FEDERAL AID TO FISH RESTORATION

COMPLETION REPORT

MAN-MADE LAKES INVESTIGATIONS

PROJECT NO. F-160-R

Study 7007. Assessment of the significance of recruitment and angler exploitation to the walleye fishery at Rathbun Lake

Job 1. Assessment of cost and benefit of the walleye stocking program

Job 2. Assessment of the significance of harvest to the density of adult walleye in Rathbun Lake

Job 3. Management guidelines

Period covered: 1 July 1990 - 30 June 2008
Iowa Department of Natural Resources
Richard Leopold, Director

July, 2008

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ANNUAL REPORT

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Study 7007. Assessment of the significance of recruitment and angler exploitation to the walleye fishery at Rathbun Lake

Period Covered: **July 1, 1990-June 30, 2008**

Prepared by: ______________________ July 1, 2008
Fisheries Research Biologist **Date**

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Fisheries Research Supervisor **Date**

CONSERVATION AND RECREATION DIVISION

Iowa Department of Natural Resources
Richard Leopold, Director

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STUDY 7007

Assessment of the significance of recruitment and angler exploitation to the walleye fishery at Rathbun Lake.

OBJECTIVE

To maintain the Rathbun walleye population ($\geq$ 17 inches) at a minimum biomass of 3 lbs per acre, using the most cost effective stocking strategy.

JOB 1

Assessment of cost and benefit of the walleye stocking program

OBJECTIVE

To determine the cost/benefit ratios of stocking walleye to the fishery as age 1 fish by measuring abundance, mortality rates, and growth and costs

JOB 2

Assessment of the significance of harvest to the density of adult walleye in Rathbun Lake

OBJECTIVE

To delineate the importance of harvest by measuring exploitation rate, natural mortality, growth and abundance of walleye $\geq$ 17 inches.

JOB 3

Management guidelines

OBJECTIVE

To prepare a completion report with emphasis on walleye management

COMPLETION REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

JOB NO.: 1, 2, and 3

TITLE: Assessment of the significance and angler exploitation in the walleye fishery in Rathbun Lake

ABSTRACT

Oxytetracycline (OTC) is an antibiotic with the ability to mark developing calcified structures and has been used to assess survival of stocked juvenile walleyes. Our objective was to determine the contribution of 2 inch walleye stocked in tributary streams to the young-of-the-year population sampled during the fall in Rathbun Lake. With the exception of 1999, fingerling walleye were stocked in streams flowing to Rathbun Lake and the average stocking was 45,145 fingerlings stocked during the June/July period. Fish were immersed in 500-600 g of OTC for 6 h during transport and stocked. Streams were sampled with a backpack shocking unit and walleye were collected and analyzed to determine short-term mark retention and growth rates. Two calcified structures were analyzed for OTC: dorsal spines and otoliths. OTC marks were very difficult to detect in dorsal spines and the results were unreliable, therefore this part of the study was discontinued Mark retention, however, was 98.1% when otoliths of fish (N = 53) collected up to 65 days post stocking were examined. Mean daily growth of walleyes collected 8-65 days post stocking was 0.99 mm/d. An electrofishing boat was used on the main lake in the fall to collect YOY walleyes, in search of OTC marked fish that had been stocked in the tributaries. Unfortunately, we did not find OTC marked fish (N = 255) in the main lake. Potential explanations include: 1) tributary stocked walleyes did not contribute to the main lake YOY population due to poor survival, 2) tributary stocked walleyes did not move downstream to the main lake (i.e. fish over-wintered in tributaries), or 3) the number of fish analyzed for OTC marks was inadequate due to the low ratio of marked to unmarked fish in the main lake. Population characteristics of walleye at Rathbun Lake were estimated from 1991-2000 and included growth, body condition, abundance, survival, recruitment and angler harvest. These statistics were used to assess the impact of various minimum size limit restrictions on the population through Fishery Analysis and Simulation Tools (FAST). Present condition (no limit and 20% exploitation) yielded an estimated annual harvest of about 14,000 fish at 3.3 lb/ac. Simulated 16-inch minimum length limit restriction yielded an estimated 10,600 fish at 3.5 lb/ac. Considerably higher levels of exploitation (50%) showed minimum length limit might be warranted; however, the fishery at Rathbun Lake is presently at the 20-25% level of exploitation. Harvest regulation on walleye at Rathbun Lake would provide little increase in broodstock or abundance or biomass. At the present level of exploitation of about 20-25%, a regulation protecting 16-inch and smaller fish might increase density of walleye brood stock by 10%, however, angler harvest would be reduced 32%. Management recommendations were presented including a model to estimate walleye population abundance based upon spring sex ratio and catch per unit effort in gill net catches.

INTRODUCTION

Immersion marking juvenile fish with chemicals can be an effective tool for fisheries managers. Immersion marking techniques have been used and described in previous studies (Brooks et al. 1994; Lucchesi 2002). In particular, immersion marking is often used to evaluate the success of different stocking regimes (Brooks et al. 2002; Isermann et al. 2002; Lucchesi 2002; Vandergoot and Bettoli 2003).

Oxytetracycline hydrochloride (OTC) is a chemical that is commonly used as a mass-marker of fish. OTC is an antibiotic that is assimilated by fish and deposited on developing calcified structures, such as spines and otoliths. Assimilation of OTC forms rings that can be visually detected through magnification of cross-sectioned structures viewed under ultraviolet light.

In the 1970's and early 1980's the walleye *Sander virtues* population in Rathbun Lake was not meeting the expectations of anglers or the brood fish requirements of the Iowa Department of Natural Resources' (IDNR) walleye program. A management objective of doubling the adult (>17.5 in) walleye population in Rathbun Lake was initiated in 1984. This goal was reached in 1990 by increasing the fry stocking rate from 1,000 to 2,000 walleye per acre and stocking extensively reared fingerlings in the fall. Subsequently, the goal of tripling the pre-1984 adult walleye population was proposed. This was accomplished in 1997 by increasing the fry stocking rate from 2,000 to 3,000 per acre and supplementing the fry stocking with intensively reared fingerlings (Mitzner 2002).

Previous sampling revealed that tributaries in the Rathbun Lake watershed were found to contain abundant minnow populations and few predators, an ideal habitat for the growth and survival of walleye fingerlings. Successful tributary stockings could potentially become an important management strategy for walleye populations at Rathbun Lake and other large reservoirs.

The walleye population in Rathbun Lake originated from an initial stocking of 800 fry per acre on May 1970. Subsequent plants of fry and fingerling resulted in a walleye population that became an important source of broodfish for the state's hatchery system. The Rathbun Fish Hatchery, built in 1977, and located below the dam, has the capability of producing about 40 percent of the sac fry needed statewide. Annual gill net collection of walleye broodfish peaked in 1980 and 1981 at over 2,000 fish. A systematic decline in numbers of broodfish taken by netting crews began in 1982, and reached a low of 609 fish in 1987. Length-frequency distribution of brood walleye taken during the mid 1980's indicated poor recruitment was the primary cause of diminishing numbers. Larger fish dominated the population and recruitment of smaller fish into the populations was poor. Walleye caught by anglers fishing at Rathbun Lake, likewise, showed a similar trend of larger but fewer fish. Nearly 14,000 walleye were harvested by anglers in 1972; however, the number decreased to 4,600 by 1975, and varied between 1,000-3,000 through 1986.

An investigation was initiated in 1984 to evaluate walleye recruitment associated with an intensified stocking program, the objective of which was to triple the biomass of walleye at Rathbun Lake. This objective was attained and is reported by Mitzner (1992; 2002). The initial objective of tripling the walleye population in Rathbun Lake was attained during the early 1990's.

Therefore, in 1997 we proposed to further improve the walleye fishery at Rathbun Lake by 1) implementing a tributary walleye stocking regime for Rathbun Lake using 2 inch fingerlings and 2) marking the fish with OTC to evaluate their contribution to the young-of-the-year (YOY) walleye population in the main lake. Additionally, we calculated various costs associated with marking juvenile walleyes via different marking techniques and gave suggestions for stocking walleye in tributaries above large reservoirs. In addition, we evaluated the impact of angling upon the walleye population and, in particular, assess concerns of overharvest.

STUDY AREA

Rathbun Lake is an 11,000-acre impoundment within the Chariton River basin in Appanoose, Wayne, Lucas and Monroe Counties. The project was built during with 1960's with gate closure in 1969 and operated for flood control, recreation and navigation benefits. Normal reservoir operation discharge rates range from 10 to 1,200 cfs; however, the maximum discharge is 5,000 cfs. Storage at conservation pool (904 ft MSL) is 205,400 ac-ft and maximum volume is 551,600 ac-ft at crest elevation (926 ft MSL). The watershed to lake surface area ratio is 32:1 at conservation pool and 17:1 at spillway elevation. Mean depth at conservation pool is 19 ft, while at crest elevation it is 26 ft. Maximum depth at conservation pool is 49 ft and 74 ft at crest elevation. Shoreline is quite irregular with many small embayments; its development is 7.3. Thermal stratification develops only during hot, still periods. Sport fish also present in the lake include white *Pomoxis annularis* and black crappie *P. nigromaculatus*, channel catfish *Ictalurus punctatus*, white bass *Morone chrysops*, largemouth bass *Micropterus salmoides*, bluegill *Lepomis macrochirus*, flathead catfish *Pylodictis olivaris*, northern pike *Esox lucius*, and black bullhead *Ameirus melas*.

The entire watershed lies within the Chariton River sub-basin identified by hydrologic unit code (HUC) 10280201. Elevation ranges from 904 ft MSL, which is the conservation pool of Rathbun Lake to 1,167 ft (MSL) at the highest point of the watershed. The watershed is predominately grassland/pasture (45%), row-crop agriculture (35%) and forest (15%) (http://wqm.igsb.uiowa.edu/activities/stream/monthly%20sites/chartn12.htm).

The Rathbun Lake watershed is comprised of two primary tributaries, the Chariton River (CR) and the South Fork of the Chariton River (SF). Several higher order streams flow into the two primary tributaries including: Chariton Creek (CC), Wolf Creek (WC), Fivemile Creek (FM), Honey Creek (HC), Dick Creek (DC), Ninemile Creek (NM), Jordan Creek (JC), Jackson Creek (JA), West Jackson Creek (WJ), Walker

Branch and South Fork of Walker Branch (Figure 1).

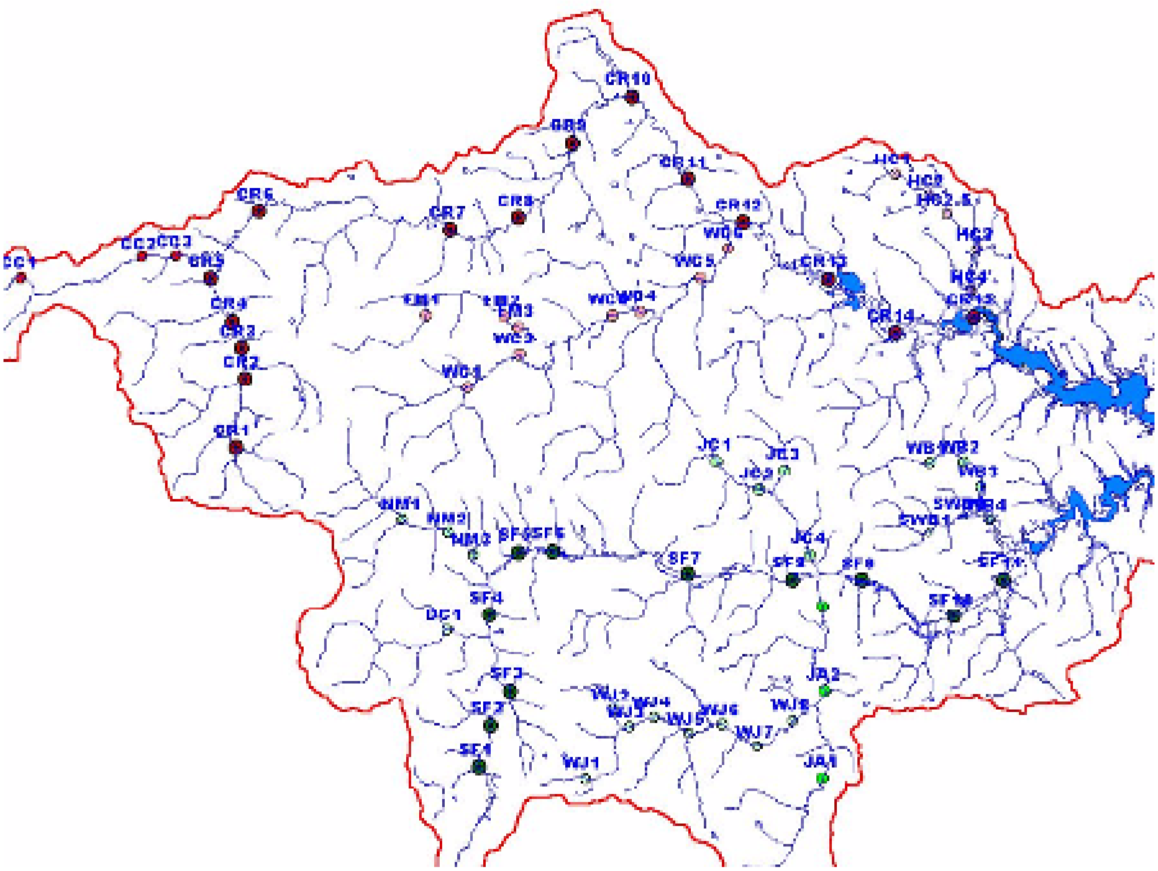

Figure 1.—Map of the Rathbun Lake watershed. Potential stocking sites are indicated (see text for description of stream codes).

METHODS

Determining stocking sites

Bridge crossing sites on tributaries of Rathbun Lake were selected for walleye stocking sites. These sites were selected because 1) there was easy access for hatchery trucks, 2) the sites were delineated during a previous long-term bio-monitoring project (Figure 1), and 3) preliminary data existed for most of the sites (Schultz 2006). Eight preliminary fish population surveys were conducted at 5 potential stocking sites in 1996 to determine the abundance and diversity of prey populations. These sites were located on the Chariton River, South Fork of the Chariton River, and Wolf Creek. Surveys were conducted using backpack electrofishing. Total effort was 2.8 h, utilizing a Coffelt® model BP-10 operated at 70-100 volts of pulsed DC. Sites with good prey populations and reasonable flow were then selected as stocking sites for the study.

Marking and detection of OTC

Approximately 50,000, 2-in walleye fingerlings were provided by the IDNR Spirit Lake Fish Hatchery in 1997, 1998 and 2000-2005. The fish were collected from hatchery rearing ponds in late June/early July and were loaded onto a hatchery truck. The fish were immersion marked with 500-600 mg/L of OTC for 6 h during transport to the Rathbun Fish Hatchery. The pH of the water was buffered (held at 7.0) by adding the appropriate amount of sodium phosphate dibasic. The fish were then stocked at predetermined tributary sites (Table 1; Appendix A).

Table 1.—Number of fingerling walleye (mean TL = 65 mm) stocked in the Rathbun Lake watershed, 1997 – 2005. Fish were not available for this study in 1999.

Stream	County	1997	1998	2000	2001	2002	2003	2004	2005
Chariton River	Lucas	3,787	2,377	5,180	4,409	4,666	9,633	4,296	3,398
Chariton River	Wayne	9,736	4,157	12,880	9,812	11,666	9,872	10,955	8,496
Dick Creek	Wayne	3,606	7,539	0	3,974	4,407	0	3,523	3,209
Five Mile Creek	Lucas	5,229	3,189	7,140	5,837	6,442	0	6,014	4,692
Jackson Creek	Wayne	2,524	5,141	3,360	2,788	0	0	2,749	2,205
Jordan Creek	Wayne	2,524	1,948	3,360	2,757	0	0	3,179	2,180
Ninemile Creek	Wayne	0	7354	0	3974	4323	0	3,952	3,148
South Fork River	Wayne	2,344	2,600	5,180	4,223	4,745	11,927	3,523	3,456
West Jackson Creek	Wayne	4,327	2615	5,740	4,844	5,259	6,844	4,897	3,830
Wolf Creek	Wayne	5,589	3,487	5,880	6,179	6,780	7927	6,444	4,938
Total		39,666	40,407	48,720	48,798	48,288	46,203	49,532	39,552

We tested two different methods for identifying OTC-marked fish. The first method involved cross-sectioning dorsal spines and applying ultraviolet light to visually detect a ring. The second analysis used otoliths analyzed with methods similar to Brooks et al. (1994).

