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Fishing has become a very popular recreational activity in the United States. A change from fishing for food to fishing for recreation has created the demand for improved-quality sport fisheries. Comparison of relative weight (W_r) and weight of five fish species were made to distinguish changes in fish quality during two different management plans at a 72.9 hectare lake in Woodson County Kansas. W_r represents an index of condition calculated by dividing the weight of a fish by a length-specified standard weight for that species (Murphy and Willis, 1996) Data collected during management monitoring (spring electrofishing and fall netting) in 1980-1983 and 1995-1998 were used for the study. Supplemental feeding and selective harvest regulations were the main changes that occurred between the study periods. Fish quality increased significantly during the 1995-1998 study period over the 1980-1983 period. Creel census data supports the findings, showing an increase in average size harvested, total harvest, and total number harvested. A recreational fishery that emphasizes the optimum sustained yield concept can be created with appropriate fisheries management methods.

FISH QUALITY CHANGES UNDER TWO FISHERIES MANAGEMENT PLANS

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PREFACE

This thesis is written for the Division of Biological Sciences at Emporia State University. The manuscript follows the instructions of the *Prairie Naturalist*, the journal to which this research will be submitted for publication.

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INTRODUCTION

Fishing once was done only to obtain food, but as times changed, so did the reason for fishing. Documentation of fishing exists as far back as the late upper Paleolithic Era (Eddie, 1983). Fishing has remained a necessity in many cultures as a source of food and income; however, the United States is now highly advanced in food production and fishing has become a very popular pastime, rather than a necessity. Technological advancements in sport fishing and fishing equipment have given anglers the best equipment for angling in modern society. For example, an angler twenty years ago likely had only one or two poles for fishing. Today, anglers can choose from a variety of poles, each geared to a certain type of fishing, with enormous selections of bait, equipment, and tackle. Today, we value lakes for their recreational assets and the feeling of being close to nature that a "day at the lake" provides (National Research Council, 1992). As a result, recreational fishing is very popular and important to modern society.

A total of 100,000 lakes and ponds have been constructed in Kansas for storage of water and regulation of flow downstream (Cross and Collins 1995). These waters provide many new habitats for fishes. Kansas now has about 200,000 acres of lake habitat, much of it in central and western Kansas where surface water was formerly least plentiful. In new lakes, fishing was generally good, at least for the first few years after filling. As these waters aged and more people began fishing, appropriate management was needed to provide and maintain quality fisheries. An overall decline in fishing quality has resulted from increased angler efficiency because of more effective equipment, angler education, and more leisure time spent fishing (Coble 1988, Olson and Cunningham 1989).

The economics of recreational fishing show that dramatic changes have occurred during the last few decades in the United States. In 1979, expenditures on freshwater recreational fishing were approximately $17 billion (Lackey and Nielsen 1980), as compared with $69 billion in 1992 (Fedler and Ditton 1994). These examples show the economic changes that have occurred during the periods of 1980-1983 and 1995-1998 referred to in this study. In Kansas, anglers spend more than 30 million dollars each year on their angling activities (Cross and Collins 1995). This shows the economic value, but this represents only part of the story. For example, a fish protected by a minimum length limit can be caught and released several times before harvest, adding to its recreational value. However, a problem exists for fisheries managers, because fishing quality is perceived differently by anglers, based upon their individual measure of gratification and success (Anderson 1976).

Fisheries managers have attempted to improve fisheries using experimentation, past experiences, and previous documentation (Hubbs and Eschmeyer, 1937), a statement that still applies to challenges in managing public waters for recreational fishing today. Radonski and Martin (1985) defined fisheries management as continuing, dynamic processes concerned with the protection, enhancement, and allocation of living aquatic resources in a way that provides the greatest benefits to society. Management of small, warmwater fisheries have always been a challenge for fisheries managers (Anderson 1976). The technological advancements, growth of the sport fishing industry, and a shift from fishing for food to recreation has created demand for improved recreational fisheries.

Early fisheries managers developed the idea of maximum sustained yield (MSY) or harvest from fish stocks. The MSY concept involves the abundance and age structure of fish stocks maintained at levels that produce the highest yearly harvests that can be sustained throughout time (Nielsen 1993). MSY is concentrated on numbers harvested and the philosophy that more fish means better fishing (Anderson 1976). A shift from the MSY concept began to occur in the early 1970s with development of the concept termed optimum sustained yield (OSY). Martin (1976) stated that the narrow axiom of MSY is no longer viable for sport fisheries if, indeed, it ever was. OSY includes consideration of fisheries-specific sociological and economic characteristics plus the biological condition and production potential of a fish stock (Nielsen 1993).

What is OSY? Replacing the concept that more is better, optimum implies relationships that ascend to an optimum level and then decline (Anderson 1975). Sustained implies that over the long term, the fishery can be maintained at an optimum level. Yield is intended to reflect all the benefits the fishery has to society. By this definition, yield of angling includes more than numbers and weight of fish caught or harvested (Anderson 1975). Anderson (1975) stated that the concept of OSY in reality is an idealistic dream. Optimum as considered by one angler reflects on that person's perception of quality fishing, whereas another angler might perceive "quality" very differently.

Anderson (1975) suggested that optimum yield in sport fishing is related to the quality of fishing. Quality fishing means many different things, depending on individual angler perceptions. For example, a bass angler views a fishery differently than does a catfish angler. In creating socially-successful management, it is necessary to provide variety in a recreational fishery, creating opportunity for choice (Anderson 1975). Managers might not be providing an appropriate balance of angling opportunities to meet public needs by ignoring angler motivations (Fedler and Ditton 1994). Although idealistically, the concept of OSY might not be achievable, it has given a new direction to fisheries management. Fisheries managers' goals and objectives should evolve so that an OSY orientation can eventually replace the traditional MSY orientation (Malvestuto and Hudgins 1996). The focus of this research was to compare two fisheries management plans that conceptualize the theory of OSY. This research addresses two different management plans at Woodson State Fishing Lake (WOSL), in Woodson County in Southeastern Kansas. Each plan attempted to address the OSY concept in creating a better-quality fishery. Under past management at WOSL, trends in fish population structures have, over time, resulted in a poor-quality fishery. This lake has been renovated three times since it opened to fishing on 30 May 1938. Rehabilitation of the lake occurred in 1949-1953, 1976-1979, and 1991-1994, showing that relatively short time management was effective. My research focused on the 1976-1979 and 1991-1994 renovations. These renovations are explained in the Materials and Methods section.

