REVIEW AND SUMMARY OF THE LAKE SHARPE FISHERY

Prepared for the Lower Brule Sioux Tribe

by Robert J. Behnke

May, 1995

ABSTRACT

Lake Sharpe is one in a series of upper Missouri River multi-purpose reservoirs. It was created in 1963 and during the early years rapid changes in the fish fauna occurred, resulting in virtual complete dominance by walleye (Stizostedion vitreum) which has persisted to the present. All attempts to diversify the species composition and abundance of other fish species by stocking and habitat manipulation have failed to alter the complete dominance by walleye. The walleye population of Lake Sharpe is self-perpetuated and self-regulated. It has apparently attained a steady-state dominance, immune to any fisheries management method used to date, to modify its dominance.

INTRODUCTION

Lake Sharpe, South Dakota, is one of a series of mainstem Missouri River reservoirs constructed by the U.S. Corps of Engineers. The dam impounding Lake Sharpe was completed in 1963. The lake covers 56,000 surface acres and receives flow released from Lake Oahe (375,000 surface acres, completed 1958). The relatively cold water and large volume flow from Oahe determines the environmental conditions in Lake Sharpe. An important environmental feature is that Lake Sharpe does not stratify during the summer into a warm epilimnion, a transitional thermocline, and a cold hypolimnion, typical of a lake of this size. The significance of the absence of thermal stratification is that different fish species do not segregate by temperature preference. Predator species such as walleye can utilize the entire lake volume (max. depth 70 ft.) and prey species do not have ready access to refuge habitat to avoid predation. Lake Sharpe was the only upper Missouri reservoir which had considerable amounts of rocky-rubble shore area when the reservoir was filled--rocky-rubble substrate is the typical habitat used by walleye for spawning. Lake Sharpe also is lacking in shallow, vegetated bays and backwaters--the type of habitat preferred by most other fishes such as bass, bluegills, crappie, pike, yellow perch, etc. for spawning and early juvenile rearing. Lake Sharpe is also somewhat unique among the upper Missouri reservoirs in that its water level is stable. Annual fluctuations are only one to two feet.

The water from Lake Sharpe flows into Lake Francis Case (filled in 1953, 86,000 surface acres at normal pool, can be filled to 120,000 acres for surplus storage and flood control). Although Lake Francis Case is larger and has greater fluctuation in water level, it has a somewhat similar environment and walleye also became completely dominant in the fishery of Lake Francis Case.

During the early years, fisheries research in the upper Missouri reservoirs was conducted by the North Central Reservoir Investigations of the U.S. Fish and Wildlife Service. The involvement of the USFWS in research and management officially ended in 1977. Since then, South Dakota Department of Game, Fish, and Parks has been in charge of the fisheries management of Lakes Oahe, Sharpe, and Francis Case, but federal hatcheries continued to provide fish for stocking and state-federal cost sharing projects with the Corps of Engineers and federal aid (formerly Dingel-Johnson, now Wallop-Breaux funds) administered by the USFWS has continued some federal involvement in fisheries management.

My assessment of the Lake Sharpe fishery is based on about 100 publications and reports produced by USFWS and SDGFP biologists (numbered exhibits). For the theoretical basis to attempt to understand "why" types of questions concerning why walleye became and remained completely dominant in the Lake Sharpe fishery--the "scientific basis"--I refer to such literature as Kerfoot and Sih (1987), Opusznski and Shireman (1995), Hall and Van Den Avyle (1986), Giller et al. (1994), and Clepper (1979). These publications are typical of literature used in my fisheries-limnology graduate seminar where students and faculty discuss theoretical aspects of the determinants of structure, functioning, and processes of aquatic ecosystems.