Tributary data collection

A backpack shocking unit (described above) was used to collect walleyes in the streams after stocking. Sampling was conducted from June – September, 1997-2005. Each shocking sample was 15-30 min. Collected walleyes were measured (TL) and then frozen for later processing of spines and otoliths. In addition, other species of fish were identified (Pflieger 1978) and enumerated. A Fish Index of Biotic Integrity (FIBI) was calculated using modified methods of Karr (1981). Catch per effort (CPE) for fish was also determined as the number of each species per electrofishing min.

Methods similar to Wang et al. (1998) were used to determine habitat quality at most of the stocking sites during a long-term bio-monitoring project in the Rathbun watershed (Schultz 2006). Habitat variables that were analyzed included: stream width, % boulders, % over hanging vegetation, % undercut banks, % woody debris, % total instream cover, % bank erosion, % buffer vegetation, % channelization, age of channelization, thalweg depth, standard deviation of thalweg depth and sinuosity. Historical discharge data for the Chariton River and the Southfork of the Chariton River were obtained from the United States Geological Survey (USGS) (http://waterdata.usgs.gov/ia.nwis/rt). The mean monthly discharge (cfs) of these primary tributaries was calculated for the study period (Table 2).

Table 2.—Mean monthly discharge (cfs) of the Chariton River and the South Fork of the Chariton Rivers during the study period. The historical mean monthly discharges (cfs) are also provided for comparison.

	Chariton River near Chariton				South Fork Chariton River near Promise City			
Year	June	July	August	September	June	July	August	September
1997	75.5	36.8	17.9	5.1	56.4	4.7	38.4	5.9
1998	198.2	91.7	5.4	7.4	315.1	38.0	2.6	3.5
2000	124.4	46.4	5.3	0.9	113.4	10.7	3.0	0.5
2001	606.6	24.6	1.9	7.2	624.5	15.2	3.9	3.1
2002	33.6	12.0	0.6	0.4	20.3	2.1	2.1	1.0
2003	27.6	8.2	0.0	2.1	36.0	7.7	0.5	3.4
2004	237.7	36.9	513.8	24.3	167.3	65.4	643.9	10.9
2005	69.4	2.7	1.7	0.1	99.4	11.0	2.0	0.7
Long-term*	159.8	178.6	77.1	142.3	149.6	210.5	53.2	161.2

* Chariton data are from 1966-1996, South Fork data are from 1968-1996

Lake fish collection

The main lake was sampled for OTC marked YOY walleyes using night electrofishing in October of 1997, 1998, 2000, 2003 and 2005. The electrofishing boat emitted pulsed DC current at 6 A and 350 V during sampling. In addition to the tributary stocked walleyes, the main lake also receives fry in May and advanced fingerlings in October. The advanced fingerlings were distinguishable from the rest of the fish because they had significant wear on their lower caudal fins from hatchery raceways, and our sampling was initiated within 2 weeks of advanced fingerling stockings. Advanced fingerlings were measured (TL) and returned to the lake. Fish that were fry stocked or potentially stocked in the tributaries were measured (total length: TL) and frozen for later analysis of spines and otoliths.

Walleye harvest and density relationships

Age, growth, size structure, and weight-length statistics were derived from otoliths or scales and total lengths and weights taken from walleyes during brood fish collection in April. Walleyes were collected with 2.5-inch bar mesh gill net. Growth calculations were performed with DisBcal (Frie 1982), while relative weight was based on standards by Murphy et al. (1990). In addition, growth was determined from lengths of Visual Implant (VI) tagged brood fish and data obtained during brood walleye collection and from angler-caught fish. Size structure was best described by length-frequency histograms.

Walleye population densities were estimated by the Jolly - Seber method of mark-recapture (Ricker 1975; Hayes et al. 2007). All fish ≥ 17 inches in total length (TL) brought into the hatchery for spawning in April were marked with a partial fin-clip or VI tag, stripped and returned to the lake. Marks were distinctive for each year of the investigation. Angler-caught walleye were examined by the creel clerk for marks or tags. Biomass of the population was computed as a function of the population estimate, length-frequency distribution and length-weight regression.

Survival of adult walleye was estimated from the recapture of VI tagged fish during successive spawning seasons (Ricker 1975; Hayes et al. 2007). Recaptures of these fish were recorded separately by year and by sex. Annual mortality was estimated by the Jolly - Seber method. Survival was verified by year class strength of stocked fingerlings. Each year stocked fingerlings were clipped on alternate sides. For example, fish were marked with a left pectoral clip in 1984, a right clip in 1985 and a left clip in 1986. This alternate year marking continued through 1999. These fingerlings entered the brood fish population in approximately four to five years. From left or right clip ratios and length frequency distributions it was possible to estimate the relative contribution of these year classes. These values were then compared to the survival rates based on VI tag recapture statistics.

Walleye harvest was estimated by an expandable roving creel survey conducted from 1972-1997. The daily survey period was stratified by early (AM) and late (PM) fishing with further stratification by weekend and weekday, and boat and shore. Angler counts were made on an hourly basis within the stratified design. Information obtained from interviews included number in party, length of time fished, whether the trip was complete, number of each species caught, and determination of the target species. Lengths were taken on representative catches of walleye, as well as other species, throughout the survey period.

Two basic survey designs were used during the investigation. The first design divided the lake into 4 sample segments. Each segment was sampled individually for 8 hours on a random basis. This method was used from 1972-1990; details for this method are given by Bruce (1978). The second method partitioned the lake into 8 segments and each segment was sampled for 1 hour on a randomized basis. This method was used in 1991-1997 with details given by Mitzner (1994).

Population statistics were used to predict the impact of various size regulation scenarios on the walleye population at Rathbun Lake. Slipke and Maceina (2000) developed the model used to estimate the outcome of these scenarios. Input statistics included growth by age and the proportion of growth occurring during the year, length-weight coefficients, number of periods per year, minimum vulnerable size, sizes for regulation scenarios, hooking mortality, natural mortality, exploitation rates, stocking density and initial population size.

Data analysis

Linear regression analysis was used to describe the relationship between days post stocking (dps) and change in TL (mm) of walleyes that were stocked and collected in the tributaries. ANOVA was used to compare mean daily growth of tributary stocked walleyes among years. Multiple linear regression analysis was used to determine whether the habitat assessment score, mean monthly discharge, FIBI, or fish CPE were significant predictors of walleye mean daily growth (mm/d) in the tributaries. In addition, correlation analysis was used to determine which of the habitat variables (used to calculate the habitat score) were correlated with mean daily growth. Walleyes that were stocked in the main lake as fry and as advanced fingerlings were collected during lake sampling. Main-lake stocked walleyes (fry vs. advanced fingerlings) were collected in October of 2000-2005. The length distributions of these fish were compared with a Kolmogorov–Smirnov [KS] two-sample test. Fish collected > 24 cm were removed from this analysis (N=10) because we speculated that they may be age 1 fish. Statistical Analysis System (SAS) software was used for the analyses with $\alpha = 0.05$.

RESULTS

Determining stocking sites

Twenty-one species of fish were collected during the 8 preliminary backpack shocking samples, two-thirds of which were potential prey fishes (unpublished data). The most numerous prey species were red shiners *Notropis lutrensis* (32.6%), followed by sand shiners *N. stramineus* (11.4%), bigmouth shiners *N. dorsalis* (11.2%) and fathead minnows *Pimephales promelas* (6%). Potential predators included *Lepomis* spp. (22.6%), *Ameiurus* spp. (6.2%), larger creek chubs *Semotilus atromaculatus* (2%) and largemouth bass *Micropterus salmoides* (1.7%).

Walleyes were stocked at 10 sites in 9 tributaries: Chariton River 2 and 6, Dick Creek 1, Jackson Creek 1, Jordan Creek 2, Fivemile Creek 3, Ninemile Creek 2, Southfork Chariton River 3, West Jackson Creek 5, and Wolf Creek 1. During years of high discharge, however, we selected sites in the upper reaches of the watershed (Table 1; Appendix A).

Marking and detection of OTC

Dorsal spines of walleyes collected in the tributaries and the main lake (1997) were analyzed using UV light and a light microscope. In general, this technique was unreliable and it was discontinued after the first year of the study.

The mark retention of OTC in the otoliths of known marked fish that were collected in the tributaries up to 65 days post marking/stocking was over 98% (Table 3; Appendix B). Unfortunately, young walleye collected during fall sampling in the main lake did not produce a positively OTC marked fish (*N* = 255) (Table 3; Appendix B).

The cost of using OTC to mark juvenile fish is comparable to the cost of freeze-branding and is considerably cheaper than that of coded-wire tagging (CWT). The cost of using OTC as a marker is primarily associated with otolith analysis and the replacement cost of fish that are sacrificed for analysis (Table 4). CWT can, however, also result in mortalities, depending on fish size and tag implant location (Table 5).

Growth rates of the walleyes stocked in the tributaries of Lake Rathbun were comparable to fish raised in similar latitude (Carlander 1997). Interestingly, these growth rates were somewhat lower than that of walleyes fed diet WG 9206 in the Rathbun Culture Research Facility (Johnson and Rudacille 2003), which is the current recommended diet at the IDNR Rathbun Fish Hatchery (Table 6; Figure 2).

Table 3.—Results from OTC otolith analysis of fish collected in the tributaries (June-August, backpack electrofishing) and main Rathbun Lake (October, boat electofishing).

	Tributary			Lake		
	# Analyzed	# Marked	% Marked	# Analyzed	# Marked	% Marked
1998	2	2	100	4	0	0
2000	0	0	0	95	0	0
2003	26	25	96.2	86	0	0
2005	25	25	100	70	0	0

Tributary data collection

Walleyes were collected at the stocking sites 6 to 65 days post stocking (dps) (Appendix B). Mean daily growth of all walleyes over this time frame averaged 0.75 mm/d. Fish that were collected 7 dps or less had low and sometimes negative mean daily growth rates and many of the fish that were collected soon after stocking were emaciated. It was obvious that these fish did not acclimate to stream conditions and were going to expire. Therefore, those fish collected < 7 d after stocking were eliminated (*N* = 19) from our analyses unless otherwise noted. Mean daily growth of walleyes collected > 7 dps was 0.99 mm/d, which was significantly higher than that of the mean daily growth of all fish (t = -2.47, df = 118, P = 0.015) (Figure 3). Mean daily growth varied among years but was not significantly different (Table 6; $F_{3,47}$ = 2.09, df = 3, P = 0.115).

Multiple regression analysis revealed that Fish IBI, fish CPE, and discharge were not significant predictors of walleye mean daily growth, but habitat quality was (t = -2.71, df = 4 , P = 0.03) (Table 7). A correlation analysis between mean daily growth and the individual habitat variables revealed that

% channelization (r = 0.73, P = 0.002) and age of channelization (r = -0.73, P = 0.002) were significantly correlated with mean daily growth. The % woody debris (r = -0.45, P = 0.09) and % total instream cover (r = -0.46, P = 0.09) were marginally significant as well.

Table 4.—Cost comparison of three different methods for marking fingerling walleyes. Costs are estimated for marking 50,000 walleye fingerlings.

Method	Item	Cost
Oxytetracycline	OTC (1 kg)	$125
	Sodium phosphate dibasic (3 kg)	$111
	Replacement cost of 7in fish (100)	$162
	Replacement cost of 13in fish (100)	$625
	Otolith analysis (200 fish)	$600
	Labor (2 workers * 6 hr immersion* $15/hr)	$180
	Total	$1,803
Freeze branding	Liquid Nitrogen	$750
	Branding stations (6 bars)	$300
	Labor (6 workers * 14.5 hrs marking * $15/hr)	$1,305
	Total	$2,355
Coded-wire tags	Tags (100,000)	$3,200
	Automated tag injector (2)	$40,000
	Hand-held wand reader (2)	$10,000
	Labor (2 workers * 50 hrs * $15/hr)	$1,500
	Total	$54,700

Table 5.—A summary of the marking efficiency and mortality associated with 3 different methods for marking fingerling walleyes.

Method	Reference	Mark retention (%)	Mortality (%)	Fish size (mm)	Experiment duration (days)
Oxytetracycline	Lucchesi (2002)	100 (500 mg/L, 6 hrs)	NE	20-40	83-95
	Vandergoot and Bettoli (2003)	99 (500 mg/L, 6 hrs)	NE	30-70+	21
	Brooks et al. (1994)	100 (500 mg/L, 6 hrs)	< 2	50-100	1
Freeze-branding	LaJeone and Bergerhouse (1991)	95	1.6 - 7.6	50-170	~150
Coded-wire tags	Heidinger and Cook (1988)	96 (Nasal)	29	51	~180
		100 (Nasal)	6	73	~180
		97 (Cheek)	41*	51	~180
		97 (Cheek)	24*	75	~180

*mortality was significantly greater than that of sham injected controls ($P < 0.05$).
NE = not evaluated in study.

Table 6.—Mean daily growth (mm/d) of walleyes that were stocked and recovered in the Rathbun tributaries (June-Aug). Mean daily growth of walleyes reared on the currently recommended diet for the Rathbun Fish Hatchery is also presented for comparison.

Conditions	Year	Mean daily growth of all fish (mm/d)	Mean daily growth of fish collected > 7 dps (mm/d)*
Rathbun tributaries	1997	0.82	1.21
Rathbun tributaries	2000	1.16	1.16
Rathbun tributaries	2003	0.46	1.15
Rathbun tributaries	2005	0.86	0.86
Rathbun Culture Research (diet WG 9206)	2003	1.41	

*These results are presented because negative growth values were associated with fish collected in the first week post stocking. The negative values were likely a result of poor acclimation to stream conditions.

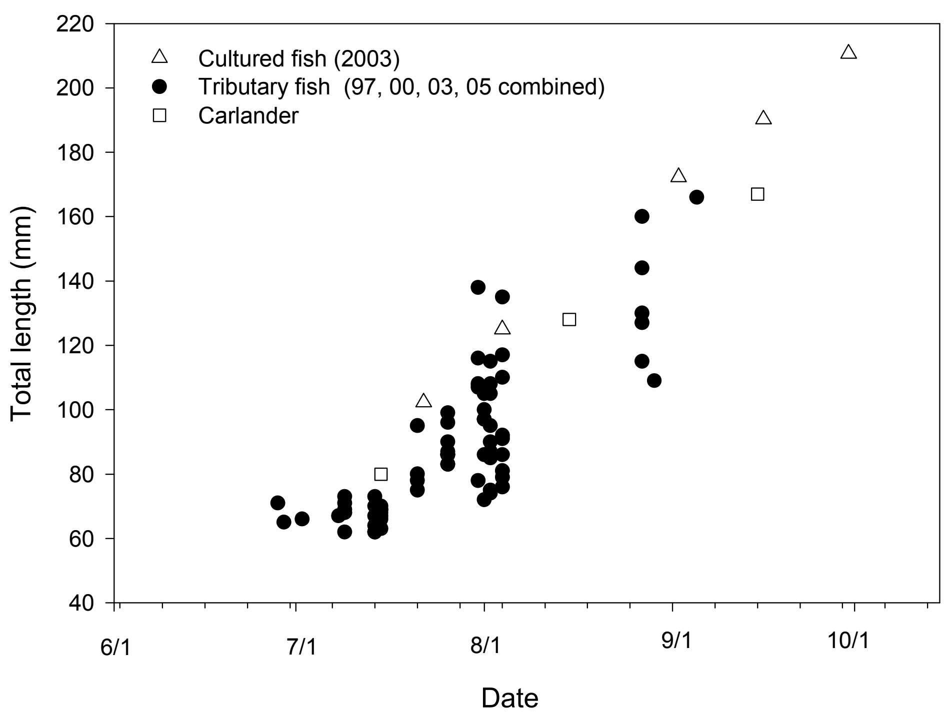

Figure 2.—Rlationship between total lengths of all walleyes stocked and collected in Rathbun Lake tributaries and time. Fingerlings (~65mm) were stocked in late June/early July. Mean total lengths of walleyes at similar latitude (Carlander 1997) and from the Rathbun Fish Hatchery Research Facility (Johnson and Rudacille 2003) are also presented for comparison.