Many publications compare strategies of stocking, regulations, population structure, and ecology, but not management in a broad sense. Insights into management plans as a whole and their effect on fish populations rarely appear in the literature. It is my intention to compare two management strategies used at WOSL. Many comparisons can be made from data that exist; however, because of changes in sampling efficiency, statistical analyses of the data were limited.

Research focused on changes in sportfish quality between the past and the present OSY management schemes. The nature of the information and calculations needed for a fish stock assessment is quite variable, depending on the biology of the species, the time scale, and the purpose of the assessment (Gulland, 1988). For obvious reasons, researching the past management scheme with any detailed plan was impossible. Therefore, fisheries management data collected each spring and fall by the Kansas Department of Wildlife and Parks (KDWP) was used for this research. It is true that what assessment is feasible is almost entirely determined by what data are available (Gulland, 1988).

Comparable catch data from the 1980-83 samples and 1995-98 samples were used to assess changes in quality of comparable fish species for each period. Original fall catch data for 1979 could not be found. Therefore, the 1994 catch data was also disregarded. Relative weight (W_r) and size (weight) were used to define fish quality. W_r represents an index of condition calculated by dividing the weight of a fish by a length-specified standard weight for that species (Anderson and Neumann, 1996). Standard weight (W_s) is established by a standardized regression of weight on length for a particular species (Anderson and Neumann, 1996). Anderson and Neumann (1996) stated "standard weight" equations usually embrace fish throughout a species' range and are based on a 75th percentile weight rather than average weight in a length-class.

The two OSY management schemes incorporated different species of fish. Therefore, this study focused on fish present in both periods. The species compared were bluegill (Lepomis macrochirus), black crappie (Pomoxis nigromaculatus), channel catfish (Ictalurus punctatus), largemouth bass (Micropterus salmoides), and walleye (Stizostedion vitreum). These fish species were stocked as part of both plans and were compared as representatives of the fishery under each type of management. W_r comparison for each species showed significant changes, with four of the five increasing in W_r during the 1995-1998 samples. Weight comparisons of species between the two study periods showed change in two species were not significantly different, two increased during the 1995-1998 period, and one increased during the 1980-1983 period. Creel census data support these findings.

MATERIALS AND METHODS

STUDY AREA

WOSL, also known locally as Fegan Lake, is a 72.9 ha lake located approximately 8 km east of Toronto, Kansas, along the northern edge of the Chautauqua Hills region. Current maximum depth is 18 m, with a mean depth of 5.4 m. The lake was constructed from 1933-1936 by the Civilian Conservation Corps and is owned by the Kansas Department of Wildlife and Parks (KDWP). The 1,606 ha watershed is primarily a tall grass prairie, with an encroachment of blackjack oaks (Quercus marilandica), with less than 5 percent in tillage. Nearly 70% of the drainage is owned and managed by the KDWP. The shoreline development index is 2.2 with a storage ratio to drainage index of 1.2. The lake is on a small, relatively clear, intermittent tributary to Big Sandy Creek, which in turn is a tributary to the Verdigris River. It was primarily constructed for recreational purposes.

A combination of deep water, steeply-sloping basin, and protective wooded hills provides the lake with a situation that is conducive to thermal and chemical stratification. By the first week of June, a sharp thermocline becomes established at a depth of about 4.5 m (Jirak 1977b). This leaves a large portion of lake volume in a non-productive state to the fishery during the peak of the fish growing season. Another variable that limits fish production in WOSL is fertility, or the recycling of nutrients. Located on a drainage that is primarily on good grasslands, inflows are rather clear and free of agricultural fertilizers. Wave action has eroded the topsoil along the shoreline, redepositing it at lower levels of the lake. Mid-summer secchi transparencies of over 2 m are common, suggesting low-density plankton populations. Because many of the nutrients are within the basin, but not available to the aquatic animal community, there is a lack of fertility. Thermal and chemical stratification inhibits the recycling of nutrients in the lower basin, whereas aquatic plants bind the nutrients in littoral areas, adding to the fertility problem.

RENOVATION (1976-1979)

On 15 November 1976 the valve was opened and the lake was allowed to drain until mid-January, 1977. Approximately 12 ha of water remained in the basin at this time. The lake remained iced over through mid-February 1977. The heavy ice cover and crowding conditions were favorable for a winter kill, which did occur. In March 1977, the water remaining was sampled and proved the winter kill to be complete. As a precaution, all potholes in the basin and the entire watershed were treated with rotenone. The valve was closed the first week of May 1977.

It was estimated that 3,301 sportfish, weighing 1,413 pounds, were winter killed (Jirak 1977b). Estimates of rough fish (undesirable crappie and undesirable bluegills) showed 34,106 fish, weighing 34,120 pounds, were winter killed (Jirak 1977b). This shows that 91% of total fish and 96% of the total fish biomass were undesirable, with desirable gamefish representing only 9% by number and 4% by weight. Of these desirable fish, largemouth bass and walleye comprised only 0.003% by number.

A management plan was developed to optimize the potential of the fishery, taking into consideration the physical and biological limitations of the lake. The new approach was designed to optimize the fishery (combine quality with quantity) production at WOSL. Effective management needs sound concepts and principles--not simple recipes and formulas (Anderson 1976). The 1977 management plan was based on sound biological principles and concepts designed to optimize the potential at WOSL, with consideration to its physical and biological characteristics.