FISH FAUNAL CHANGES

After impoundment of Lake Sharpe in 1963, walleye rapidly increased in abundance to become the dominant fish species by 1970, and its dominant position has been maintained since then. Before impoundment in the Missouri River segment that was to become Lake Sharpe, the sauger (Stizostedion canadense), a close relative of the walleye, was the most abundant top level predator. Nelson and Walberg (1977) presented catch estimates for the fishery in the Lake Oahe tailwaters during 1960-63 (before Lake Sharpe was created). The annual catch of sauger, before impoundment, ranged from 27,085 to 58,565 and walleye catches ranged from 3,782 to 5,553. The sauger averaged about 10 times more abundant than walleye before impoundment, which reflects the fact that the sauger is more specialized, better adapted for life in large rivers than walleye which is a lake-adapted species. Ten years after impoundment, during the 1973-74 angling year, the sauger catch was 529 in the Oahe tailwater section of Lake Sharpe and 1,222 in the lake itself (total sauger catch 1,751); the 1973-74 walleye catch was 11,599 in tailwater section and 59,317 in lake (total of 70,916 walleye--walleye-sauger ratio changed from 1:10 to 40:1 during first 10 years). After 1974, sauger essentially disappeared as an important component of the Lake Sharpe fishery. The 1976-77 tailwater fishery creel census recorded no sauger in the catch.

Benson (1980) rated 14 fish species in relation to the degree they were affected by impoundment. Only walleye was favorably affected by a dramatic increase in abundance. This was demonstrated by data from net samples over time. The catch per unit of effort (catch per net set) for adult walleye in Lake Sharpe, was 4.8 in 1965. During the five year period of 1970-74, the walleye catch per effort ranged from 23 to 31.2, averaging 27--more than a five-fold increase occurred between 1965 and 1970.

This rapid increase in walleye abundance led to a decrease in growth rate (many more walleye must share an essentially unchanging food supply--there is less food available per individual walleye). An undated paper (unpublished manuscript?) by J. E. Elrod and F. C. June titled "Biology of the walleye (Stizostedion vitrieum) in Lake Sharpe, South Dakota" (exhibit 54), contains the most comprehensive data on Lake Sharpe walleye. Their data show that in 1964-65, walleye in Lake Sharpe (at relatively low abundance) attained a size of 16 inches after three years. During 1970-75, at high abundance, it took five years for the average walleye to grow to 16 inches. Elrod and June made the only attempt, of which I am aware, to estimate the total population of "catchable" size walleye in Lake Sharpe (fish of 12 inches and larger). In 1973 they estimated between 153,000 to 473,000 (best guessimate 196,000) catchable size walleye were in Lake Sharpe. The catch that year was estimated to be 71,000 (weighing about 78,000 pounds).

Concerns were expressed about the forage fish base to maintain the walleye population in Lake Sharpe (after the first year of life, the walleye diet is virtually 100% fish). Benson (1968) listed 60 species of fish recorded from upper Missouri reservoirs--potential species to inhabit Lake Sharpe. Annual net sampling of the fish fauna in Lake Sharpe (1970s-1980s) list 21 species but walleye were consistently dominant, especially by weight. Over several years, sampling in various reservoir areas typically found walleye to make up 30 to 60% of the weight of all species. No more than one other species, such as carp, sturgeon, or channel catfish, made up 10% or more of the total weight in the numerous net samples. Obviously, walleye had assumed dominance by 1970 and maintained this dominance thereafter. The reasons for this are assumed to be the favorable spawning conditions for walleye and the large generations produced each year exert intense predation pressure, limiting the abundance of other species. In any event, the walleye fishery became self-regulating, completely dominant, and essentially immune to any management action to diversify the fishery.

MANAGEMENT

In the early years, management activities consisted mainly of stocking a variety of species such as largemouth and smallmouth bass, northern pike, etc. in hopes they would become established in Lake Sharpe. Particular heavy stocking of trout and salmon (millions of fish of several different species and sizes) were made in the Oahe tailwater section of Lake Sharpe in an attempt to diversify the fishery. These stockings failed to change the dominance of walleye. The trout and salmon stocking contributed to the food supply of walleye in Lake Sharpe. A South

Dakota GFP report on stocking the Oahe tailwaters (exhibit 34) contains the results of a 1976 stocking of 115,000 rainbow trout (3-5 inches) in the tailwaters which produced a catch of 36 trout to anglers--a return of about three trout per 10,000 stocked. The report presumed the "unaccountable" loss was due to "heavy predation". A similar fate met 235,000 rainbow and brown trout stocked in the Lake Sharpe tailwaters of Lake Francis Case in 1968 (where walleye also were dominant). Not one of the 235,000 trout was found during subsequent intensive sampling by gill nets, seines, and trawls. The stocking of many millions of trout and salmon over many years can be considered as an expensive experiment for feeding walleye.

