters (0.36 and 0.33 respectively). The mean rate of 0.47 was observed during the summer. The mean quarterly electrofishing c/h values paralleled the angler values with high levels during the spring and summer quarters (126.0 and 123.6, respectively) and low levels in the fall and winter (75.7 and 71.0, respectively). However, monthly correlation between the 2 sets of data for the 3 plants combined was only significant during the December-February quarter (Tau = 0.61, P = 0.22). The Gallatin angler c/h did not indicate any major trends, and by excluding this plant from the calculations, there was significant seasonal correlation between electrofishing and angler c/h at John Sevier and Kingston (Tau = 0.51, P = .0007). Other studies have found maximum harvest rates to occur somewhat earlier in the spring or winter (Moore and Frisbie 1972, Hanson 1973). The high period observed in this study coincided with the peak angler harvest found by Marcy and Galvin (1973) during a 6 mo study in Connecticut. They observed the greatest c/h during May (4.11) but also noted a high rate (greater than 1.0) in January.

The greatest angler harvest rate over the study period (0.72 fish/h) was observed at the John Sevier basin, and the monthly c/h during the initial 3 spring months of the study was 1.0 or more fish/h at this site (Fig. 5). Again at John Sevier the maximum monthly c/h of 2.34 in May 1975 was the highest recorded from any area during the study, and the highest winter period monthly c/h (10.9) was also recorded there in December 1975. This peak was followed by a sharp decline to the lowest level (0.29 in January) found from that area. The high angler harvest rates occurred within 1 month of the peak electrofishing c/h (Fig. 5).

The mean angler harvest rate over the entire study period at the Kingston plant was 0.42, and the highest monthly rate (1.22) occurred in April 1975 at approximately the same time the electrofishing c/h peaked (Fig. 5). The c/h from both sampling methods declined steadily through the summer, but lowest angler levels were not reached until the winter.

At Gallatin overall average angler c/h was the lowest of the 3 plants (0.37 fish/hr). The 13 mo electrofishing c/h was the second highest of the 3 basins and showed peaks during September and April to June (Fig. 5).

Total mean angler catch rate for the 3 discharge basins combined was 0.50, and this was a much lower rate than reported from other thermally affected areas. Hanson (1973) reported an average fisherman c/h of slightly over 1.0 from a warm water section of Thomas Hill Reservoir, Missouri. Short-term studies in Maryland (Moore and Frisbie 1972) and Connecticut (Marcy and Galvin 1973) have shown total mean catch rates of 0.71 and 2.37, respectively, from heated discharge canals.

Electrofishing samples provided some instantaneous, quantitative insight into the magnitude of the resource that was present in the discharge basins. The combined electrofishing catch at the three TVA plants varied from approximately 10 to 500 fish/h and was consistently at least one order of magnitude greater than the angler c/h. By considering this catch rate as a general indicator of the abundance and potential availability of the sport fish population, it appeared that at 2 discharge basins the fluctuations in angler catch rates reflected actual seasonal changes in the sport fish population. This was indicated by the relatively close correlation between angler and electrofishing c/h at John Sevier and Kingston. Also, the consistently larger electrofishing c/h showed a substantially greater quantity of harvestable fish available in the discharge basins than were being caught by anglers. Thus, the management implication was that the resource could accommodate increased pressure and harvest.

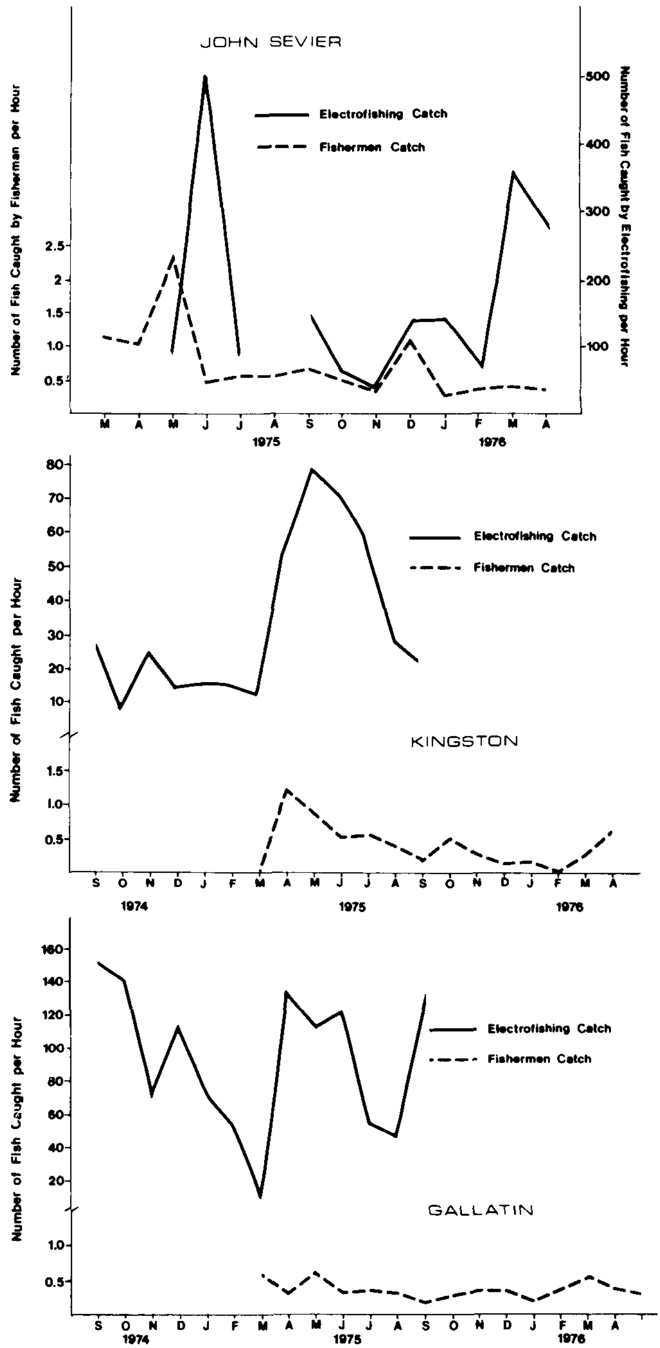

Fig. 5. Mean monthly sport fishermen and electrofishing catch per hour for all species from John Sevier, Kingston, and Gallatin Steam Plant discharge basins (March 1975 through April 1976).

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