The 1977 plan included the use of the pelagic zone, not just the littoral zone as was used as in the past (Jirak 1977a). The plan called for matching fish species to the limitations of the water and a buffer system of species that complimented each other in case one should fail. By mid-June 1977, a stand of vegetation was present in the dry portions of the lake basin. Fish stocking (Table 1) began in June 1977 and continued throughout the summer. Gamefish species stocking rates were kept low to allow a strong forage base to become established (Jirak 1977a).

Shoreline seining showed that orangespotted sunfish, Mississippi silversides, fathead minnows, gizzard shad, and crayfish were quite plentiful by mid-summer 1977 (Jirak 1977b). Gamefish survival was noted as excellent with growth being quite favorable. The lake remained closed to fishing until 28 April 1979. When the lake reopened, fishing was excellent at first, but a key part of the management plan was missing. Selective harvest regulations were part of the plan. These were rejected by the Kansas Fish and Game administration, except a 381 mm (15-inch) minimum length limit on largemouth bass. Creel limits (per day) were 10 channel catfish, 5 largemouth bass and 5 walleye, and no limits on bluegill and black crappie. The selective regulations were key for the OSY concept of management.

RENOVATION (1991-1994)

By the late 1980s the fishery at WOSL was diminishing in quality, most likely

Table 1. Initial and supplemental stocking records from WOSL 1977-1983.

Date	Species	Size	Number Stocked	Number/ha
10 May 1977	Orangespotted Sunfish	25-52 mm	500	6.9
19 May 1977	Fathead Minnow	Adults	40.8 kg	0.56 kg
21 May 1977	Mississippi Silverside	Adults	120	1.6
22 May 1977	Red Shiner	Adults	100	1.4
25 May 1977	Bluntnose Minnow	Adults	100	1.4
25 May 1977	Sand Shiner	Adults	100	1.4
15 June 1977	Gizzard Shad	152-203 mm	500	6.9
20 July 1977	Brook Silversides	Adults	500	6.9
01 July 1977	Walleye	453.6/kg	3000	41.2
15 July 1977	Smallmouth Bass	453.6/kg	1000	13.7
19 July 1977	Black Crappie	50 mm	5000	68.6
15 Sept. 1977	Bluegill	Adults	150	2.1
22 Sept. 1977	Largemouth Bass	*	3000	41.2
03 Nov. 1977	Channel Catfish	1.4/kg	4000	54.9
06 Dec. 1977	Redear Sunfish	227.3/kg	*	*
05 June 1979	Walleye	498.9/kg	5500	75.4
11 Nov. 1979	Channel Catfish	1.1/kg	3618	49.6
11 Nov. 1983	Channel Catfish	1.3/kg	3620	49.7

*Not available.

because of a failure to impose selective harvest regulations and the establishment of common carp (Cyprinus carpio) and white crappie (Pomoxis annularis). Jirak (1990) noted that the common carp population continued to increase in size and number as the quality of the bluegill and channel catfish populations continued to decline. The quickest way to restore the deteriorating fishery was complete renovation (Jirak 1990). It was imperative that selective harvest regulations and a feeding program were approved before renovation. New management options (selective harvest regulations and a supplemental feeding program) fueled the decision to renovate rather than implement new options on a mediocre fishery. In October 1991, the KDWP approved the new management options.

In late October 1991 the valve was opened and WOSL drained throughout the winter. By January 1992 water levels were low enough for a public fish salvage. The salvage rescinded length and creel regulations and allowed snagging and seining to prevent fish from being wasted. Hundreds of channel catfish, crappie, and walleye were removed by anglers during the salvage (Jirak 1992). Several thousand common carp remained in the undrained portion of the lake basin (Jirak unpubl. data 1992).

On 29 January 1992 the valve was closed and 60 gallons of rotenone was applied to the lake and watershed (Jirak 1992). WOSL refilled to about 12 ha by April 1992. Restocking of the lake began and continued throughout the summer (Table 2). Brush piles were placed at various locations in the lake, and part of the dry lake bottom was seeded to oats in 1992 (Jirak 1992).

In 1992, an intensive fishery management plan that focused on OSY was

Table 2. Initial and supplemental stocking records from WOSL 1992-1998.

Date	Species	Size	Number Stocked	Number/Hectare
01 Apr. 1992	Fathead Minnows	Adults	227 kg	24.9 kg
15 Apr. 1992	Redear Sunfish	1102/kg	9000	123.5
26 Apr. 1992	Channel Catfish	14.3/kg	10000	137.2
26 May 1992	Walleye	2,506/kg	1815	24.9
10 June 1992	Smallmouth Bass	1,433/kg	500	6.9
25 June 1992	Wipers	2,672/kg	2545	34.9
01 July 1992	Largemouth Bass	1,102/kg	1900	26.1
27 Aug. 1992	Black Crappie	132/kg	4000	54.9
10 Sept. 1992	Bluegill	1,102/kg	18000	246.9
28 Sept. 1994	Wiper	11/kg	1814	24.9
18 May 1995	Channel Catfish	2.4/kg	2430	33.3
04 July 1995	Gizzard Shad	0.8-1.3cm	200	2.7
14 Sept. 1995	Channel Catfish	6.4/kg	3600	49.4
26 Sept. 1995	Wiper	16.0/kg	916	12.6
28 Feb. 1996	Channel Catfish	5.2/kg	206	2.8
17 Sept. 1996	Channel Catfish	5.5/kg	4502	61.8
01 Oct. 1997	Wiper	11.4/kg	914	12.5
14 Oct. 1997	Channel Catfish	5.3/kg	4000	54.9
16 Sept. 1998	Wiper	10.9/kg	922	12.6
30 Sept. 1998	Walleye	5.3/kg	882	12.1
14 Oct. 1998	Channel Catfish	2.6/kg	4500	61.7

implemented at WOSL. The objective of the new management was to create a fishery that emphasized both quality and quantity. Many tools were used to achieve this task, including selective harvest regulations (Table 3), a feeding program, adjusted stocking procedures, and enforcement of the regulations. This is a put-grow-take system that 1) allows fish to mature before they are harvested, and 2) increases catch and release recreation. Four DF-1 automatic Sweeney fish feeders were placed on WOSL in 1992. Feeding rates were 55.7kg/ha in 1992-93, 111.4kg/ha in 1994-96, 139.2kg/ha in 1997, and 144.8kg/ha in 1998. Fish feed was commercial floating and sinking feed with 28-32% protein content. Feeders operated from mid-April through October each year.