Exhibits 11, 12, and 14 are designs for three "fish rearing subimpoundments" (Medicine Knoll Creek, Chapelle Creek, and Big Bend Dam) whose purpose was to create shallow bays-backwaters conducive for spawning and rearing of young of such species as bass, crappie, and northern pike. The subimpoundment projects are cost-sharing projects between the Corps of Engineers and South Dakota G.F.P.

None of the reports presently available to me indicate any beneficial results from creation of fish rearing habitat, and personal communication with Dennis Unkenholz, SDGFP, in 1992, confirmed that no evident changes had occurred in relation to the complete dominance of walleye in the Lake Sharpe fishery.

Since walleye became the dominant species by 1970, they have continued to maintain their dominance and have defied all attempts to diversity the Lake Sharpe fishery. The walleye population is self-regulating, essentially on "autopilot" in no need of management actions except for regulations on season and catch limits designed to maintain adequate spawning stocks.

Many North American walleye fisheries benefit from special size limits--for example, only fish of 18 or 20 inches and larger may be legally kept by anglers. Such fisheries are characterized by walleye populations which are not the dominant species and which have abundant food for rapid growth. Such a regulation would not work for the Lake Sharpe walleye population, unless their growth rate vastly improved, comparable to the 1964-65 period, the first years of Lake Sharpe impoundment when walleye density was about 20% of the 1970 abundance. Thereafter, the abundance attained by walleye resulting in decreased growth rate, led to a population structure that relatively few fish exceed a size of 18 or 20 inches. Eliminating angler harvest of 12 to 18-20 inch walleye would only worsen growth by maximizing walleye density and, with a relatively constant food base, growth would further decline.

DISCUSSION

The walleye dominance of the diverse fish fauna of Lake Sharpe raises some interesting theoretical questions of trophic ecology and energetics--how one fish species becomes a "keystone" species. A keystone species influences how energy flows through an aquatic ecosystem and governs the population structure and abundance of other fishes, invertebrates and possibly even plant life of the system, by controlling the pathways of energy--in the case of walleye of Lake Sharpe, by intense predation on other fishes, regulating their abundance and the roles they play.

Basically, with bottom-line simplicity, all life in an ecosystem can be conceptually grouped into three boxes representing how an ecosystem functions. One box is labeled "producers", one "consumers", and one "decomposers"--the three "macro niches". Producers include all plant life, which by photosynthesis, creates all energy. Plants in aquatic ecosystems include phytoplankton (unicellular algae suspended in the water column), macrophytes (large, multicellular algae and higher vegetation), and algae attached to substrates (periphyton). The consumers can be broken down into primary consumers (herbivores or organisms feeding on plant life), and various second-third-fourth level consumers that feed higher on the hierarchy of trophic levels. For example, for the first few weeks of life, a one-two inch walleye fry is typically a secondary consumer, feeding on small herbivorous zooplankton and other small invertebrates such as detritivore midge larvae. With increasing size, walleye become third and fourth level consumers--a predator at the top of the food chain. When walleye feed on gizzard shad (a secondary consumer) they are feeding at third trophic level; when they prey on yellow perch (a secondary and tertiary consumer) walleye would be utilizing the third and fourth trophic levels. The interpretation of trophic levels relates to the fact that as energy moves from primary production (plants) through the food chain up through first, second, third, and fourth level animal consumers, a significant amount of energy is lost at each step of the food chain. For example, for every 1,000 calories of energy produced by plants only one or two calories might be incorporated into the bodies of third and fourth level consumers such as walleye.