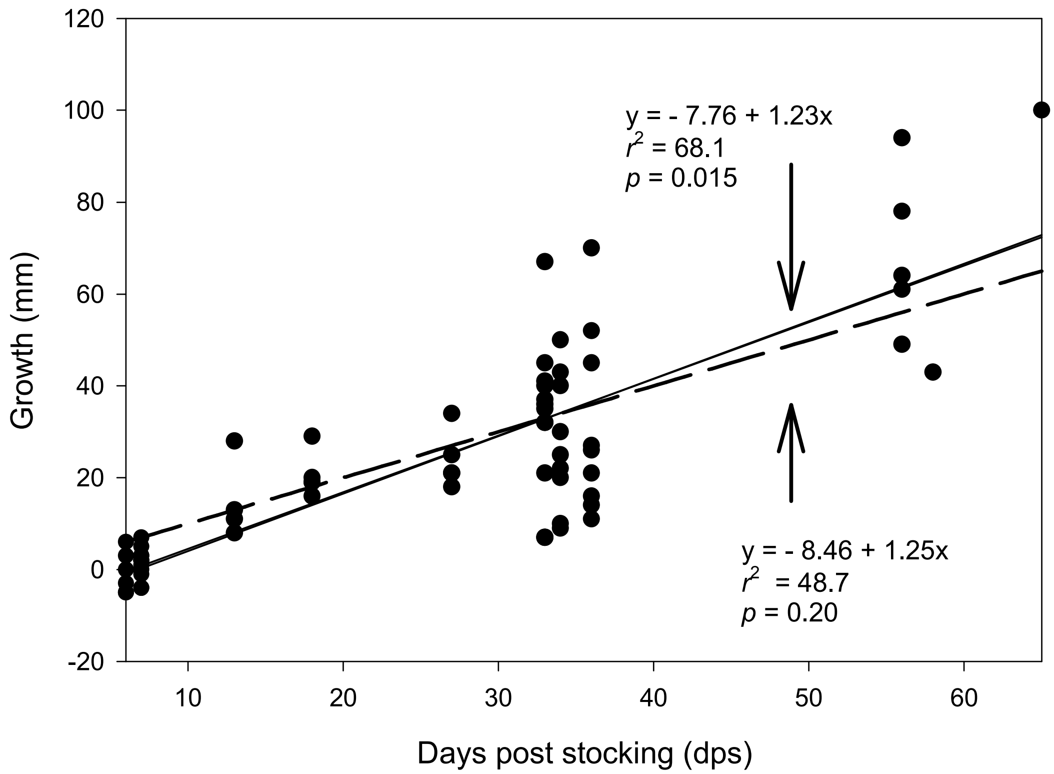

Figure 3.—Linear relationship between the growth in walleye total length and time after walleyes were stocked in Rathbun Lake tributaries. The solid line indicates the relationship between growth of all fish and time; the dashed line indicates the relationship between growth of fish collected >7 days post stocking and time.

Table 7.—Results of a multiple linear regression analysis with environmental and biological parameters used as predictors of walleye mean daily growth (mm/d) at specific tributary sites.

Variable	*t* value	*P* value	df
Intercept	3.86	0.006	1
Habitat score*	-2.71	0.03	1
Discharge	-0.90	0.40	1
Fish IBI score	-0.94	0.38	1
Fish Catch per Effort	0.39	0.71	1

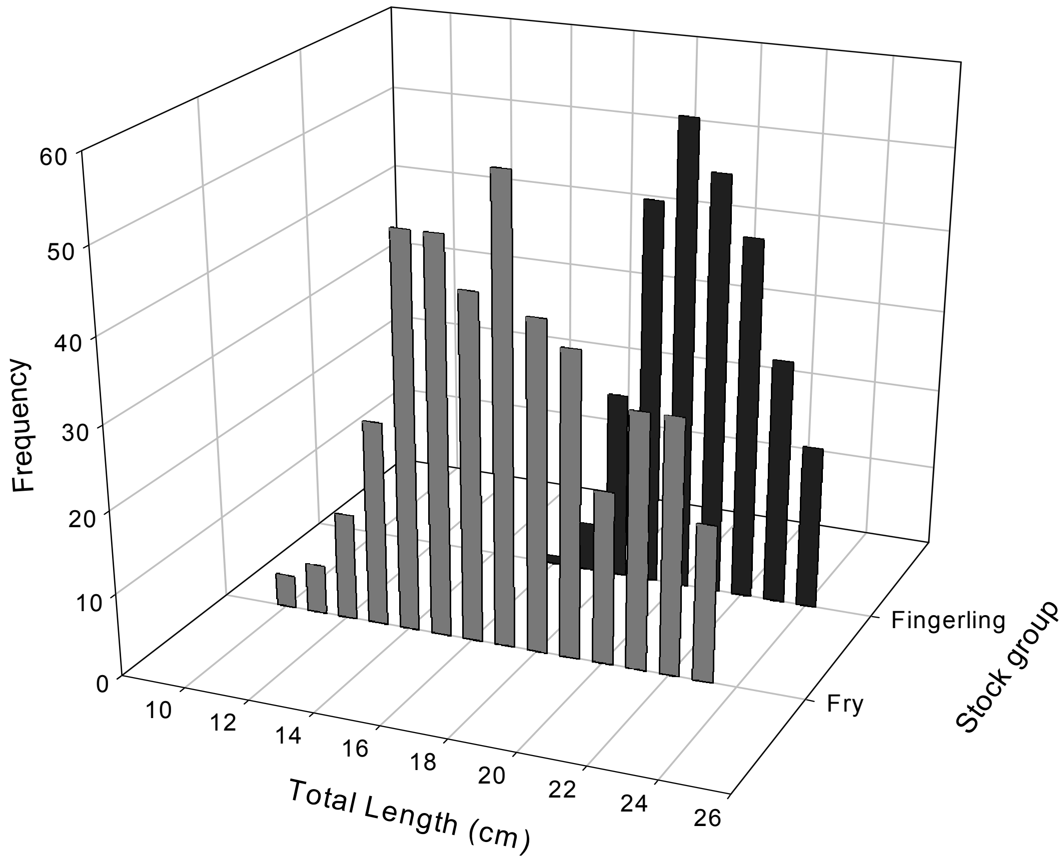

Figure 4.—Comparison of the total length of YOY walleyes stocked in Rathbun Lake as fry (May) and those stocked as advanced fingerlings (October). Fish were collected in the main lake while fall electrofishing October, 2000-2005.

Lake fish collection

Walleyes stocked as advanced fingerlings had a mean TL of 20.7 cm and the mean TL of stocked fry was 17.4 cm. The length distribution of these two groups of fish were significantly different (Kolmogorov–Smirnov [KS] two-sample test, asymptotic KS statistic [KSa] = 7.05, $P < 0.0001$; Figure 4). The contribution of tributary stocked fish to the YOY walleye population in Rathbun Lake, as measured by the ratio of marked to unmarked walleye, was not determined due to a lack of OTC-marked walleye recaptured in fall..

Adult Walleye Growth and Condition

Walleye growth from measurements of known age fish in October, in addition to back-calculated lengths at age from otoliths and scales, showed females grew more rapidly than males (Mitzner 1992). Female walleyes averaged 22 inches after 5 years of life, about 2 inches larger than males (Table 8). By age ten, females averaged 27.6 inches, a length nearly 4 inches larger than males.

Growth of walleye was also calculated from VI tag returns obtained during April broodfish collections. Walleye were not aged at that time, but a regression of length at year t against length at year t + 1 showed incremental growth as shown in Figure 5.

Several measurements were discerned from the regression. The first was the intercept, the theoretical length at one year of age. In Figure 1, this was 6.4 inches. Secondly, the regression slope showed the decreasing rate of annual incremental growth. Thirdly, the maximum length (L_∞) which walleye can theoretically attain was calculated where the regression line intersected the Y = X line or the 1:1 line in the Figure 1. In this case, maximum attainable growth for females sampled in 1997 and again in 1998 was 30.3 inches. Statistics for other years of collection are shown in Table 9.

Table 8.—Composite of back-calculated lengths (in) at age and empirical measurements of known age Rathbun Lake walleye, 1984-1989.

	Age											
	1	2	3	4	5	6	7	8	9	10	11	12
Male	6.1	11.5	15.0	17.4	19.1	20.9	21.7	23.1	23.5	23.6	24.2	24.4
Female	6.1	11.8	16.1	19.7	22.0	23.6	24.6	25.8	26.8	27.6	28.3	29.1

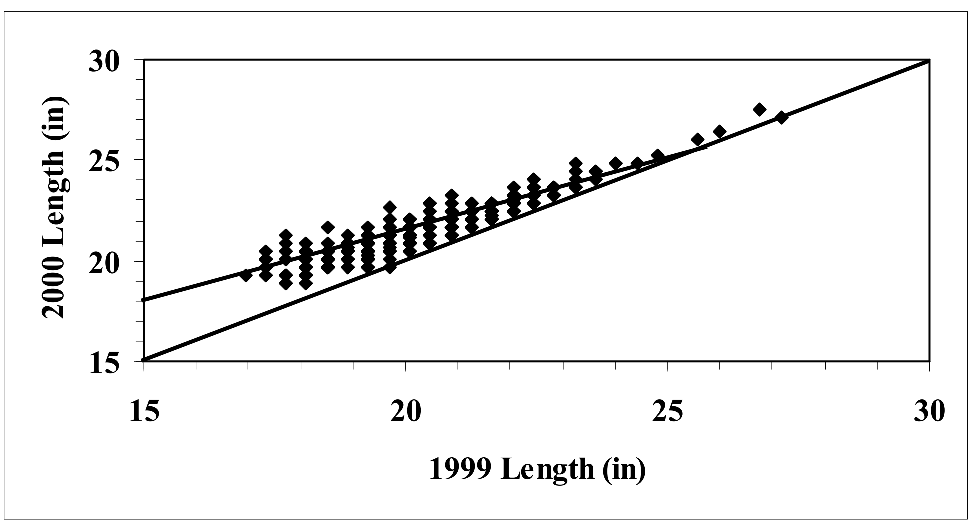

Figure 5.—Walford graph of VI-tagged male walleye captured and measured in April 1999, and subsequently measured in April 2000.

Table 9.—Growth statistics for male and female walleye at Rathbun Lake, based on recapture statistics of VI tags in subsequent years. Length was measured in inches.

	Males			Females		
Year	Growth Coefficient (B)	Length Infinity	Intercept Length at age I	Growth Coefficient (B)	Length Infinity	Intercept Length at age I
1990	0.76	25.7	6.1	0.72	28.8	8.0
1991	0.78	25.2	5.6	0.76	29.2	7.1
1992	0.75	25.0	6.3	0.76	29.0	7.1
1993	0.83	27.4	4.6	0.79	30.2	6.3
1994	0.82	25.3	4.5	0.84	31.6	5.2
1995	0.77	25.4	5.9	0.75	28.6	7.0
1996	0.72	23.4	6.5	0.84	31.2	5.1
1997	0.73	24.1	6.6	0.85	32.4	4.9
1998	0.72	24.4	6.8	0.72	28.3	7.8
1999	0.78	25.8	5.8	0.79	30.3	6.4
Average	0.77	25.2	5.9	0.78	30.0	6.5

Length-weight regression constants (intercept; *a*, and slope; *b*) were both significantly greater for female walleye from 1990-1999 (paired t-test; $P = 0.03$ and 0.02, respectively) (Table 10). Additionally, condition (W_r) was significantly greater in the Rathbun Lake female population (paired t-test; $P < 0.0001$) during this time frame (Table 10). Length-weight regressions for walleye do not typically differ for males and females (Carlander 1997); however the data in this report is from a spawning population for which Carlander (1997) did not detail.

Average coefficients from 1990-1999 were used to construct length at age statistics for both male and female walleyes. Regression equations were

T + 1 = 5.9 + 0.77 * T for males, and

T + 1 = 6.5 + 0.78 * T for females

where T is total length, in inches, at first year of measurement of tagged fish and T + 1 is total length, in inches, after one year of growth. Lengths at age are represented in Figure 6. Values were nearly identical to those determined from back-calculated lengths from otolith and scale readings (Table 8).

Walleye growth, as represented by growth coefficient (b), was regressed against body condition (W_r) during 1990-1999. The relationship for females was positive with an r-value of 0.61 at a p-value of 0.06. The relationship for males was also positive but not nearly as well defined ($r = 0.45$, $P = 0.61$).

Walleye body condition was regressed with population density each year, 1984-2000. The relationship between average male W_r and density was not significant (r = 0.03, p = 0.91). Similar results were shown for female W_r and population density ($r = 0.29$, $P = 0.26$).

Abundance

Population estimates of walleye ≥ 17 inches were based on fish tagged during the April spawning run and recaptured in subsequent years during the same time period (Appendix C and Appendix D).

The population estimates ranged from 3,565 in 1992 to 6,468 in 1997 (Figure 7). Male estimates were somewhat lower than females, ranging from 1,200 in 1992 to 2,517 in 1997. Female estimates ranged from 1,515 in 1995 to 3,951 in 1997. Abundance of mature walleye at Rathbun Lake in 1997 is the highest recorded, and is about 3 times the density of 1984 estimates when the investigation started. It should be noted that these estimates do not represent the total spawning population at Rathbun, but only the subpopulation that uses the dam for spawning.

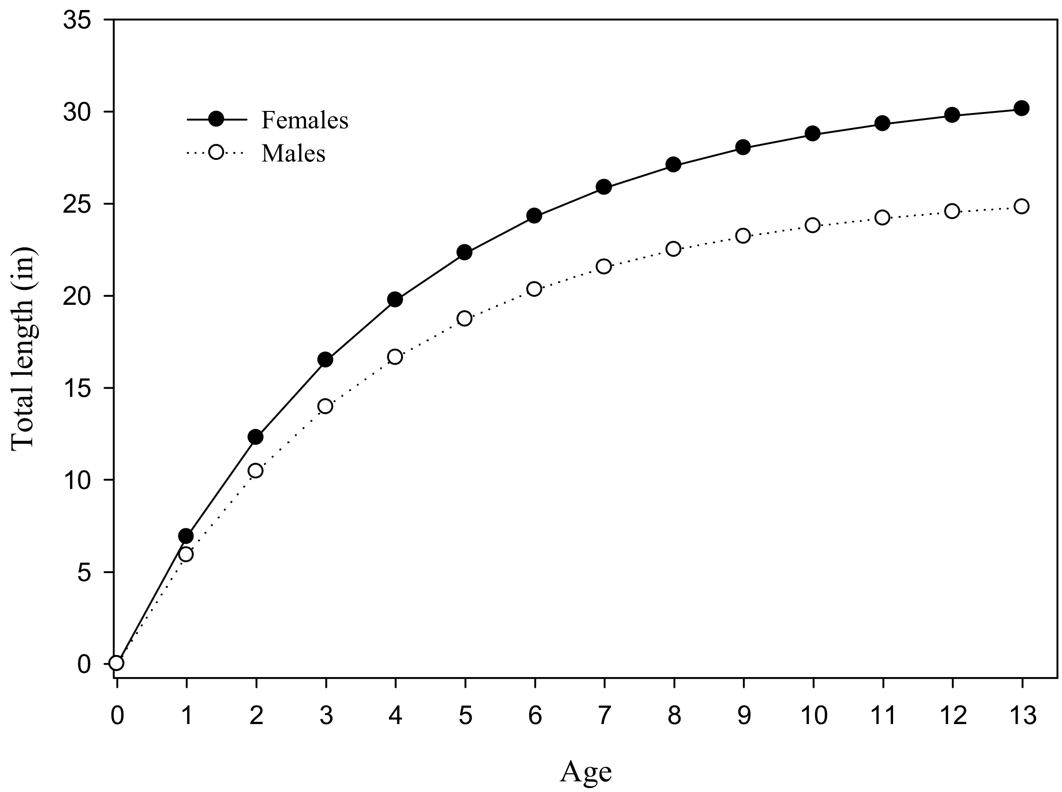

Figure 6.—Length at age of male and female walleye based on subsequent measurement of tagged fish after one year of growth

Table 10.—Length-weight regression constants of intercept (*a*), slope (*b*), and W_r for male and gravid female walleye sampled from Rathbun Lake, 1984-1997, measurements in mm and grams.