As mentioned earlier, I used data collected by traditional fisheries management practices for my research. Baker et al. (1993) stated that firsthand information on the status of the fish community is necessary to evaluate fisheries problems and the effectiveness of management programs. The methods used to collect data were spring electrofishing, fall gill netting, and fall trap netting. These sampling techniques are widely used in fisheries research and management (Hubert 1996). Technology made electrofishing and gill netting equipment more efficient in the time between the 1980-83 and 1995-98 sampling periods. Therefore, no analysis of catch per effort (CPE) was made.

FIELD METHODS:

Mosher and Willis (1997) described fish survey techniques for small Kansas lakes. Electrofishing involves the use of electricity to immobilize fish, which are then captured by dip nets (Baker et al. 1993; Reynolds 1996). Baker et al. (1993) and

Table 3. Selective harvest regulations at WOSL for 1994-1998.

Common Name	Minimum Length (mm)	Creel Limit Per Day
Black Crappie	254	10
Bluegill	none	none
Channel Catfish	406*	2
Largemouth Bass	457**	2
Walleye	457	2

* Changed to 381 mm minimum length limit in 1998.
** Changed to 330 mm to 457 mm slot length limit in 1995.

Reynolds (1996) stated that the art of effective electrofishing is selecting the best current type (usually pulsed DC) that captures the greatest number of fish with the least injury or mortality, given the specific environmental conditions in the field. Because of the physical limitations of the electrical field, electrofishing is effective only in relatively shallow water (less than 3.7m) (Baker et al. 1993). Fish that inhabit littoral areas in lakes are more vulnerable to capture than are pelagic or benthic species. Predators and spawners might be more vulnerable than other fish to electrofishing, not only because of their large size but also because their territorial behavior makes them less likely to avoid an oncoming electrofishing operation (Reynolds 1996).

In Kansas, largemouth bass and bluegill are sampled by electrofishing for management monitoring purposes (Mosher and Willis 1997). Electrofishing was conducted at WOSL in the spring of each year when water temperatures were approximately 15-18 degrees Celsius. Largemouth bass and bluegill inhabit the shallows of the shoreline during this time, making them vulnerable to capture by electrofishing. Other species of fish were also collected, but in smaller quantities. Captured fish were measured (total length) to the nearest millimeter, weighed to the nearest gram, and the data were recorded. Mortality incurred from electrofishing is extremely low.

During the 1980-83 spring samples, the department made electrofishing boat was mounted with a 240 volt, 2400-4000 watt generator, and the current was rectified to give 220-250 volts DC current with 5-10 amps of power to boom-mounted electrodes (Mosher and Willis 1997). The 1995-98 electrofishing samples were taken with a Smith Root (model SR-18) electrofishing boat. The current was 6-8 amps pulsed 60 times per second. Mosher et al. (1989) showed that the Smith Root boat was significantly more effective than the department-made boat in water greater than one meter deep. Although the technological advancements have increased the efficiency of the electrofishing procedure, it did not affect this study. This study focused on changes in fish quality, not on CPE. Sample sizes varied but were sufficient for insight into bluegill and largemouth bass populations. Effort varied somewhat from year to year.

Gill nets were generally fished as a single-layer web wall and depend on fish to become entangled for capture (Baker et al. 1993). During the 1980-83 fall samples experimental monofilament gill nets of multiple panels were used. Each panel consisted of different mesh size and were used along with standard gill nets of one mesh size (Table 4). Gill nets were set at standard locations each year. The 1995-98 fall samples used all standard and comparable sizes of gill nets (Table 5). These were monofilament gill nets with a foam-core float line and lead-core lead line. A 100' by 8' with 4-inch mesh was also used in the 1995-98 sampling. Data collected from this net was disregarded during analyses because the 1980-83 sampling did not include this large mesh size (leaving no opportunity to sample larger sizes of fish).

Gill netting took place in the fall of each year. Gill nets sampled fish that were not collected effectively by electrofishing or trap netting, and were used when water temperatures were approximately 11-13 degrees Celsius. Catch data for black crappie, channel catfish, and walleye were used in the study in lieu of this method. Nets were set overnight, then retrieved with the captured fish in the morning. Fish were removed,

Table 4. Sampling procedures at WOSL, 1980-83.

Date	Gear	Size	Effort
7 May 1980	Electrofisher	220v DC	1.4 hours
21 & 22 Oct. 1980	Gill Net	100'x8'x1"	2NN
	Gill Net	100'x8'x1.5"	2NN
	Gill Net	100'x8'x2.5"	2NN
	Gill Net	180'x6'x1,1.5,2,2.5,3,3.5"	2NN
	Mod. Fyke Trap	1/2" mesh	4TNN
14 May 1981	Electrofisher	220v DC	3.0 hours
28 & 29 Oct. 1981	Gill Net	100'x8'x1"	2NN
	Gill Net	100'x8'x1.5"	2NN
	Gill Net	100'x8'x2.5"	2NN
	Gill Net	180'x6'x1,1.5,2,2.5,3,3.5"	2NN
	Mod. Fyke Trap	1/2" mesh	4TNN
18 May 1982	Electrofisher	220v DC	2.3 hours
19 & 21 Oct. 1982	Gill Net	100'x8'x1"	2NN
	Gill Net	100'x8'x1.5"	2NN
	Gill Net	100'x8'x2.5"	2NN
	Gill Net	180'x6'x1,1.5,2,2.5,3,3.5"	2NN
	Mod. Fyke Trap	1/2" mesh	4TNN
1 June 1983	Electrofisher	220v DC	2.4 hours
25 & 26 Oct. 1983	Gill Net	100'x8'x1"	2NN
	Gill Net	100'x8'x1.5"	2NN
	Gill Net	100'x8'x2.5"	2NN
	Gill Net	180'x6'x1,1.5,2,2.5,3,3.5"	2NN
	Mod. Fyke Trap	1/2" mesh	4TNN

NN = Net Nights.
TNN = Trap Net Nights.