Most of this lost energy is recycled by the decomposers releasing nutrients for plant life by breaking down waste products of living organisms, and decomposing dead plants and animals. Decomposers are mainly bacteria and fungi (functioning as they do in compost). Decomposers also create an additional source of food energy (bacteria are high in protein) which is utilized by detritivore feeding animals. Typically, detritivores are various species of insect larvae and crustaceans, but some fishes such as gizzard shad can extract energy by feeding on detritus (and digesting its associated bacteria).

Concerning the walleye dominance in Lake Sharpe in light of concepts of trophic ecology and energetics in aquatic systems, a paradox is evident. The paradox concerns the question: how can walleye maintain such a dominance (perhaps 30-50% of all fish biomass in Lake Sharpe) if it is so high on the trophic hierarchy? The walleye is at the apex of the trophic pyramid (envision a pyramid consisting of trophic layers, plants at the bottom, supporting four diminishing tiers representing 1-2-3-4 levels of consumers). Thus, if gizzard shad, yellow perch, and white bass were the main food of walleye in Lake Sharpe, the biomass of all of the most common prey species might be expected to be 10 times or more the biomass of the walleye population. Indeed, this high ratio of prey to predator is typical of lakes where walleye are much less dominant than they are in Lake Sharpe. In such lakes with high prey biomass, walleye have more rapid growth and attain larger maximum sizes than they do in Lake Sharpe.

The explanation of the paradox probably concerns production/biomass ratios (P/B). I suspect that most of the fish consumed by walleye are young-of-the-year (fish in their first year of life). For rapidly growing young-of-year fish, the P/B ratio is extremely high. For example, a gizzard shad at hatching might weigh one milligram. A few weeks later, it may grow to one gram, a 1000 fold increase in production. By the end of the growing season it may weigh 100 g -- an additional 100 fold increase from the time it weighed one gram. The rapid multiplication of growth by fish in their first year of life produces enormously high P/B ratios, which provides a great food supply to predators. The walleye, on the other hand, has a low P/B ratio, especially when they depend on a fish diet after their first year of life. A three year old walleye weighing one pound, may grow to 1.3 pounds in one year at age four which results in a P/B ration of 0.3. This is only a tiny fraction of the P/B ratio of young-of-the-year forage species which probably provide the bulk of the food to the walleye population, and would explain how such a high ratio of walleye to prey fishes has been maintained in Lake Sharpe. This intense predation on the young of other species, would also explain why the walleye is a "keystone" species in Lake Sharpe, determining the abundance of other species.

Walleye abundance in lakes where they are not as dominant as in Lake Sharpe, typically is determined by the prey species. For example, walleye growth and abundance in Oneida Lake, New York, is essentially determined by yellow perch. Trends in walleye abundance mirror trends in perch abundance (Mills et al. 1987).

I am personally familiar with the walleye population in Horsetooth Reservoir near Fort Collins, Colorado. Smelt were introduced as a forage fish to improve the growth of walleye. The smelt greatly increased in abundance and became the main food for walleye which exhibited a significant increased rate of growth. Walleye reproduction, however, was limited by the amount of spawning habitat and the walleye population could not keep up with smelt abundance. Intense predation of zooplankton by the abundant smelt reduced zooplankton density from 30 to 1 organism per liter in a few years. The newly hatched walleye could not find sufficient food (zooplankton) and they starved. There has been no recruitment of young in the walleye population in Horsetooth Reservoir since 1990. Here the prey species, smelt, became the keystone species determining walleye abundance by intense predation of zooplankton (this impact ramifies throughout the ecosystem affecting all trophic levels).

The above outline and examples illustrating the trophic-dynamic aspects of ecosystem functioning may help to conceptualize how and why the walleye became dominant in Lake Sharpe.. Unless major environmental changes greatly impair the reproductive success of walleye, this dominance is not likely to change and any management options also are not likely to change this "autopilot" dominance.