	Male				Female			
Year	*N*	*a*	*b*	W_r	*N*	*a*	*b*	W_r
1984	55	-5.029	3.0206	98	58	-5.0639	3.0373	98
1985	53	-4.6938	2.8912	94	57	-5.1823	3.0861	102
1986	50	-5.4296	3.1600	94	52	-5.3802	3.1519	99
1987	51	-5.1805	3.0807	101	52	-4.6536	2.9075	112
1988	66	-5.1654	3.0857	108	37	-4.8848	2.9948	115
1989	50	-5.4279	3.1723	102	58	-6.2737	3.4843	103
1990	57	-4.2423	2.1750	90	84	-4.7536	2.9066	93
1991	658	-5.8319	3.3038	91	776	-5.4411	3.1708	98
1992	732	-5.4945	3.1723	87	239	-5.8080	3.2929	104
1993	777	-5.2719	3.0957	90	148	-5.9245	3.3580	103
1994	178	-4.8944	2.9612	92	111	-5.1115	3.0695	109
1995	136	-5.0742	3.0265	92	92	-5.0935	3.0602	107
1996	634	-5.2738	3.1046	95	127	-5.3215	3.1434	108
1997	1367	-4.3384	2.7636	98	180	-5.2504	3.1231	112
1998	1079	-4.8670	2.9545	95	123	-5.4758	3.2012	109
1999	1147	-5.2935	3.1106	94	294	-5.4028	3.1704	106
2000	1209	-5.6281	3.2333	94	349	-6.1770	3.4527	107

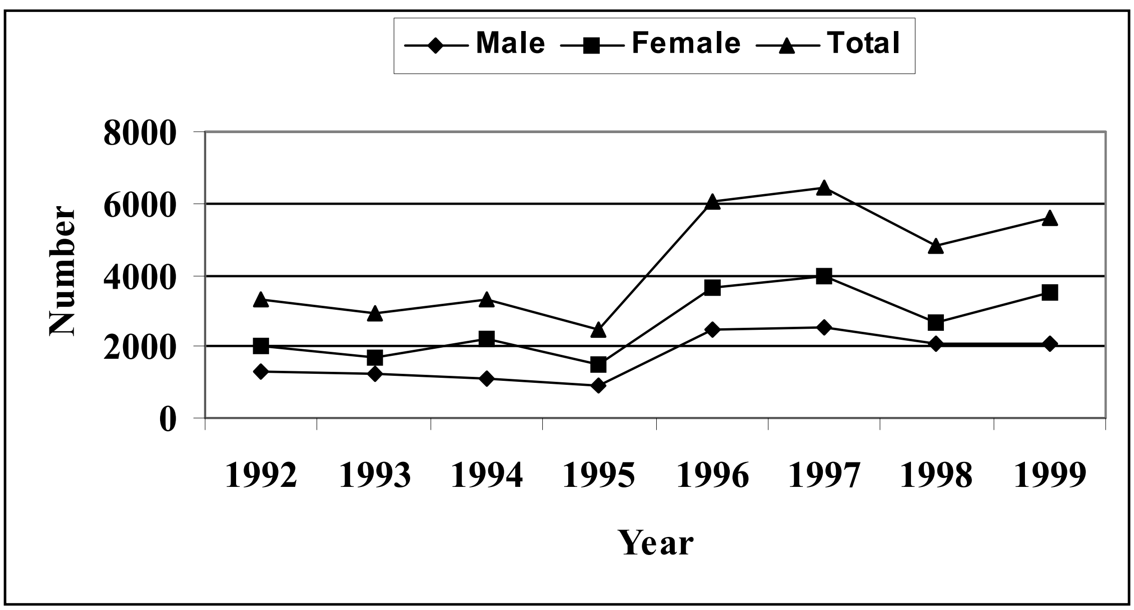

Figure 7.—Population estimates of male and female walleye, > 17.5 inches at Rathbun Lake, 1992-99.

There was a positive relationship between population abundance and April gillnetting catch per unit effort (CPUE) during brood fish collection. Figures 8 and 9 show these relationships for male and female. As population density increased so did the CPUE. For example, when the estimate was greater than 2,500 the CPUE for males was about 140 per net night. When female density increased to about 4,000 the CPUE was approximately 200 per net night. Lower densities yielded lower CPUE values for both males and females. The *r*-squared value for males was 0.86, while the *r*-squared value for females was 0.66.

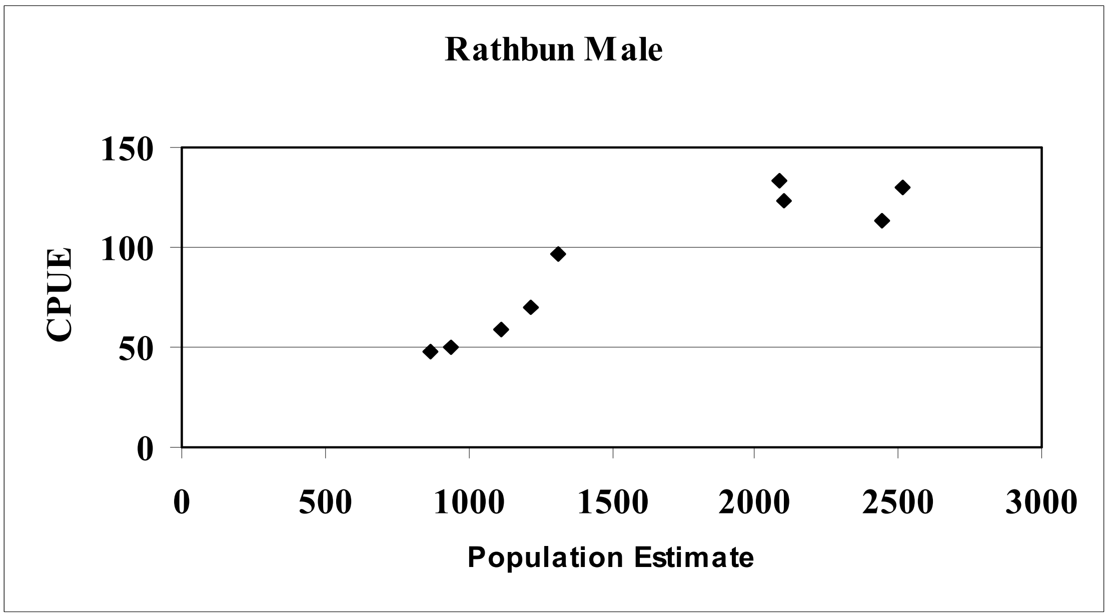

Figure 8.—Relationship between population abundance and spring gillnetting CPUE for male walleye at Rathbun Lake.

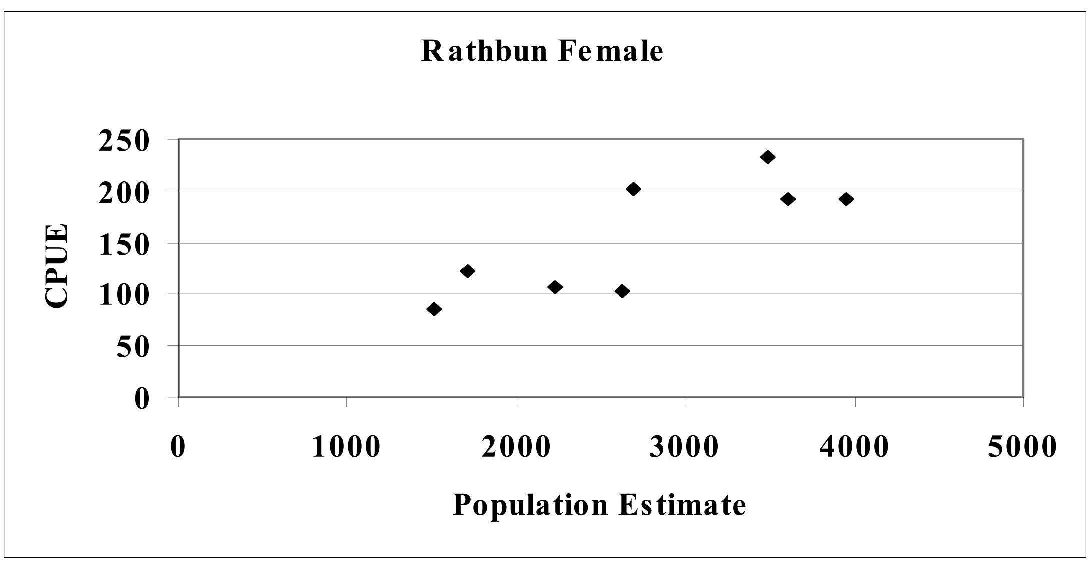

Figure 9. Relationship between population abundance and spring gillnetting CPUE for female walleye at Rathbun Lake.

There were also positive relationships between sex ratios, CPUE and population estimates. For example, in 1989 when CPUE was low the sex ratio was 0.5 males to 1 female. The opposite was true in 1997 when CPUE and population density was high. During this period the sex ratio was over 2 males to 1 female (Figures 10 and 11). A correlation coefficient between sex ratio and population estimate for males was 0.52. The coefficient between sex ratio and male CPUE was 0.57. Females showed the same relationship between sex ratio and population estimate, and sex ratio and CPUE. These correlations were 0.02 and 0.27, respectively.

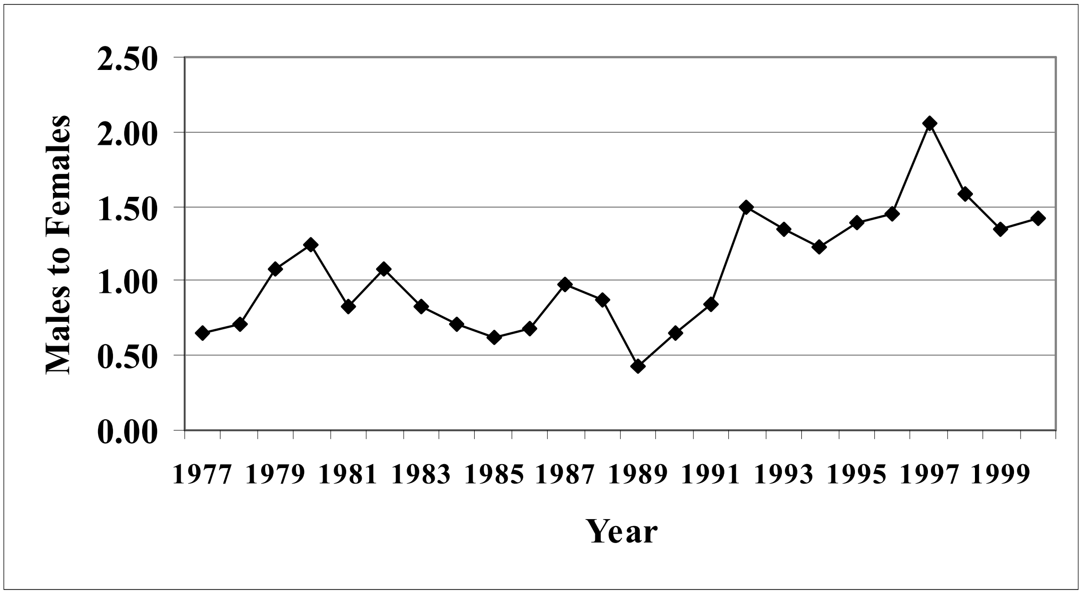

Figure 10.—Sex ratios of walleye at Rathbun Lake, 1977-2000.

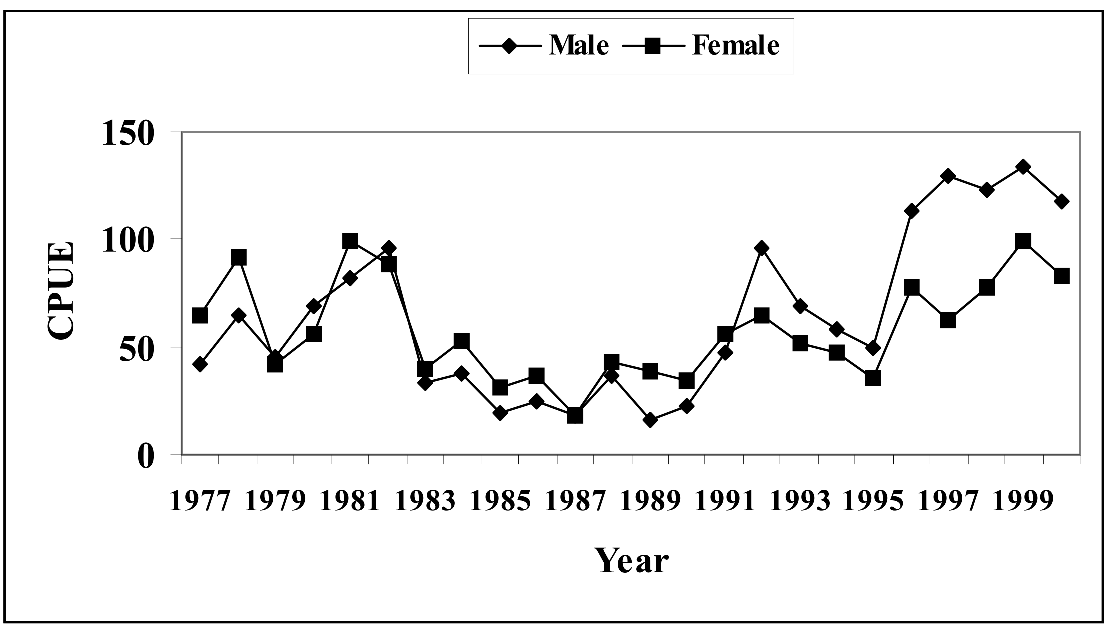

Figure 11. –CPUE of walleye in April broodfish gillnetting, 1977-2000.

Multiple regression between the dependent variable, population estimate, and independent variables, sex ratio and CPUE yielded *r*-values of 0.93 and 0.72, respectively for male and female. These multiple regression models were then used to estimate the population size previous to 1984 when population estimates by VI tagging were not available. Sex ratios and CPUE data were available from 1977-2000 (Figures 10 and 11). Predicted population abundance is shown in Figure 12.