Table 5. Sampling procedures at WOSL, 1995-98.

Date	Gear	Size	Effort
16 May 1995	Smith Root 220v DC	6-8 amps	1.10 hours
20 Sept. 1995	Gill Net	100' x 8' x 1"	1 NN
	Gill Net	100' x 8' x 1-1/2"	1 NN
	Gill Net	100' x 8' x 2-1/2"	1 NN
	Mod. Fyke Trap	1/2" mesh	2 TNN
13 May 1996	Smith Root 220v	6-8 amps	1.06 hours
9 Oct. 1996	Gill Net	100' x 8' x 1"	1 NN
	Gill Net	100' x 8' x 1-1/2"	1 NN
	Gill Net	100' x 8' x 2-1/2"	1 NN
	Mod. Fyke Trap	1/2" mesh	2 TNN
19 May 1997	Smith Root 220v	6-8 amps	1.07 hours
26 Sept. 1997	Gill Net	100' x 8' x 1"	1 NN
	Gill Net	100' x 8' x 1-1/2"	1 NN
	Gill Net	100' x 8' x 2-1/2"	1 NN
	Mod. Fyke Trap	1/2" mesh	2 TNN
07 May 1998	Smith Root 220v	6-8 amps	0.57 hours
09 Sept. 1998	Gill Net	100' x 8' x 1"	1 NN
	Gill Net	100' x 8' x 1-1/2"	1 NN
	Gill Net	100' x 8' x 2-1/2"	1 NN
	Mod. Fyke Trap	1/2" mesh	2 TNN

NN = Net Nights.
TNN = Trap Net Nights.

weighed, measured, and data were recorded using the same techniques used in electrofishing.

Advancements in construction of gill nets occurred between the two test periods, and therefore no CPE comparisons were made. Mesh sizes of nets vary, so sizes of fish captured vary according to net size, giving data about all sizes of fish in the population. However, gill nets have one disadvantage in that they generally result in death of all or most of the fish caught (Baker et al. 1993).

Frame nets (Modified Fyke Traps) were used concurrently during the fall gill-netting procedure. Frame nets were 1.2 m high by 1.5 m wide with 25 mm galvanized conduit frames with a 6 mm hot rolled steel hoop for connection to the hoop net (Mosher and Willis 1997). Webbing consisted of one-half inch bar mesh of size 9 multi-filament nylon that was tarcoated for durability. Frame nets were used in addition to gill nets for sampling black crappie. The frame nets were placed at standard locations for the same time period as the gill nets. Fish data were collected as described earlier. Mortality with these nets is less than when gill nets are used.

CREEL CENSUS

A creel survey provides valuable data on angler demands and fish harvest (Mosher and Willis 1997) and creel census information from 1979, 1980, 1994, and 1995 was used in this study. The 1979 and 1994 censuses were conducted from May through October. During 1980 and 1995 the creel censuses were conducted from April to October. Statistical analyses were not performed on the creel census data. Creel census information was used to support the results of the W_r and weight analysis. Over the years, creel census procedure has changed slightly. Prior to 1981, creel census information did not include fish released and included a post-sunset survey period. Thus, information from the creel surveys were used to reinforce and support other findings.

In Kansas, the generic creel survey employs a randomly-stratified sample scheme. Sampling efforts consist of two-hour survey periods organized to reflect gross variations in user patterns influenced by month, time of week (week days or weekend days/holidays), and time of day (morning, midday, and evening) (Mosher and Willis 1997). Anglers actively fishing from shore and boats are counted at the beginning and at the end of each sample period; these counts are recorded as instantaneous (Mosher and Willis 1997). Total angling pressure (hours of angling effort) is estimated from the mean number of anglers per count (Mosher and Willis 1997). The fishing pressure exerted on weekdays and weekend days/holidays are independently calculated (Mosher and Willis 1997). High angler-use months (April, May, and June) were sampled more often than light-use months (March, July, August, September, and October). High-use months received 36 hours of sampling time per month per unit, whereas light-use months received 24 hours of sampling time per month per unit (Mosher and Willis 1997).

ANALYSES

Original catch data for each of the four years from the sampling periods 1980-1983 and 1995-1998 were compared for the five fish species present in each period. Combined data for the four-year periods were compared as a whole. A two-way analysis of variance (ANOVA) was performed for W_r and weight of each species using the SAS program (SAS, 1990). Because of the limitations of the available data and the multiple two-way ANOVAs, a Bonferonii correction was used to ensure a conservative analysis. The Bonferonii correction lowers the significance level to reduce the chance of falsely rejecting the null hypothesis.

Significance levels were $P \geq 0.005$ for all tests after the Bonferonii correction. Standard weight equations from Murphy et al. (1991) were used to calculate W_r for each species using the Aquatic Data Analysis System (ADAS) program (Hartmann and Mosher 1978). No attempt was made to test any of the independent variables (feeding, stocking, regulations, etc.) between the two management schemes. The two management approaches were examined as a whole. This study examined changes in fish quality for each management plan. Quality was defined by length and weight relationships; an overall larger size with better body condition is most desirable.