FUTURE MANAGEMENT

Many Native American tribes have active fisheries and recreation programs with considerable expertise which may be useful to assist developing and maximizing the economic benefits of recreation if the Lower Brule Tribe assumes jurisdiction for Lake Sharpe and its tailwaters in Lake Francis Case. As discussed, the Lake Sharpe fishery is driven by walleye which attracts anglers from long distances. Exhibit 3 of appendix concerns how regional economic benefits of a fishery are calculated. Of particular significance in comparing a tribal managed vs. state managed fishery concerns regional (or site-specific) economic impacts vs. state-wide impacts. On a state-wide basis, in regards to economics, it is the total number of recreational days that matter, not how they are distributed among different regions of the state. For a tribal managed fishery and recreational program it is the regional, site-specific (Lake Sharpe) fishery that is of paramount importance. Visitors attracted from long distances can be expected to spend several days in the region they are attracted to. Money will be spent on food, lodging, fuel, repairs, etc.

Opportunities should be looked for that can maximize the multiplier effect of economic benefits derived from a fishery attracting anglers from long distances.

REFERENCES

Benson, N. G. 1968. Review of fishery studies on Missouri River main stem reservoirs. U.S. Fish and Wildlife Service Research Rep. 71.

Benson, N.G. 1980. Effects of post-impoundment shore modifications on fish populations in Missouri River reservoirs. U.S. Fish and Wildlife Service Research Rep. 80.

Carline, R. F. 1986. Assessment of fish populations and measurements of angler harvest. Pages 46-56 in Hall and Van Den Avyle (1986).

Clepper, H. (editor). 1979. Predator-prey systems in fisheries management. Sport Fishing Inst., Wash. D.C.

Giller, P.S., A. G. Hildrew, and D. G. Raffaelli (editors). 1994. Aquatic ecology: scale, pattern and process. Blackwell Scientific Publications.

Hall, G. E. and M. J. Van Den Avyle (editors). 1986. Reservoir fisheries management strategies for the 80's. Am. Fish. Soc., Bethesda, MD.

Kerfoot, W. C. and A. Sih (editors). 1987. Predation: direct and indirect impacts on aquatic communities. Univ. Press of New England.

Mills, E. L., J. L. Forney, and K. J. Wagner. 1987. Fish predation and its cascading effect on the Oneida Lake food chain. Pages 118-132 in Kerfoot and Sih (1987).

Nelson, W. R. and C. H. Walburg. 1977. Population dynamics of yellow perch (Perca flavescens), sauger (Stizostedion canadense), and walleye (S. vitreum) in four mainstem. Missouri River reservoirs. Jour. Fish. Res. Bd. Canada 34(10):1748-1763.

Opuszynski, K. and J. V. Shireman. 1995. Herbivorous fishes: culture and use for weed management. Lewis Publishers.

Schorr, M.S. and four other authors. 1995. Regional economic impact of the Lake Texoma (Oklahoma-Texas) striped bass fishery. Fisheries 20(5):14-18.

APPENDIX

Exhibit 1. Qualifications: Curriculum vitae of Robert J. Behnke (enclosed).

Exhibit 2. Theoretical basis for understanding predator-prey relationships and walleye dominance in Lake Sharpe: Fisheries-Limnology seminar announcement and outlines of seminars presented on topic of predator-prey interactions (enclosed).

Exhibit 3. Copy of article from Fisheries 1995, Vol. 20, No. 5, concerning regional economic impacts of Lake Texoma fishery and implications for Lower Brule Sioux Tribe.

Compensation. My rate is $100.00 per hour which includes time for formal testimony. Payment should be made within 60 days of receipt of invoice. After 60 days, interest will be charged at rate of one percent per month on unpaid balance.

Cases in which I have testified as expert at trial or by deposition during past four years. To the best of my knowledge, my deposition for the Lower Brule Sioux Tribe vs. South Dakota is the only such testimony.

Questions to Discuss

1) What evidence is there for Sih's suggestion that "(if all else is equal) fixed morphological traits should be favored in a stable environment, whereas flexible behavioral responses to predators should be favored in variable conditions"?