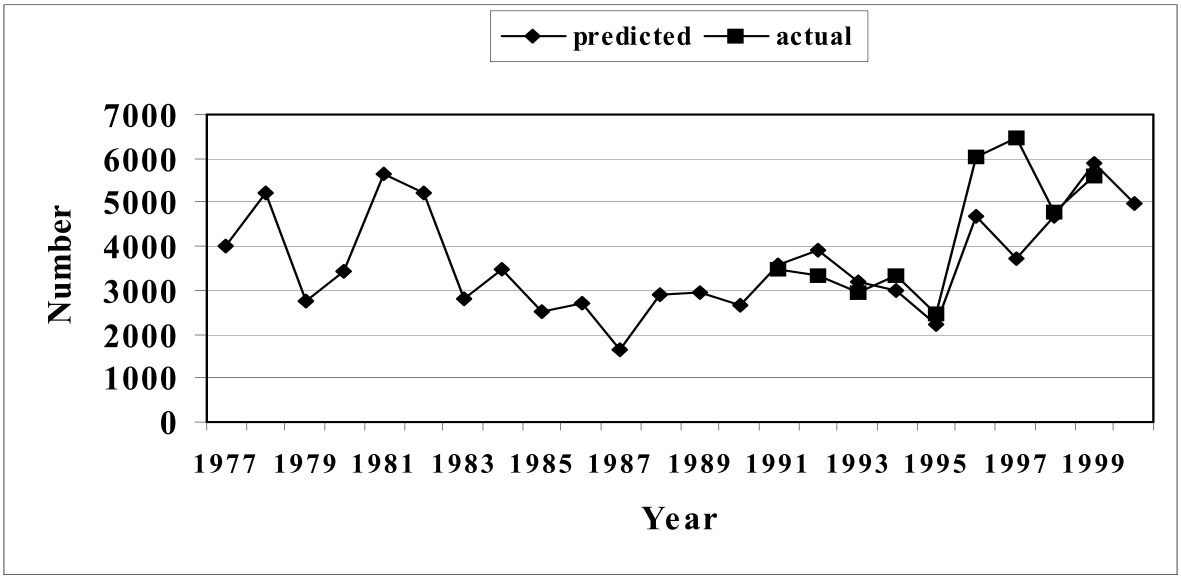

Figure 12.—Predicted population abundance of Rathbun Lake walleye, 1977-2000 based on multiple regression of 1992-1999 population estimates on sex ratio and CPUE.

Size Structure

Length-frequency distribution of walleye caught in gill nets in April, 1984-2000, showed a decrease in size, particularly for female fish. For example, in 1985 mean length of females was 26.7 inches with a mode of 27 inches. Length statistics for males was 22.7 inches mean length and a mode of 23 inches (Figure 13). In 2000, female walleye were more uniformly distributed in size groups from 18-31 inches with a mode at 23 inches and a mean length of 24.0 inches (Figure 14). Male walleye size distribution in 2000 showed a size range of 15-28 inches with an average of 21.6 inches and a mode of 21 inches.

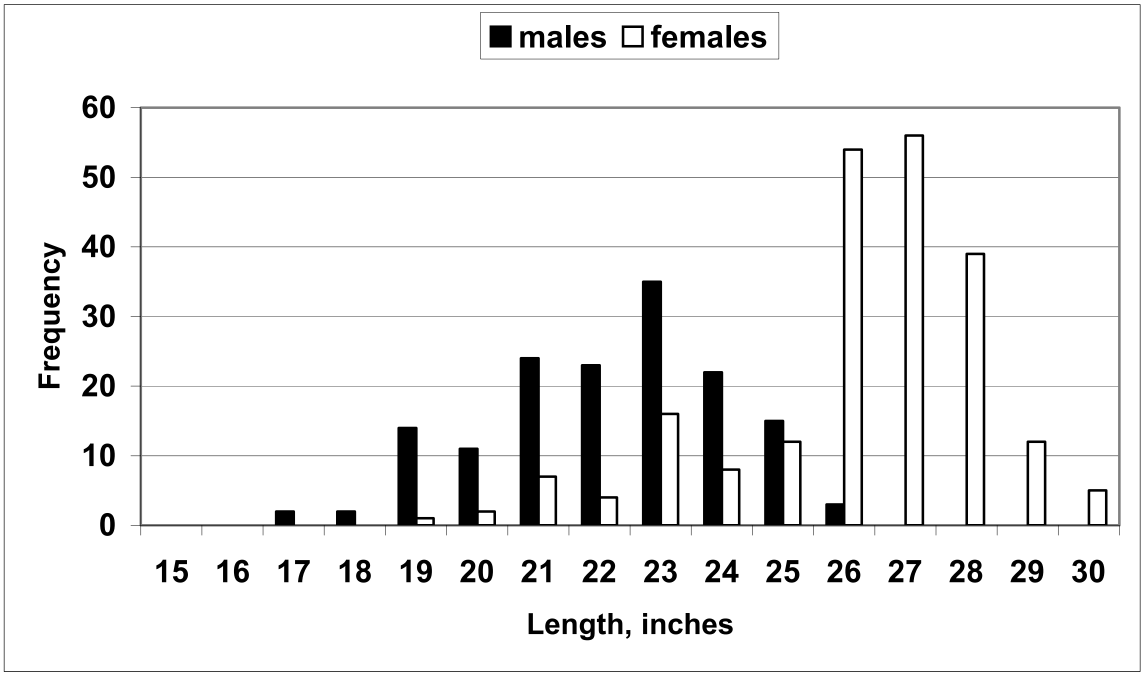

Figure 13.—Length frequency distribution of male and female walleye collected during broodfish take at Rathbun Lake, 1985.

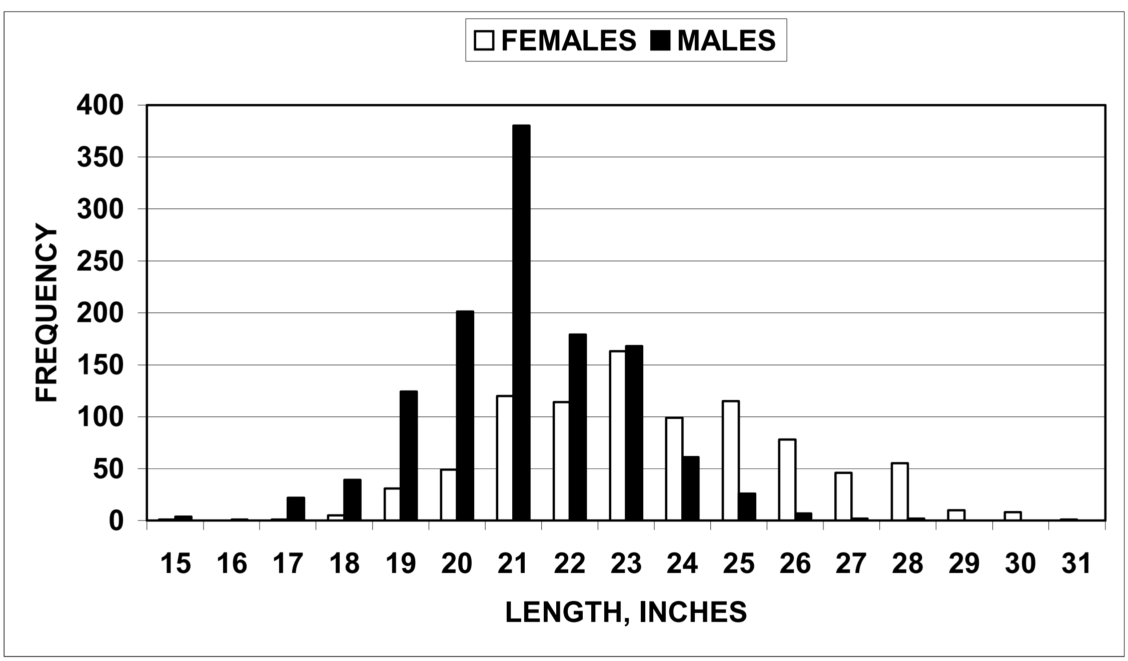

Figure 14.—Length frequency distribution of male and female walleye collected during broodfish take at Rathbun Lake, 2000.

Recruitment

Size distribution of walleye in spring brood collections varied primarily as result of recruitment. As stocked fish were recruited to the population at about age four, the mean length increased or decreased depending on the strength of these year classes. For example, improved recruitment caused mean length of female walleye to decrease to a low of 22.2 inches in 1989 from a high of 26.7 inches in 1985 (Figure 15). A similar trend was shown for male walleye where recruitment caused a decrease in mean length from 22.7 inches in 1985 to 20.6 inches three years later. After 1989 mean length became stable, but varied depending upon recruitment from year to year.

Overall survival rate for male walleyes was 0.50 with no significant difference between years ($P > 0.05$). Annual survival rate of female walleye was more variable between years and ranged from 1.37 for fish bearing 1991 tags to 0.18 for fish bearing 1992 tags (Figure 16). The overall average survival rate of 0.69 for females was significantly greater than that of males ($P < 0.01$).

Sources of Mortality

Survival estimates from Visual Implant tag returns, 1990-1998, were based upon recoveries shown in Appendix C and Appendix D. Annual survival rate for male walleye ranged from 0.65 for fish bearing 1995 tags to 0.48 for fish bearing 1998 tags (Figure 16).

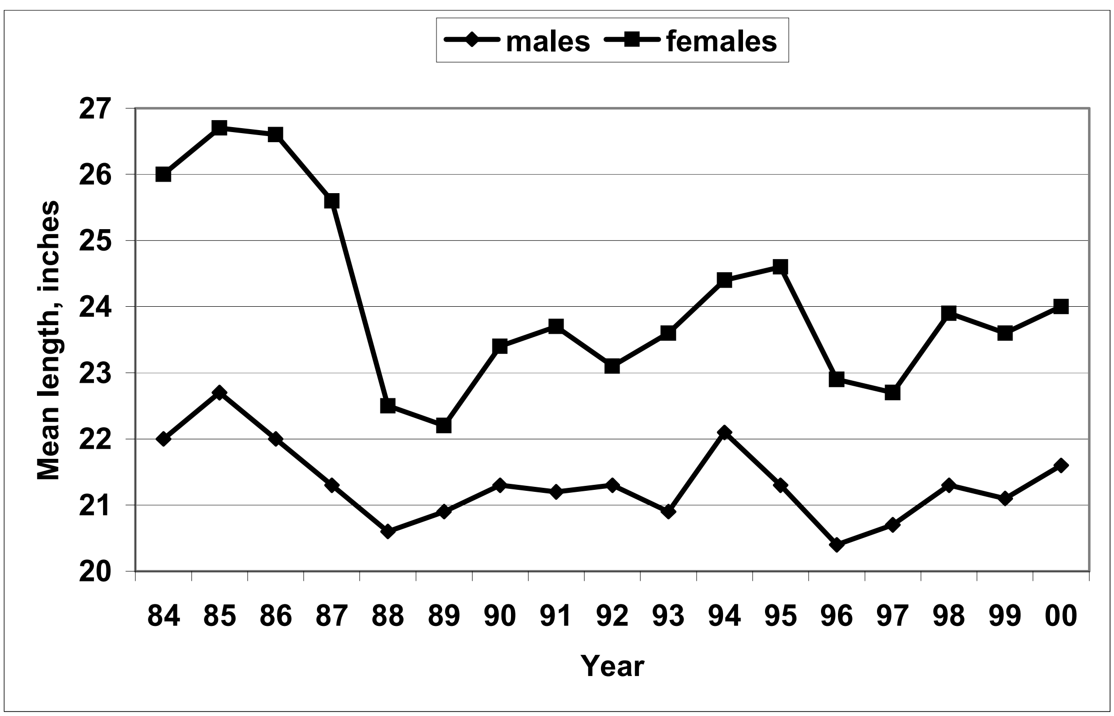

Figure 15.—Mean length of male and female walleye caught during broodfish collection at Rathbun Lake, 1984-2000.

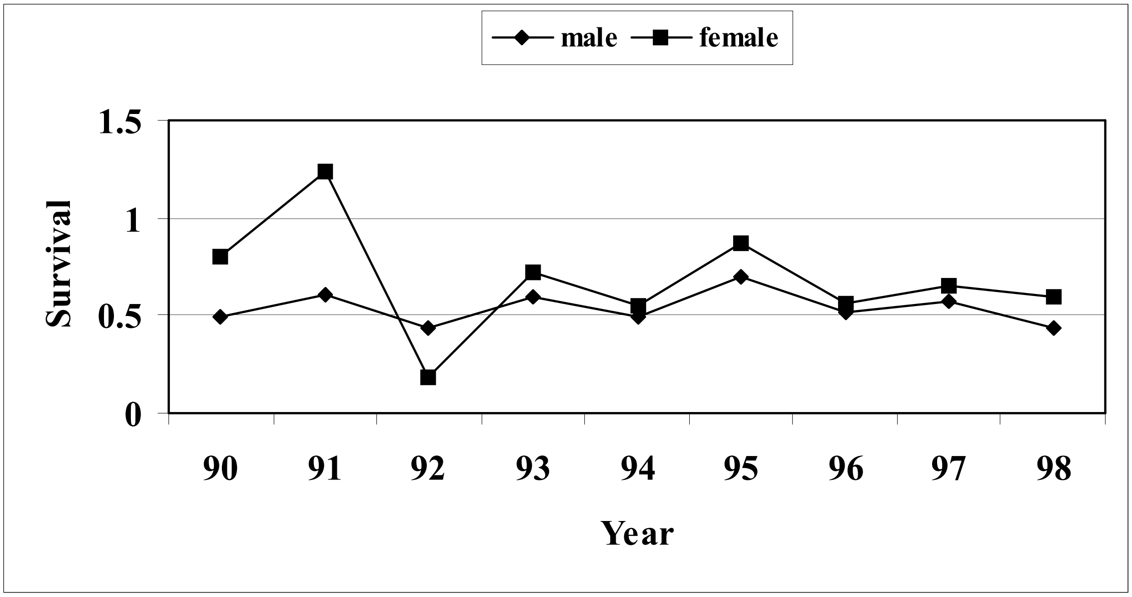

Figure 16.—Survival estimates of male and female walleye at Rathbun Lake, 1990-98.

Natural mortality rate of walleye greater than 18 inches was estimated from the function

$$A = m + n - (m*n)$$

where A is average annual mortality, males and females combined, m is average annual fishing mortality and n is average natural mortality. Solving for n yielded a natural mortality rate of 29.2%.

Walleye harvest at Rathbun Lake ranged from 13,585 in 1972 to approximately 900 in 1986 and 1995 (Table 11). Trends in harvest showed the lack of recruitment in the late 70's and early 80's. This was evident by low harvest and large fish in the creel. For example, catches in 1981-1985 showed annual harvest of about 1,000 walleye and mean length in the creel increased to 18.7 inches. Intensified and more uniform stocking commenced in 1984 and these year classes began to recruit to the sportfishery in 1987. As a result, catches increased and size decreased. In 1988, harvest had increased to 9,242 fish and fluctuated between 1,200 in 1993 and 8,500 in 1996. The low catch in 1993 and 1995 was attributed to the record floods and high water those years. Size of harvested fish ranged from 18.7 inches in 1985 to 14.0 inches in 1989. Mean length of walleye caught increased to 17.5 inches in 1992, but decreased to 14.9 inches in 1995, followed by an increase to 16.7 inches in 1997.

Rate of angler exploitation was estimated by the ratio of marked to unmarked fish ≥17 inches examined by the creel clerk. These estimates ranged from 6% in 1986 to 28% the following year (Table 11). Over the 12-year period, exploitation rate averaged 16% with a median of 18%. Exploitation rate was not computed in 1995, because only 5 walleyes, ≥ 17 inches, were examined by the creel clerk and no recaptures were found. Exploitation rate in 1997 was estimated at 11% based on volunteer angler diary information as well as walleyes examined by the creel clerk.

Table 11.—Walleye harvest, number released, mean length of fish harvested and exploitation rate at Rathbun Lake.