RESULTS

The assumption was made that the five populations were the same throughout the lake, because the management strategy in Kansas is based upon the premise that electrofishing and test-netting samples taken randomly around the lake are representative of the populations that exist in the lake as a whole (Berger 1982). Comparisons of W_r and weight were made to distinguish changes in fish quality during each management plan. Because W_r is only an indicator of body condition, weight comparisons were used to clarify any change in quality. Total length, weight, and W_r ranges for the 1980-1983 and 1995-1998 combined samples of the five species compared at WOSL are presented in Table 6. Sample size for each period is shown in Table 7.

Comparison of W_r values for black crappie, bluegill, channel catfish, largemouth bass, and walleye were made. The 1980-1983 data represent the management imposed in the 1977 plan and the 1995-1998 data reflects management for the 1992 management plan. The W_r data for each period (1980-1983 and 1995-1998) were tested for each of the five species. A significant difference was observed in W_r values for all five species. Black crappie, bluegill, channel catfish, and largemouth bass showed significantly higher W_r values during the 1995-1998 samples. However, walleye W_r values were significantly higher in the 1980-1983 samples. Figure 1 represents the mean W_r values for the five species during each period.

Weight comparisons were done following the same procedure as described above for W_r. Weight was significantly higher for bluegill and largemouth bass in the 1995-1998 samples. Walleye weight was significantly higher in the 1980-1983 samples. No

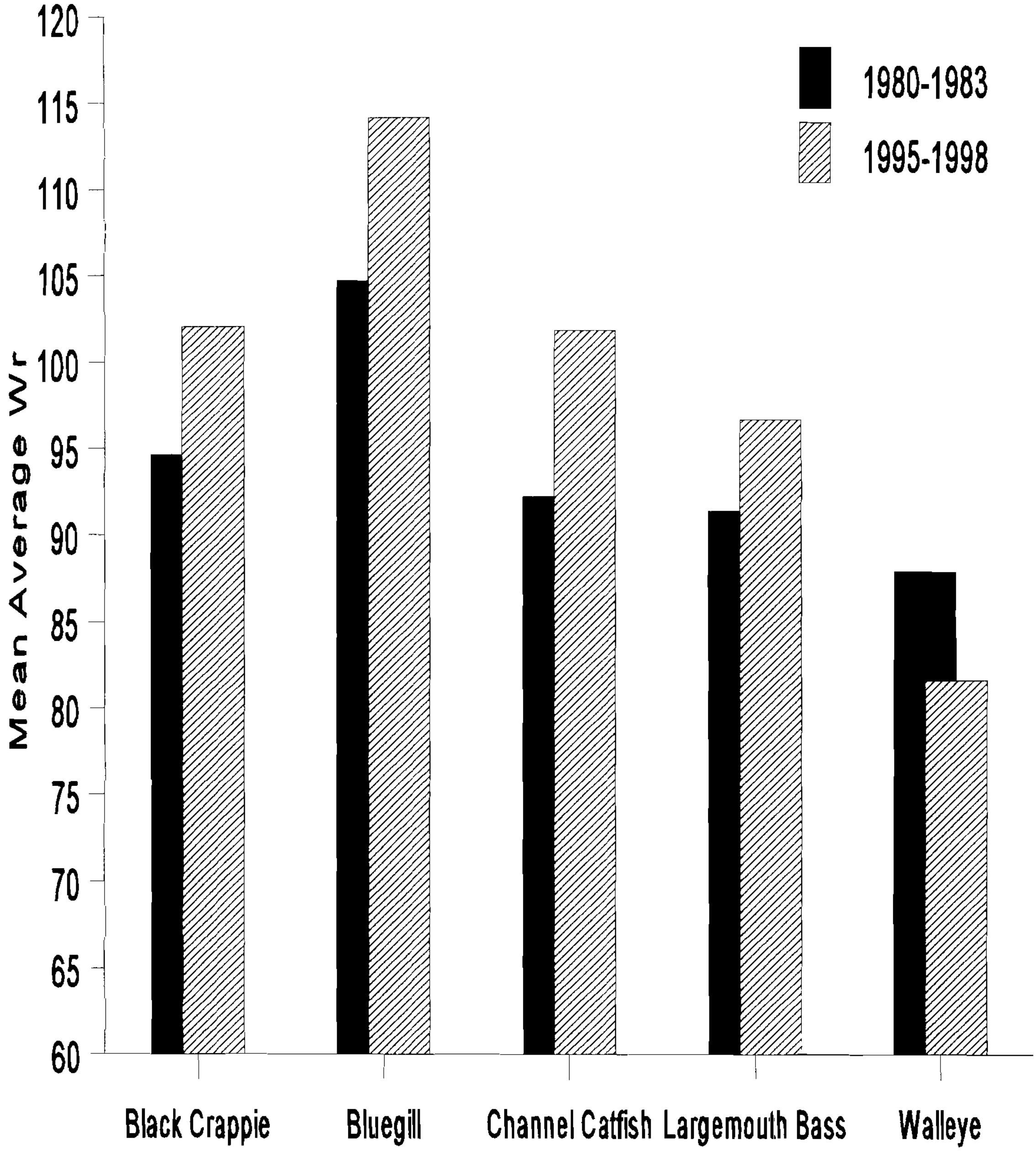
Table 6. Total length, weight, and W_r ranges for combined samples at WOSL for sampling periods 1980-1983 and 1995-1998.

	Total Length (mm)		Weight (g)		W_r	
Common Name	1980-83	1995-98	1980-83	1995-98	1980-83	1995-98
Black Crappie	155-340	145-310	50-950	42-460	66-147	88-124
Bluegill	100-235	110-223	20-240	29-289	64-134	90-146
Channel Catfish	232-770	220-830	90-5150	98-8853	68-127	73-151
Largemouth Bass	158-490	150-460	50-1950	40-1500	62-143	69-144
Walleye	225-630	260-450	105-2700	150-693	68-122	66-99

Table 7. Sample sizes for each species for 1980-1983 and 1995-1998 sampling periods.