2) To what extent are fugitive and stress-tolerant lifestyles shaped by anti-predator needs rather than simply being consequences of specialization to transient or stressful environments?

3) Does the lifestyle terminology and emphasis on behavior help one predict what will happen when new/novel introductions of predators/prey occur?

Additional References

Dodson, S. I. 1988. Cyclomorphosis in Daphnia galeata mendotae Birge and D. retrocurva Forbes as a predator-induced response. J. Freshwat. Biol. 19:109-114.

Grime, J. P. 1979. Plant strategies and vegetation processes. John Wiley & Sons, NY.

Hairston, N. G., F. E. Smith, and L. B. Slobodkin. 1960. Community structure, population control, and competition. Am. Nat. 94:421-425.

MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press. Princeton, NJ.

Stearns, S. C. 1976. Life-history tactics: a review of the ideas. Quart. Rev. Biol. 51:3-47.

Stearns, S. C. 1977. The evolution of life history traits: a critique of the theory and a review of the data. Ann. Rev. Ecol. Syst. 8:145-171.

Table 14.1. *Prey attributes that decrease predation risk and possible constraints associated with these traits*

Stage	Prey attribute	Possible constraint
ESCAPE AFTER ENCOUNTER		
Reduce probability of attack	Unpalatability	Cost of producing chemical
Reduce capture success	High speed of movement aided by deimatic and protean displays	Conflict between capacity for rapid and efficient movement
	Weapons for active defense	Conflict between optimal morphology for fighting vs. feeding
	Living in groups	Increased competition, intragroup aggression
Reduce handling success	Unwieldy size or shape	Conflict with optimal size or shape for feeding
AVOID ENCOUNTERS		
Reduce proximity to predators	Reduce activity, restrict activity in space or time	Slow life-style
	Use stressful habitats	Slow life-style
	Use ephemeral habitats	Fast life-style
Reduce probability of detection and recognition	Crypsis and reduced activity	Slow life-style

Department of Fishery and Wildlife Biology
College of Natural Resources

MEMORANDUM

June 14, 1995

To: Bob Behnke

From: Brett Johnson

Re: Lake Sharpe walleyes

I read your summary of the walleye "plague" in Lake Sharpe. What a problem to have to endure. We did the most a state could muster to enhance the walleye population in Lake Mendota with rather modest success.

I agree with your analysis of how the dominance of walleye may have come about. I've not seen the upper Missouri reservoirs but I know walleye have done well in some of the others in the chain. I'd be interested to see the annual thermal regime at Lake Sharpe- it is interesting that it is so deep yet isothermal yearround. I am not surprised that efforts to stock competing predators only made fatter walleyes. I also agree that low habitat diversity (a homogeneous, isothermal reservoir) may prevent other species from taking hold. I also liked the way you reasoned through the apparently paradoxical prey:predator biomasses. I agree that comparing standing stock of prey to predator biommass may be misleading. As you say, it's the prey production that gets channeled into predators. I suspect there is heavy cannibalism in this walleye population as well. This would allow the population of larger fish to find acceptable prey sizes when the non-walleye forage base appears to be mostly YOY fishes. Cannibalism seemed important in some years on Lake Mendota.

As for management recommendations, I would be inclined to emphasize the recreational harvest. Walleye populations are sensitive to heavy fishing pressure, and they are desirable as a food fish at even rather small sizes. I agree that the Tribe should consider promoting this fishery, and that walleye anglers are willing to travel a long way to catch fish. I firmly believe that sport anglers are a powerful tool that fishery managers can manipulate to achieve ecological goals. Size limits make little sense under the conditions you described (except perhaps a maximum size limit or restricted bag of fish over a threshhold size in order to preserve some large fish for that part of the fishing experience). I suspect that heavy harvest would alter this population, and biologists should monitor population parameters in case some harvest restrictions become necessary in the future.

I know that some of the SD DNR biologists are members of the AFS North Central Division Walleye Technical Committee. What is the Tribe's relationship with the state like? Can they get advice from the state or are they on their own?

Thanks for letting me read your review.