Year	Harvest	Released	Mean length (inches)	Exploitation rate ≥ 17 inches
1972	13,585		--	
1973	9,194		13.3	
1974	4,627		14.8	
1975	7,131		15.2	
1976	1,292		14.2	
1977	1,746		14.1	
1978	2,929		15.0	
1981	1,345		11.0	
1984	1,064		19.8	.12
1985	1,317	2,160	18.7	.11
1986	872	1,247	16.3	.06
1987	6,456	8,069	15.2	.28
1988	9,242	7,823	15.2	.24
1989	5,823	7,765	14.0	.22
1990	--	--	14.5	--
1991	2,223	9,686	15.0	.15
1992	5,142	1,136	17.5	.21
1993	1,167	10,276	16.9	.09
1994	5,213	33,824	16.1	.23
1995	845	11,325	14.9	--
1996	8,492	10,560	16.5	.07
1997	4,457	10,172	16.7	.11

In April 1997, 1,497 walleye were VI tagged. During the fishing season 105 walleye ≥ 17 inches were examined or reported in diaries, and of these 22 carried 1997 VI tags. Expansion of the creel survey data revealed an estimated 758 walleye ≥ 17 inches were harvested, thus exploitation rate was estimated at 11%. Exploitation rate of walleye less than 18 inches was unknown.

Length distribution of walleye in the creel showed anglers harvested walleye when they reached 14-15 inches in length (Figure 11). This length was a self-imposed length limit and was apparent throughout the entire study. The creel clerk also inquired how many walleyes were released and the estimated lengths of these fish. The size distribution of released fish indicated 98.7% of the fish were < 13 inches. Number of released fish ranged from 1,136 in 1992 to 33,824 in 1994, most of which were yearling walleyes (Table 11) and most of these were inadvertently caught by crappie anglers in May-June.

Walleye regulations

One of the objectives of this investigation was to determine if there was a need to regulate the walleye fishery at Rathbun Lake. Two approaches were available including the empirical method of implementing restrictions and "see what would happen"; the other option was to examine population models and simulate responses to various harvest restrictions.

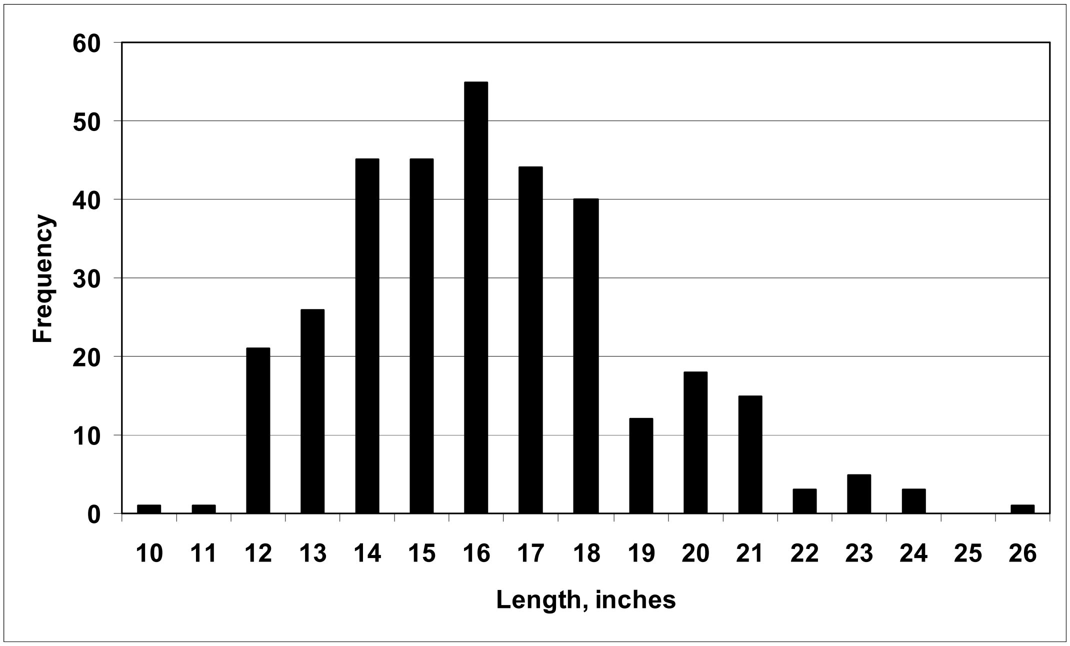

Figure 17.—Length frequency of harvested walleye at Rathbun Lake, 1997.

The advantage of the latter approach was that it had the capability of examining various regulations simultaneously. This investigation provided information since 1984, adequate to simulate population response to size limits and angler noncompliance. The Fishery Analyses and Simulation Tools (FAST 1.0) was chosen to provide these scenarios (Slipke and Maceina 2000).

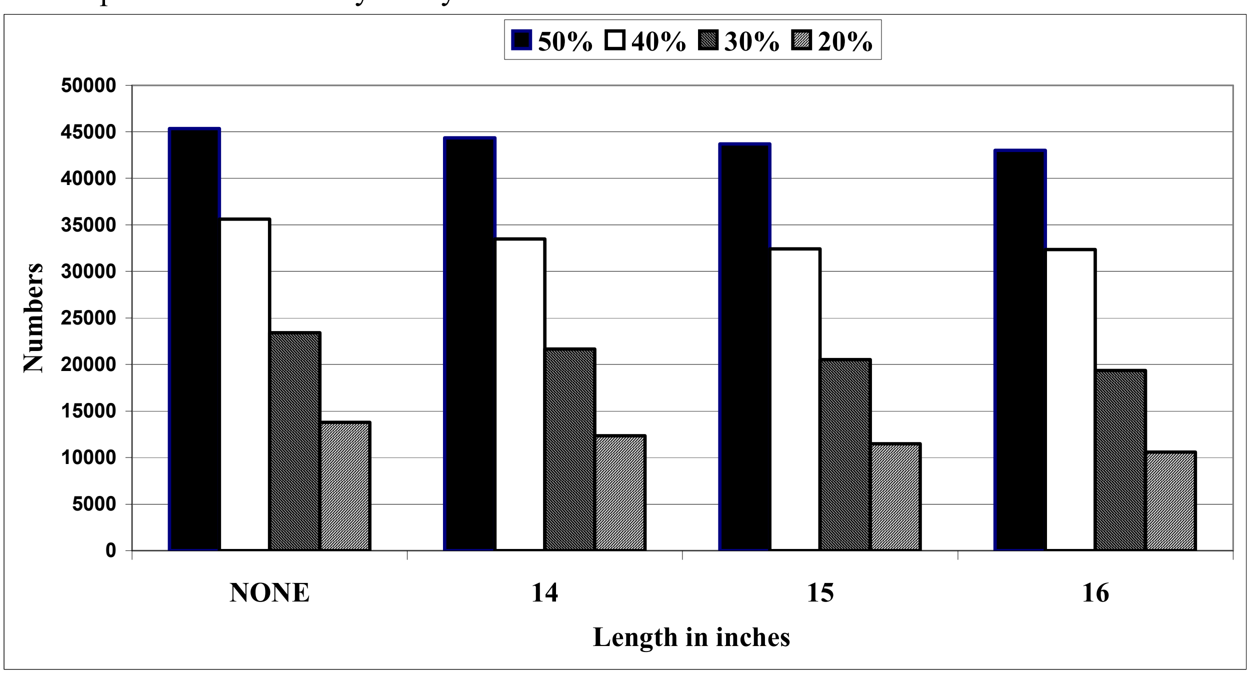

Figure 18.—Estimated harvest of walleye at Rathbun Lake when subjected to four levels of angler exploitation, plus the impact of three length limits imposed to restrict walleye harvest.

Output statistics were selected when equilibrium was attained after 16 consecutive years of stocking at the current rate, and assuming 100 percent compliance by anglers. Estimated walleye harvest increased with increasing exploitation rate; however, as harvest restriction changed from none (present) to 16 inches angler harvest remained nearly constant (Figure 18). For example, with no restriction, angler harvest was estimated about 14,000 fish for a 20 percent rate of exploitation. Harvest increased to 45,000 fish when the rate of exploitation was increased to 50 percent. Angler harvest decreased from 14,000 fish to 10,600 fish when low levels of exploitation (20%) were combined with a 16-inch minimum limit.

Yield followed the opposite trend. As regulation became more restrictive, yield increased, although not greatly (Figure 19). For example, at low exploitation of 20 percent yield increased from 3.3 lb/ac (no limit) to 3.5 lb/ac (16-inch minimum). As exploitation rate increased to 50 percent yield increased from 8.0 lb/ac (no limit) to 11.3 lb/ac (16-inch minimum).

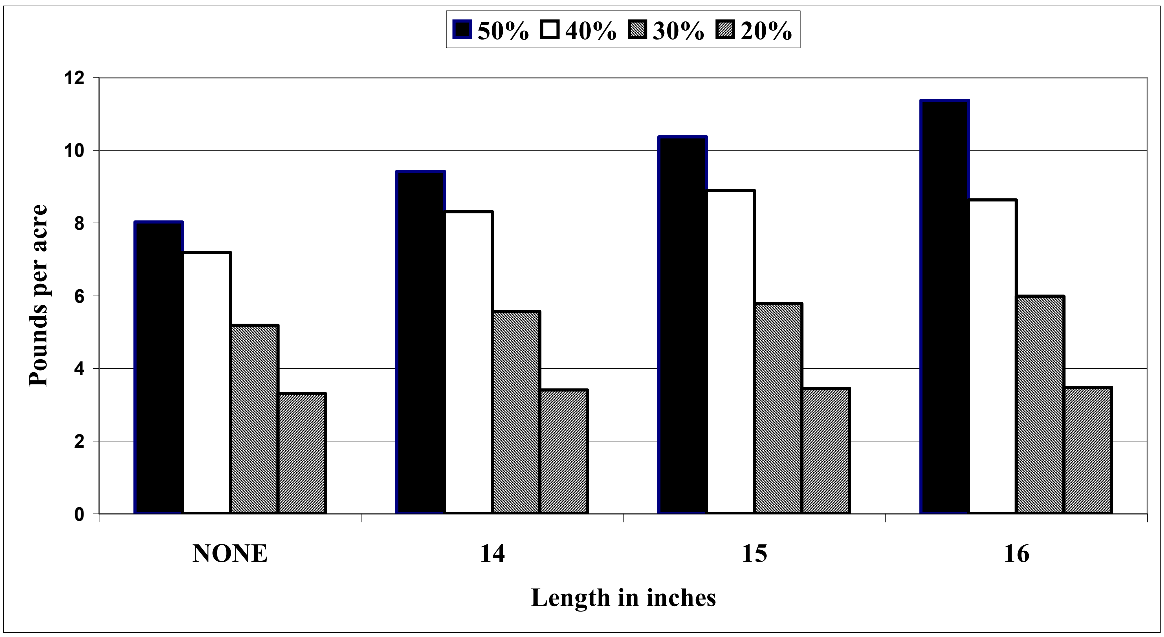

Figure 19.—Estimated yield of walleye at Rathbun Lake when subjected to four levels of exploitation, plus the impact of three length limits imposed to restrict walleye harvest.

The foregoing simulations and scenarios were based on several assumptions such as constant and uniform recruitment and a hooking mortality of 15 percent. Another fixed stipulation of model was 100 percent compliance of the restriction. Multiple simulations were compared to establish the effectiveness of various size restrictions based on varying degrees of noncompliance. These comparisons showed a small amount of noncompliance would rapidly negate the effectiveness of the size limit. Computer simulation showed the effectiveness of a 14-inch limit would be reduced to 13 inches if 10 percent of the fish harvested were illegal (under-sized). Therefore, the number of fish harvested and the number of fish remaining would not be that expected due to a 14-inch length limit, but rather that of a 13-inch limit. Other combination of size limit restriction and percent of illegal fish in the harvest are shown in Table 12. As noncompliance increased (greater percentages of illegal fish in the harvest) the impact of the size limit restriction would become greatly reduced.

Table 12.—Relationships between percent of illegal fish harvested at Rathbun Lake and three limits imposed to restrict simulated harvest of walleye. Values in the table show effective length limit with NE indicating no effect.

	Percent illegal fish in creel					
Length limit (in)	10	15	20	25	30	35
14	13.0	12.6	NE	NE	NE	NE
15	14.0	13.6	13.2	NE	NE	NE
16	14.7	14.2	13.8	13.4	13.0	NE

DISCUSSION

An average of 45,145 fingerling walleyes were stocked annually in Rathbun Lake tributaries from 1997-2005, excluding 1999. Mean daily growth was nearly 1 mm/d on fish collected > 7 dps in the tributaries. Mark retention in otoliths was high (> 98%) when fish were collected in the tributaries up to 65 dps. OTC marks were not found in any YOY walleyes that were collected during fall electrofishing in the main lake.

Sites with good prey abundance and reasonable flow were chosen for stocking sites. However, fish were stocked at alternate upstream sites during some years because of high flows. We felt that high flows might “flush” the small fish downstream to Lake Rathbun too early, not allowing them adequate time to take advantage of abundant prey in the tributaries.

Mark retention is an important factor when chemically marking fish, because one assumption is that the marks remain identifiable on the fish (Nielsen 1992). OTC has become a popular chemical mass marker for assessing the success of various stocking methods (Brooks et al. 2002; Isermann et al. 2002; Lucchesi 2002; Vandergoot and Bettoli 2003).

The cost of using OTC to mark juvenile fish is comparable to the cost of freeze-branding and is considerably cheaper than that of CWT. The cost of using OTC as a marker is primarily associated with otolith analysis and the replacement cost of fish that are sacrificed for analysis

Spine analysis for OTC marks is an attractive method because it is non-lethal and eliminates costs associated with replacement of sacrificed fish. In the present study detection of OTC marks in the dorsal spines of known marked fish was unreliable. Marks on the spines were very difficult to detect and spine analysis was discontinued after the first year of the study. Despite our results, others have had success analyzing spines for OTC. For example, Brown et al. (2002) found that OTC was easier to detect in spines than otoliths of yellow perch. Our difference in results could be due to the fact that these are different species. Hawkins (2002) found that analysis of dorsal spines using high pressure liquid chromatography (HPLC) was 100% accurate, but was considerably more expensive than visual detection methods.

OTC mark retention in otoliths of known marked fish that were collected in the tributaries was good. Similar mark retention of OTC in otoliths of juvenile walleyes has been observed in other studies (Vandergoot and Bettoli 2003, Lucchesi 2002; Brooks et al. 1994). Mark retention of OTC is similar for both juvenile and adult walleye. Also, CWT can cause higher mortality rates, depending upon fish size and tag implant location (Heidinger and Cook 1988).

Growth rates of the walleyes stocked in the tributaries of Lake Rathbun were comparable to fish raised in similar latitude (Carlander 1997). Interestingly, these growth rates were only somewhat lower than that of walleyes fed diet WG 9206 in the Rathbun Culture Research Facility (Johnson and Rudacille 2003), which is the current recommended diet at the IDNR Rathbun Fish Hatchery.

We used multiple regression analysis to determine whether certain biological and environmental factors were significant predictors of mean daily growth of walleyes in the tributaries. Fish IBI and fish CPUE described the condition of the fish community and species abundance, respectively. These measurements were calculated from sampling at the sites where walleyes were stocked and then collected post stocking. They were not good predictors of mean daily growth, which may be due to the fact that backpack electrofishing may have failed to collect the smaller larval prey fishes, which would have been the walleye's main diet, thus influential in their growth rate. We speculate that we mainly collected fish that were too large for the walleye's gape.

Discharge was not a significant predictor of mean daily growth. Unfortunately, discharge data was not available for individual sites or even tributaries. The USGS currently has two gauging stations in the Lake Rathbun watershed; one on the Chariton River near Chariton (06903400) and one on the Southfork of the Chariton River near Promise City (06903700). A more detailed description of discharge in the watershed may have been better able to predict walleye growth.

Habitat assessment scores were significant predictors of walleye growth. In particular, the percent channelization and age of channelization were significantly and positively correlated with mean daily growth. In other words, mean daily growth increased in stream reaches where channelization was recent. Recently channelized stream reaches were very uniform in shape and had little instream cover. Interestingly, mean daily growth was negatively correlated with % total instream cover and % woody debris, although the relationships were marginally significant for both variables. Potential predators were commonly collected in non-channelized reaches with significant instream cover, especially woody debris. Walleyes may have experienced better growth in channelized reaches because there was less competition for food, greater supply of small prey species, and a lesser threat of being preyed upon themselves.