Year	Black Crappie	Bluegill	Channel Catfish	Largemouth Bass	Walleye
1980	110	34	31	103	48
1981	13	25	32	42	64
1982	53	36	31	48	43
1983	37	33	28	77	47
1995	3	42	26	60	7
1996	8	19	15	79	8
1997	19	36	19	115	12
1998	9	13	19	75	21

Figure 1. Mean W_r comparisons at WOSL.


120
115
110
105
100
95
90
85
80
75
70
65
60
Mean Average Wr
1980-1983
1995-1998
Black Crappie
Bluegill
Channel Catfish
Largemouth Bass
Walleye

significant difference was observed in black crappie and channel catfish. Figure 2 represents mean weight values for the five species during each sampling period.

Creel census harvest data for 1979 and 1980 (79-80) and 1994 and 1995 (94-95), the first two years after opening were averaged for the following comparisons. Total black crappie harvest increased from 342 (79-80) to 654 (94-95). Black crappie harvest also shows an increase in average size from 0.190 kg (79-80) to 0.301 kg (94-95). Harvest of bluegill increased from 2,867 (79-80) to 4,175 (94-95). Average bluegill size also increased from 0.075 kg (79-80) to 0.145 kg (94-95). Channel catfish harvest increased greatly from 2,216 (79-80) to 4,175 (94-95). More channel catfish were harvested in 1994 (3,036) than 1979 and 1980 combined. Average channel catfish size increased from 0.518 kg (79-80) to 1.532 kg (94-95). Harvest of largemouth bass showed a large decrease from 1,578 (79-80) to 127 (94-95). Average largemouth bass size was 0.837 kg (79-80) and 0.748 kg (94-95). Walleye harvest also showed a large decrease from 1,068 (79-80) to 73 (94-95). However, average walleye size increased from 0.509 kg (79-80) to 1.274 kg (94-95).

Total harvest of these five species was 8,071 (79-80) and 9,141 (94-95), representing only a small difference by total number. However, combined total weight increased dramatically from 3,293 kg (79-80) to 7,289 kg (94-95). Combined average size almost doubled from 0.408 kg (79-80) to 0.797 kg (94-95). Computed hours of effort from creel census at WOSL were 33,116 in 1979, 16,213 in 1980, 26,861 in 1994, and 24,967 in 1995. Angler effort indicates that quality fishing was sustained during 1995 with only a slight decline in effort. Additional harvest information is presented in

Figure 2. Mean weight comparisons at WOSL.

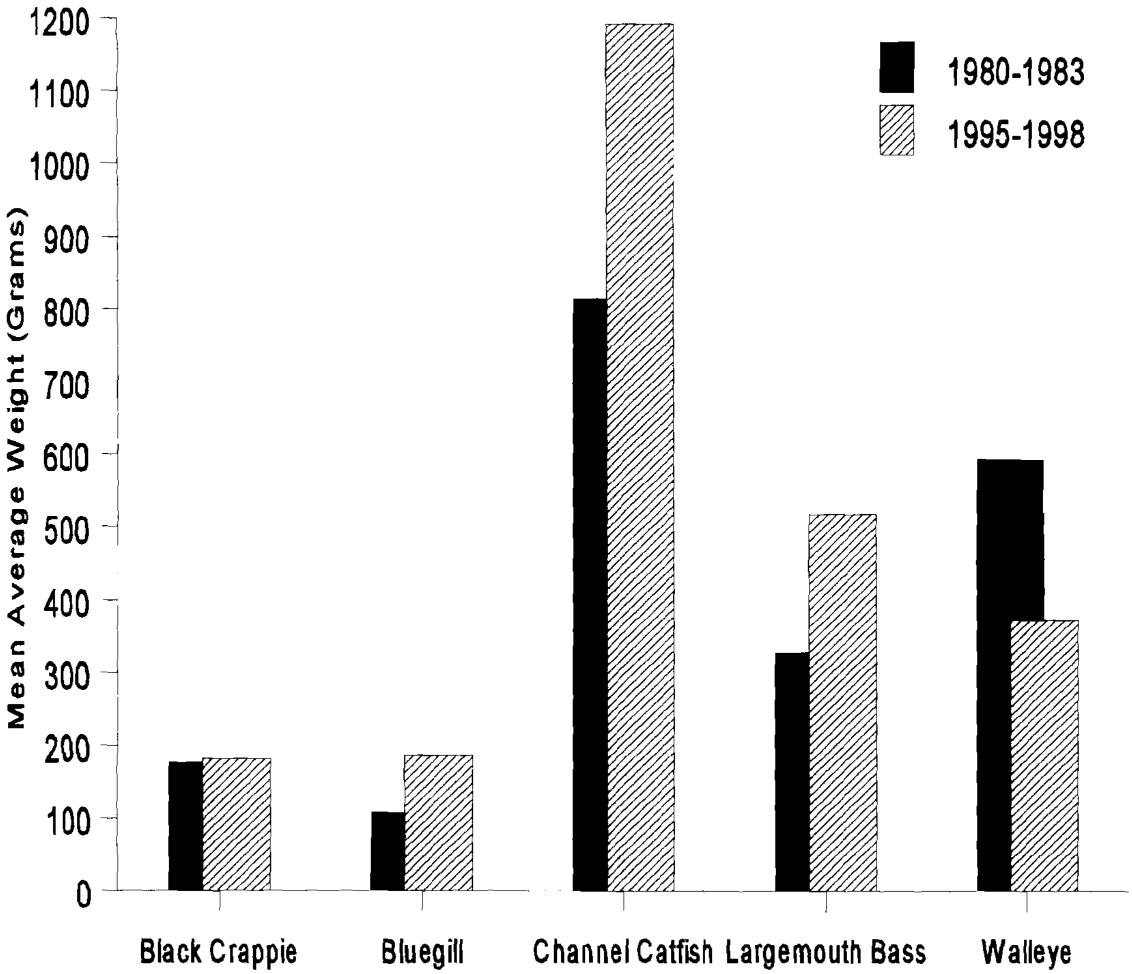

1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Mean Average Weight (Grams)
1980-1983
1995-1998
Black Crappie
Bluegill
Channel Catfish
Largemouth Bass
Walleye

Table 8 for the first years (1979 and 1994) after opening, and Table 9 for the second years (1980 and 1995).