We did not collect any OTC-marked fish while fall electrofishing in the main lake. This could be the result of several factors. First, our sample size may have been too small. For example, in 2005, the ratio of main lake stocked fish to tributary stocked fish was 1,141 to 1. We only analyzed 70 fish from the main lake for OTC-marked otoliths. In addition, we failed to identify OTC-marked spines in sampled fish, perhaps due to poor assimilation of OTC in the spines. Second, it is possible that the tributary-stocked fish failed to contribute to the main lake YOY population (i.e. due to poor survival). Gelwicks (2001) stocked 2 in fingerlings in the tributaries of some of Iowa's large interior rivers. The contribution of these fish to their fall electrofishing samples was lower than expected, and lower than the contribution of walleye stocked into the main stem of the rivers. Gelwicks (2001) also observed that 2 in fingerlings stocked into the larger interior rivers resided near their stocking site until the following spring. So, as a third explanation, walleyes in the present study may not have entered the main lake until the following spring, and our study concentrated on collecting and analyzing YOY walleye for OTC marks. In addition to the tributary-stocked fish used in this study, fry and advanced fingerlings are stocked in the main lake. The walleyes that were stocked as advanced fingerlings in the fall were significantly larger than fingerlings stocked as fry. The difference in the size of these two groups is likely due to the intensive culturing (i.e., consistent, high protein diet received through the growing season).

Minimum length regulations on the harvest of walleye from Rathbun Lake would provide little increase in walleye broodstock abundance or biomass. At the present level of exploitation, of approximately 25%, the brood stock population might be anticipated to increase by less than 10% if a 14-inch minimum size limit were imposed. Such a small response would be offset by 10-15 % illegal fish in the creel. Little has been mentioned in the literature on the impact of angler noncompliance of walleye regulations. However, noncompliance studies for other species exist. Pierce and Tomcko (1998) found high angler noncompliance of a slot length limit for northern pike in the order of magnitude of 6-19 percent with an average noncompliance of 13 percent. Voluntary tag returns showed an average of 19 percent of creeled fish were illegal, negating the affect of the regulation. Paragamian (1984) found 8 percent noncompliance on a minimum length limit for smallmouth bass, while Mayers (1988) found angler noncompliance rates of 29 percent for largemouth bass in four Wisconsin lakes. Lower levels of noncompliance were demonstrated by Mosher (1991) for bass in Kansas impoundments. In 20 creel surveys the average was 7 percent noncompliance; however in five surveys the range was 11-23 percent noncompliance.

Although some investigations on the impact of size restrictions are presently underway, few walleye size limit restrictions have been thoroughly evaluated. Brousseau and Armstrong (1987) addressed the role of walleye size limits in management, but only as a general topic. Schneider (1978), likewise, addressed the general impact of size restriction on walleye populations, but applied a more analytical approach to the subject. Serns (1978) and Serns and Kempinger (1981) have provided the only long-term, comprehensive assessment of walleye size limit restrictions. These studies at Wolf and Crooked Lakes, Wisconsin, showed the importance of treating populations as individual entities. That is, what may work for one population may not work in a nearby lake. The inference by all four studies (Brousseau and Armstrong (1978), Schneider (1978), Serns (1978), and Schneider and Serns and Kempinger (1981)) is that distinctive characteristics of the populations in question will determine the value of any regulation that is imposed.

Investigations designed to assess changes in walleye harvest regulations have produced mixed results. For, example Moser (1991) demonstrated no effects were apparent from a 15-inch minimum length limit in Ohio. Conversely, Munger and Kraai (1997) provided evidence that a 16-inch size limit and a 10-fish daily bag limit improved the fishery at Meredith Reservoir, Texas. Harvest rate and yield both increased, but the change was not significant. Density of legal-size fish increased. Mosindy et al. (1987) demonstrated the need for harvest restriction on highly vulnerable, slow-growing walleye populations in a boreal lake in Ontario.

Goeman et al. (1995) developed criteria for assessment of special fishing regulations, regardless of species. They emphasized the importance of sound science as the basis for implementation and assessment of special regulations. Furthermore, politically influenced special regulations based on whim or fad should be treated with caution. Johnson and Martinez (1995), and Radomski and Goeman (1996) suggested modeling as a necessary tool for fisheries management, particularly when fisheries regulations are at stake. For example, Jacobson (1996) showed the value of modeling a walleye population for a trophy fishery in Minnesota. Similarly, Zagar and Orth (1986) showed the value of modeling various regulation scenarios for largemouth bass.

In summary, walleyes stocked in the tributaries of Lake Rathbun had high OTC mark retention in their otoliths, up to 65 days post stocking. The growth rates of walleyes in the tributaries were comparable to those of walleyes in similar latitude, and intensively-grown walleye in culture facilities. The contribution of tributary stocked fish to the main lake YOY walleye population remains uncertain. This study has important implications for stocking and managing walleyes in Iowa's reservoirs and lakes. This project warrants further investigation. However, the methods must be revised to provide more conclusive results, including recommendations 1 - 4 below. Additionally, walleye population modeling at Rathbun Lake showed minimum length limits would provide little if any improvement in the biomass of brood-sized walleye. Furthermore, the angler would have to sacrifice harvest with little benefit to the resource.

RECOMMENDATIONS

1. Freeze-branding - Visual detection of brands is simple, inexpensive, and non-lethal. A unique brand could be designated for each tributary. The contribution of tributary-stocked fish to the main lake YOY walleye population, the brood stock population, and the creel could be visually determined.

2. Tributary sampling - Sampling for walleyes in the tributaries should be completed for all streams on the same dates, 2-3 times post stocking. This may require a reduction in the number of sites where fish are stocked. Environmental and biological variables should also be measured (e.g. flow, invertebrates, larval fish, etc.) in conjunction with fish sampling. This sampling regime would allow better statistical comparisons to be made among streams, which would allow us to determine those factors that are influential to growth, survival, etc.

3. Movement of fish to main lake - Backpack shocking the tributaries in the winter months (weather permitting) could help determine whether these fish over-winter in the tributaries their first year. If walleyes do over-winter in the tributaries, deep holes may be important for their survival.

4. Growth in channelized streams - Future research in channelized streams should focus on growth, density and biomass.

5. Continue to measure the adult walleye population – Emphasis should be on exploitation rate and contribution of stocked fry and fingerling to the broodfish population.

6. Catch per unit effort (CPUE) and size structure—Continue to document male and female in April gillnetting.

7. October experimental gillnet sampling—Continue to document to provide further evidence of year-class strength.

8. Population size—Use spring brood collection CPUE and sex ratio to estimate population size.

9. Age-0 electrofishing—Continue fall electrofishing survey for age-0 walleye to determine success of fry and fingerling stocking. The quality of the walleye fishery is dependent upon survival and recruitment of young fish.

10. Continue creel surveys—Minimum size limit restrictions on walleye at Rathbun Lake are not needed, provided exploitation rates remain less than 30%

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Appendix A.---Dates and sites of walleye stocking in the Rathbun watershed.
Site codes for each site are also delineated.

Month	Day	Year	Sites	Site code
7	2	1997	Chariton River 2	CR2
7	2	1997	Chariton River 6	CR6
7	2	1997	Dick Creek 1	DC1
7	2	1997	Fivemile Creek 3	FM3
7	2	1997	Jackson Creek 1	JA1
7	2	1997	Jordan Creek 2	JC2
7	2	1997	Southfork Chariton River 3	SF3
7	2	1997	West Jackson 5	WJ5
7	2	1997	Wolf Creek 1	WC1
6	18	1998	Dick Creek 1	DC1
6	18	1998	Jackson Creek 1	JA1
6	18	1998	Jordan Creek 2	JC2
6	18	1998	Ninemile Creek 2	NM2
7	1	1998	Chariton River 2	CR2
7	1	1998	Chariton River 6	CR6
7	1	1998	Fivemile Creek 3	FM3
7	1	1998	Southfork Chariton River 3	SF3
7	1	1998	West Jackson Creek 5	WJ5
7	1	1998	Wolf Creek 1	WC1
6	29	2000	Chariton River 2	CR2
6	29	2000	Chariton River 6	CR6
6	29	2000	Jackson Creek 1	JA1
6	29	2000	Jordan Creek 2	JC2
6	29	2000	Fivemile Creek 3	FM3
6	29	2000	Southfork Chariton River 3	SF3
6	29	2000	West Jackson 5	WJ5
6	29	2000	Wolf Creek 1	WC1
6	27	2001	Chariton River 2	CR2
6	27	2001	Chariton River 6	CR6
6	27	2001	Dick Creek 1	DC1
6	27	2001	Fivemile Creek 3	FM3
6	27	2001	Jackson Creek 1	JA1
6	27	2001	Jordan Creek 2	JC2
6	27	2001	Ninemile Creek 2	NM2
6	27	2001	Southfork Chariton River 3	SF3
6	27	2001	West Jackson 5	WJ5
6	27	2001	Wolf Creek 1	WC1
6	21	2002	Chariton River 2	CR2
6	21	2002	Chariton River 6	CR6
6	21	2002	Dick Creek 1	DC1
6	21	2002	Fivemile Creek 3	FM3
6	21	2002	Ninemile Creek 2	NM2
6	21	2002	Southfork Chariton River 3	SF3
6	21	2002	West Jackson 5	WJ5
6	21	2002	Wolf Creek 1	WC1
7	8	2003	Chariton River 6	CR6
7	8	2003	Chariton River 8	CR8

Appendix A.—Continued

Month	Day	Year	Sites	Site code
7	8	2003	Southfork Chariton River 3	SF3
7	8	2003	West Jackson 5	WJ5
7	8	2003	Wolf Creek 1	WC1
6	23	2004	Chariton River 2	CR2
6	23	2004	Chariton River 6	CR6
6	23	2004	Dick Creek 1	DC1
6	23	2004	Jackson Creek 1	JA1
6	23	2004	Jordan Creek 2	JC2
6	23	2004	Fivemile Creek 3	FM3
6	23	2004	Ninemile Creek 2	NM2
6	23	2004	Southfork Chariton River 3	SF3
6	23	2004	West Jackson 5	WJ5
6	23	2004	Wolf Creek 1	WC1
6	30	2005	Chariton River 2	CR2
6	30	2005	Chariton River 6	CR6
6	30	2005	Dick Creek 1	DC1
6	30	2005	Jackson Creek 1	JA1
6	30	2005	Jordan Creek 2	JC2
6	30	2005	Fivemile Creek 3	FM3
6	30	2005	Ninemile Creek 2	NM2
6	30	2005	Southfork Chariton River 3	SF3
6	30	2005	West Jackson 5	WJ5
6	30	2005	Wolf Creek 1	WC1

Appendix B.—Dates, locations, total lengths and presence or absence of OTC mark on otoliths of walleyes that were collected in Rathbun lake and the tributaries. X = OTC mark was detected on the otolith, O = no mark found on otolith and NA = not analyzed.

Date	Location	Total length (mm)	OTC
7/9/1997	CR 2	73	NA
7/9/1997	CR 2	68	NA
7/9/1997	CR 2	68	NA
7/9/1997	CR 2	71	NA
7/9/1997	CR 2	69	NA
7/9/1997	CR 2	62	NA
9/5/1997	SF 11	166	NA
8/29/1997	WJ 5	109	NA
8/27/1997	CR 6	160	NA
8/27/1997	CR 6	127	NA
8/27/1997	CR 6	144	NA
8/27/1997	CR 6	130	NA
8/27/1997	CR 6	115	NA
7/8/1998	WJ 5	97	X
8/5/1998	WJ 5	134	X
9/22/1998	Rathbun L., headwaters	210	O
9/22/1998	Rathbun L., headwaters	209	O
9/22/1998	Rathbun L., headwaters	202	O
10/29/1998	Rathbun L., A3	134	O
7/31/2000	SF 3	78	NA

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
7/31/2000	WJ 5	107	NA
7/31/2000	JA 1	138	NA
7/31/2000	JA 1	108	NA
7/31/2000	JA 1	116	NA
10/16/2000	Rathbun L, Run 2	223	O
10/16/2000	Rathbun L, Run 2	152	O
10/16/2000	Rathbun L, Run 2	201	O
10/16/2000	Rathbun L, Run 2	154	O
10/17/2000	Rathbun L, N. shore, Run 1	176	O
10/17/2000	Rathbun L, N. shore, Run 1	185	O
10/17/2000	Rathbun L, S. shore, Run 3	205	O
10/17/2000	Rathbun L, S. shore, Run 3	217	O
10/17/2000	Rathbun L, S. shore, Run 3	190	O
10/17/2000	Rathbun L, S. shore, Run 3	145	O
10/17/2000	Rathbun L, S. shore, Run 3	176	O
10/17/2000	Rathbun L, S. shore, Run 3	127	O
10/19/2000	Rathbun L, Run 3	121	O
10/19/2000	Rathbun L, Run 3	164	O
10/19/2000	Rathbun L, Run 3	158	O
10/19/2000	Rathbun L, Run 3	121	O
10/19/2000	Rathbun L, Run 3	128	O
10/19/2000	Rathbun L, Run 3	115	O
10/19/2000	Rathbun L, Run 3	167	O
10/19/2000	Rathbun L, Run 1	128	O
10/19/2000	Rathbun L, Run 1	188	O
10/19/2000	Rathbun L, Run 1	180	O
10/19/2000	Rathbun L, Run 1	134	O
10/19/2000	Rathbun L, Run 1	186	O
10/19/2000	Rathbun L, Run 1	137	O
10/19/2000	Rathbun L, Run 1	187	O
10/19/2000	Rathbun L, Run 1	142	O
10/19/2000	Rathbun L, Run 1	160	O
10/19/2000	Rathbun L, Run 2	159	O
10/19/2000	Rathbun L, Run 2	156	O
10/19/2000	Rathbun L, Run 2	139	O
10/19/2000	Rathbun L, Run 2	145	O
10/19/2000	Rathbun L, Run 2	140	O
10/19/2000	Rathbun L, Run 2	159	O
10/19/2000	Rathbun L, Run 2	151	O
10/19/2000	Rathbun L, Run 2	174	O
10/19/2000	Rathbun L, Run 2	126	O
10/19/2000	Rathbun L, Run 2	172	O
10/19/2000	Rathbun L, Run 2	165	O
10/17/2000	Rathbun L , Run 2	165	O
10/17/2000	Rathbun L , Run 2	175	O
10/17/2000	Rathbun L , Run 2	196	O
10/17/2000	Rathbun L , Run 2	187	O
10/17/2000	Rathbun L , Run 2	196	O