Table 8. Computed total harvest at WOSL, 1979 and 1994 (first year open after renovation).

	Total Harvest		Total Weight (kg)		Average Size (kg)	
Common Name	1979	1994	1979	1994	1979	1994
Bluegill	1085	2934	73	389	0.07	0.13
Black Crappie	96	225	11	61	0.11	0.27
Channel Catfish	1271	3036	802	4403	0.63	1.45
Largemouth Bass	457	16	472	25	1.03	1.56
Walleye	546	68	246	86	0.45	1.26
Total	3455	6279	1604	4965	0.46	0.79
% Grand Total*	85%	76%	97%	95%		

*Grand total of all species harvested from creel census.

Table 9. Computed total harvest at WOSL, 1980 and 1995 (second year open after renovation).

	Total Harvest		Total Weight (kg)		Average Size (kg)	
Common Name	1980	1995	1980	1995	1980	1995
Bluegill	1,782	1,241	143	216	0.08	0.17
Black Crappie	246	429	54	136	0.22	0.32
Channel Catfish	945	1,076	345	1,895	0.37	1.76
Largemouth Bass	1,121	111	849	70	0.76	0.63
Walleye	522	5	298	7	0.57	1.40
Total	4,616	2,862	1,689	2,324	0.37	0.81
% Grand Total*	92%	66%	97%	88%		

*Grand total is all species harvested as shown in creel census.

DISCUSSION

The goal of this study was to compare fish quality during two periods using different fishery management plans. I expected an increase in fish quality during the 1992 management, and overall, the findings supported the expectations. W_r improved significantly in four of five species compared, increasing under the 1992 management plan. Weight increased significantly in two species for the 1992 management period, two were not significant, and one significantly increased in the 1977 management period. However, total harvest by weight during 1994-95 was more than double that of 1979-80, with about the same amount of fishing pressure. Two distinct differences occurred in management during the two study periods that suggest potential reasons for the changes in quality. These differences were: 1) selective harvest regulations and 2) supplemental feeding.

Selective harvest regulations are very important in managing recreational fisheries. Many fish stocks are depleted and their capacity to support an active fishery is limited because harvest is not effectively regulated (Ross 1997). Regulations protect fish from over-harvest, increase catch and release (adding to the recreational value), and protect predators that are needed to control panfish and forage populations. Size limits applied to recreational fisheries have proven effective in many recreational fishing settings (Ross 1997). Redmond (1986) showed that 69% of the available bass were harvested from one new reservoir during the first four days of fishing.

Supplemental feeding programs are relatively new in fisheries management. Channel catfish and bluegill both readily feed on commercial fish food. Berger (1982) found that supplemental feeding of bluegill can significantly increase size and condition of bluegill. Feeding also increases the carrying capacity of channel catfish, allowing for higher stocking rates. This is shown by the increased stocking from 4,000 in 1977 to 10,000 in 1992. Even with the higher stocking rate and smaller size of fish stocked in 1992 (compared to 1977), channel catfish increased in W_r and doubled in the average size at harvest.

The increase in quality of bluegills was likely due to predatory harvest regulations and the supplemental feeding program (Berger 1982). Novinger and Legler (1978) stated that largemouth bass can provide adequate bluegill mortality when satisfactory density and structure of bass populations are maintained. Total harvest and average size of bluegill increased in 1992, but largemouth bass harvest decreased and average size increased in 1992, showing the effects of the selective regulations. Gablehouse (1984) showed that density of 200 mm and longer bluegills actually increased after the implementation of a slot length limit in a Kansas pond. The increase in largemouth W_r and weight during the 1992 management likely resulted from selective harvest regulations.

Black crappie increased in W_r, average size harvested, and total harvest during the 1992 management. Selective harvest regulations on the predator fish and on black crappie were the likely causes for the observed changes. Predation plays a very important role in controlling crappie populations, minimum length limits allow fish to grow to quality size, and reduced creel limits spread the harvest over a longer period.

Walleye was the only species of fish that had significantly higher W_r values and weights in the 1977 management plan. However, this might be biased because of heavy stocking of wipers (Morone chrysops x saxatilis) in the 1992 management plan and retention of more largemouth bass because of the selective regulations . Walleye harvest data showed a large decrease in harvest for the 1992 management period because few were above the length limit during the creel census in 1994 and 1995. Both of these fish are pelagic predators and competition for food probably played a role in the change in quality.

This research does not provide a definitive ideal way of managing small warm-water fisheries. It does, however, support many important aspects of managing small, warmwater fisheries. Fisheries that have quality fishing are very valuable for recreation and economies . Because of changes occurring in management during both periods, pinpointing the cause of observed changes was not possible. Rather, it was likely a combination of all management tools together. It was my intention to provide a look at management as a whole, not each piece of the puzzle. Further detailed study is needed to clarify the effects of different management strategies. It is my contention that a quality fishery can be achieved through selective harvest regulations and supplemental feeding programs. Future research should be done to compare these management plans further to see if quality is sustainable over time.

This study has shown the potential exists to increase fish quality through the use of supplemental feeding, selective length and creel limits, and stocking rate adjustments. Unfortunately, applying all of these techniques at once inhibited the ability to determine which techniques were producing the desired results. Future research should focus on testing individual aspects of this management plan and will require either more years of data or more lakes evaluated to reduce the variability within the samples.

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Fish Quality Changes Under Two Fisheries Management Plans

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