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
10/17/2000	Rathbun L , Run 2	210	O
10/17/2000	Rathbun L , Run 2	189	O
10/17/2000	Rathbun L , Run 2	159	O
10/17/2000	Rathbun L , Run 2	171	O
10/17/2000	Rathbun L , Run 2	137	O
10/17/2000	Rathbun L , Run 2	177	O
10/17/2000	Rathbun L , Run 2	170	O
10/17/2000	Rathbun L , Run 2	164	O
10/17/2000	Rathbun L , Run 2	153	O
10/17/2000	Rathbun L , Run 2	125	O
10/17/2000	Rathbun L , Run 2	160	O
10/17/2000	Rathbun L , Run 2	124	O
10/17/2000	Rathbun L , Run 2	178	O
10/16/2000	Rathbun L , Run 1	187	O
10/16/2000	Rathbun L , Run 1	159	O
10/16/2000	Rathbun L , Run 1	188	O
10/16/2000	Rathbun L , Run 1	187	O
10/16/2000	Rathbun L , Run 1	187	O
10/16/2000	Rathbun L , Run 1	181	O
10/16/2000	Rathbun L , Run 1	166	O
10/16/2000	Rathbun L , Run 1	212	O
10/16/2000	Rathbun L , Run 1	146	O
10/16/2000	Rathbun L , Run 1	144	O
10/16/2000	Rathbun L , Run 1	198	O
10/16/2000	Rathbun L , Run 1	170	O
10/16/2000	Rathbun L , Run 1	152	O
10/16/2000	Rathbun L , Run 1	157	O
10/16/2000	Rathbun L , Run 1	146	O
10/16/2000	Rathbun L , Run 1	176	O
10/16/2000	Rathbun L , Run 1	155	O
10/16/2000	Rathbun L , Run 1	151	O
10/16/2000	Rathbun L , Run 1	204	O
10/16/2000	Rathbun L , Run 1	164	O
10/16/2000	Rathbun L , Run 1	163	O
10/16/2000	Rathbun L , Run 1	196	O
10/16/2000	Rathbun L , Run 1	166	O
10/16/2000	Rathbun L , Run 1	188	O
10/16/2000	Rathbun L , Run 1	173	O
10/16/2000	Rathbun L , Run 1	144	O
10/16/2000	Rathbun L , Run 1	168	O
10/16/2000	Rathbun L , Run 1	157	O
10/16/2000	Rathbun L , Run 1	228	O
10/16/2000	Rathbun L , Run 1	169	O
10/16/2000	Rathbun L , Run 1	134	O
10/16/2000	Rathbun L , Run 1	200	O
10/16/2000	Rathbun L , Run 1	179	O
10/16/2000	Rathbun L , Run 1	150	O
10/16/2000	Rathbun L , Run 1	177	O

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
10/16/2000	Rathbun L , Run 1	198	O
7/26/2001	FM 2	115	NA
7/26/2001	FM 2	74	NA
7/26/2001	FM 2	64	NA
7/13/2001	FM 3	58	NA
7/13/2001	FM 3	52	NA
7/5/2001	JA 1	45	NA
7/5/2001	JA 1	50	NA
7/5/2001	JA 1	78	NA
7/9/2001	SF 5	244 (Age 1)	NA
8/22/2001	NM 3	125	NA
7/10/2001	JC 2	50	NA
7/15/2003	WJ 5	66	X
7/15/2003	WJ 5	69	X
7/15/2003	WJ 5	69	X
7/15/2003	WJ 5	67	X
7/15/2003	SF3	63	O
7/15/2003	SF3	70	X
7/15/2003	SF3	68	X
7/14/2003	CR 3	62	X
7/14/2003	CR 3	NA	X
7/14/2003	CR 3	67	X
7/14/2003	CR 3	62	X
7/14/2003	CR 3	64	X
7/14/2003	CR 3	70	X
7/14/2003	CR 3	73	X
7/14/2003	CR 3	NA	X
7/21/2003	SF 4	80	X
7/21/2003	SF 4	78	X
7/21/2003	SF 4	75	X
7/21/2003	SF 4	95	X
7/26/2003	CR 6	83	X
7/26/2003	CR 6	86	X
7/26/2003	CR 6	86	X
7/26/2003	CR 6	87	X
7/26/2003	CR 6	96	X
10/15/2003	Rathbun L, N. shore, Run 3	157	O
10/14/2003	Rathbun L, SF, Run 2	134	O
10/14/2003	Rathbun L, SF, Run 2	144	O
10/14/2003	Rathbun L, SF, Run 2	173	O
10/14/2003	Rathbun L, SF, Run 2	126	O
10/20/2003	Rathbun L, Bridgeview, Run 2	156	O
10/15/2003	Rathbun L, N. shore, Run 1	121	O
10/15/2003	Rathbun L, N. shore, Run 1	106	O
10/15/2003	Rathbun L, N. shore, Run 1	130	O
10/15/2003	Rathbun L, N. shore, Run 1	141	O
10/15/2003	Rathbun L, N. shore, Run 1	163	O
10/22/2003	Rathbun L, SF, Run 4	147	O

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
10/22/2003	Rathbun L, SF, Run 4	189	O
10/15/2003	Rathbun L, SF, Run 4	115	O
10/15/2003	Rathbun L, SF, Run 4	148	O
10/15/2003	Rathbun L, SF, Run 4	144	O
10/22/2003	Rathbun L, SF, Run 2	111	O
10/22/2003	Rathbun L, SF, Run 2	144	O
10/22/2003	Rathbun L, SF, Run 2	167	O
10/20/2003	Rathbun L, Bridgeview, Run 1	142	O
10/20/2003	Rathbun L, Bridgeview, Run 1	142	O
10/15/2003	Rathbun L, N. shore, Run 2	110	O
10/15/2003	Rathbun L, N. shore, Run 2	171	O
10/22/2003	Rathbun L, SF, Run 3	147	O
10/22/2003	Rathbun L, SF, Run 3	181	O
10/22/2003	Rathbun L, SF, Run 3	170	O
10/22/2003	Rathbun L, SF, Run 3	167	O
10/22/2003	Rathbun L, SF, Run 3	150	O
10/22/2003	Rathbun L, SF, Run 3	151	O
10/22/2003	Rathbun L, SF, Run 3	205	O
10/22/2003	Rathbun L, SF, Run 5	142	O
10/22/2003	Rathbun L, SF, Run 5	172	O
10/22/2003	Rathbun L, SF, Run 5	164	O
10/22/2003	Rathbun L, SF, Run 5	164	O
10/22/2003	Rathbun L, SF, Run 5	148	O
10/22/2003	Rathbun L, SF, Run 5	162	O
10/22/2003	Rathbun L, SF, Run 5	145	O
10/20/2003	Rathbun L, Bridgeview, Run 3	206	O
10/20/2003	Rathbun L, Bridgeview, Run 3	158	O
10/20/2003	Rathbun L, Bridgeview, Run 3	160	O
10/22/2003	Rathbun L, SF, Run 1	238	O
10/22/2003	Rathbun L, SF, Run 1	165	O
10/22/2003	Rathbun L, SF, Run 1	150	O
10/22/2003	Rathbun L, SF, Run 1	153	O
10/22/2003	Rathbun L, SF, Run 1	143	O
10/22/2003	Rathbun L, SF, Run 1	147	O
10/22/2003	Rathbun L, SF, Run 1	119	O
10/22/2003	Rathbun L, SF, Run 1	128	O
10/22/2003	Rathbun L, SF, Run 1	141	O
10/14/2003	Rathbun L, SF, Run 3	153	O
10/14/2003	Rathbun L, SF, Run 3	152	O
10/14/2003	Rathbun L, SF, Run 3	139	O
10/14/2003	Rathbun L, SF, Run 3	145	O
10/14/2003	Rathbun L, SF, Run 3	123	O
10/14/2003	Rathbun L, SF, Run 3	147	O
10/14/2003	Rathbun L, SF, Run 3	152	O
10/14/2003	Rathbun L, SF, Run 3	133	O
10/14/2003	Rathbun L, SF, Run 3	146	O
10/14/2003	Rathbun L, SF, Run 3	129	O
10/14/2003	Rathbun L, SF, Run 3	144	O

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
10/14/2003	Rathbun L, SF, Run 3	146	O
10/14/2003	Rathbun L, SF, Run 1	151	O
10/14/2003	Rathbun L, SF, Run 1	168	O
10/14/2003	Rathbun L, SF, Run 1	148	O
10/14/2003	Rathbun L, SF, Run 1	124	O
10/14/2003	Rathbun L, SF, Run 1	173	O
10/14/2003	Rathbun L, SF, Run 1	106	O
10/14/2003	Rathbun L, SF, Run 1	153	O
10/14/2003	Rathbun L, SF, Run 1	148	O
10/14/2003	Rathbun L, SF, Run 1	174	O
10/14/2003	Rathbun L, SF, Run 5	126	O
10/14/2003	Rathbun L, SF, Run 5	179	O
10/14/2003	Rathbun L, SF, Run 5	136	O
10/14/2003	Rathbun L, SF, Run 5	155	O
10/14/2003	Rathbun L, SF, Run 5	160	O
10/14/2003	Rathbun L, SF, Run 5	131	O
10/14/2003	Rathbun L, SF, Run 4	140	O
10/14/2003	Rathbun L, SF, Run 4	162	O
10/14/2003	Rathbun L, SF, Run 4	130	O
10/14/2003	Rathbun L, SF, Run 4	156	O
10/14/2003	Rathbun L, SF, Run 4	153	O
10/14/2003	Rathbun L, SF, Run 4	162	O
10/14/2003	Rathbun L, SF, Run 4	146	O
10/14/2003	Rathbun L, SF, Run 4	162	O
10/14/2003	Rathbun L, SF, Run 4	121	O
10/14/2003	Rathbun L, SF, Run 4	153	O
10/14/2003	Rathbun L, SF, Run 4	146	O
10/14/2003	Rathbun L, SF, Run 4	151	O
7/26/2005	CR6	86	X
7/26/2005	CR6	99	X
7/26/2005	CR6	83	X
7/26/2005	CR6	90	X
7/26/2005	CR6	86	X
8/1/2005	WC1	86	X
8/1/2005	WC1	72	X
8/1/2005	DC1	105	X
8/1/2005	DC1	100	X
8/1/2005	DC1	97	X
8/1/2005	DC1	106	X
8/1/2005	DC1	97	X
8/2/2005	WJ5	115	X
8/2/2005	WJ5	108	X
8/2/2005	WJ5	95	X
8/2/2005	WJ5	105	X
8/2/2005	WJ5	74	X
8/2/2005	WJ5	87	X
8/2/2005	JC2	85	X
8/2/2005	JC2	90	X

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
8/2/2005	JC2	75	X
8/4/2005	JA1	92	X
8/4/2005	JA1	110	X
8/4/2005	JA1	91	X
8/4/2005	JA1	79	X
8/4/2005	JA1	117	X
8/4/2005	JA1	76	X
8/4/2005	JA1	86	X
8/4/2005	JA1	81	X
8/4/2005	JA1	135	X
10/20/2005	Rathbun Lake	154	O
10/20/2005	Rathbun Lake	173	O
10/20/2005	Rathbun Lake	152	O
10/20/2005	Rathbun Lake	143	O
10/20/2005	Rathbun Lake	179	O
10/20/2005	Rathbun Lake	165	O
10/20/2005	Rathbun Lake	160	O
10/20/2005	Rathbun Lake	155	O
10/20/2005	Rathbun Lake	161	O
10/20/2005	Rathbun Lake	154	O
10/20/2005	Rathbun Lake	176	O
10/20/2005	Rathbun Lake	187	O
10/20/2005	Rathbun Lake	182	O
10/18/2005	Rathbun L , Honey Cr. Ramp	147	O
10/18/2005	Rathbun L , Honey Cr. Ramp	127	O
10/18/2005	Rathbun L , Honey Cr. Ramp	131	O
10/18/2005	Rathbun L , Honey Cr. Ramp	138	O
10/18/2005	Rathbun L , Honey Cr. Ramp	131	O
10/18/2005	Rathbun L , Honey Cr. Ramp	166	O
10/18/2005	Rathbun L , Honey Cr. Ramp	154	O
10/18/2005	Rathbun L , Honey Cr. Ramp	173	O
10/18/2005	Rathbun L , Honey Cr. Ramp	153	O
10/18/2005	Rathbun L , Honey Cr. Ramp	135	O
10/18/2005	Rathbun L , Honey Cr. Ramp	144	O
10/18/2005	Rathbun L , Honey Cr. Ramp	161	O
10/18/2005	Rathbun L , Honey Cr. Ramp	138	O
10/18/2005	Rathbun L , Honey Cr. Ramp	159	O
10/18/2005	Rathbun L , Honey Cr. Ramp	149	O
10/18/2005	Rathbun L , Honey Cr. Ramp	154	O
10/18/2005	Rathbun L , Honey Cr. Ramp	157	O
10/18/2005	Rathbun L , Honey Cr. Ramp	172	O
10/18/2005	Rathbun L , Honey Cr. Ramp	124	O
10/18/2005	Rathbun L , Honey Cr. Ramp	135	O
10/18/2005	Rathbun L , Honey Cr. Ramp	178	O
10/18/2005	Rathbun L , Honey Cr. Ramp	131	O
10/18/2005	Rathbun L , Honey Cr. Ramp	135	O
10/18/2005	Rathbun L , Honey Cr. Ramp	167	O
10/18/2005	Rathbun L , Honey Cr. Ramp	151	O

AppendixB.—Continued

Date	Location	Total length (mm)	OTC
10/18/2005	Rathbun L , Honey Cr. Ramp	177	O
10/18/2005	Rathbun L , Honey Cr. Ramp	209	O
10/26/2005	Rathbun L , Run 3	155	O
10/26/2005	Rathbun L , Run 3	161	O
10/26/2005	Rathbun L , Run 2	141	O
10/26/2005	Rathbun L , Run 2	135	O
10/26/2005	Rathbun L , Run 2	164	O
10/26/2005	Rathbun L , Run 2	160	O
10/26/2005	Rathbun L , Run 2	165	O
10/26/2005	Rathbun L , Run 2	163	O
10/26/2005	Rathbun L , Run 1	144	O
10/26/2005	Rathbun L , Run 1	162	O
10/26/2005	Rathbun L , Run 1	148	O
10/26/2005	Rathbun L , Run 1	172	O
10/26/2005	Rathbun L , Run 1	173	O
10/26/2005	Rathbun L , Run 1	199	O
10/27/2005	Rathbun L, Run 2	140	O
10/27/2005	Rathbun L, Run 2	134	O
10/27/2005	Rathbun L, Run 2	135	O
10/27/2005	Rathbun L, Run 2	141	O
10/27/2005	Rathbun L, Run 2	144	O
10/27/2005	Rathbun L, Run 2	168	O
10/27/2005	Rathbun L, Run 2	180	O
10/27/2005	Rathbun L, Run 2	180	O
10/27/2005	Rathbun L, Run 2	183	O
10/27/2005	Rathbun L, Run 1	182	O
10/27/2005	Rathbun L, Run 1	160	O
10/27/2005	Rathbun L, Run 1	172	O
10/27/2005	Rathbun L, Run 1	158	O
10/27/2005	Rathbun L, Run 1	147	O
10/27/2005	Rathbun L, Run 1	197	O
10/27/2005	Rathbun L, Run 1	190	O

Appendix C.—Mark and recapture records of 5,808 female walleye at Rathbun Lake. Fish were marked with Visual Implant Tags, 1990-00. Leftmost column of 1's represent the year tagging occurred. Thereafter a 0 represents fish that were not captured and a 1 represents a captured fish. N indicates the total number of individual fish with a unique recapture history.

90	91	92	93	94	95	96	97	98	99	00	N
1	0	0	0	0	0	0	0	0	0	0	337
1	1	0	0	0	0	0	0	0	0	0	47
1	0	1	0	0	0	0	0	0	0	0	10
1	1	1	0	0	0	0	0	0	0	0	4
1	0	0	1	0	0	0	0	0	0	0	6
1	1	0	1	0	0	0	0	0	0	0	7
1	0	1	1	0	0	0	0	0	0	0	2
1	0	0	0	1	0	0	0	0	0	0	4
1	1	0	0	1	0	0	0	0	0	0	1
1	0	0	1	1	0	0	0	0	0	0	1
1	1	0	0	0	1	0	0	0	0	0	1
1	1	0	1	1	1	0	0	0	0	0	2
1	0	0	0	0	0	1	0	0	0	1	1
1	1	0	0	0	0	1	0	0	0	0	2
1	0	0	1	0	0	1	0	0	0	0	1
1	0	0	0	1	1	1	0	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1
1	0	0	0	0	1	0	1	0	0	0	1
1	1	0	0	0	0	1	1	0	0	0	1
1	1	0	0	0	0	0	0	1	0	0	2
0	1	0	0	0	0	0	0	0	0	0	578
0	1	1	0	0	0	0	0	0	0	0	34
0	1	0	1	0	0	0	0	0	0	0	24
0	1	1	1	0	0	0	0	0	0	0	3
0	1	0	0	1	0	0	0	0	0	0	13
0	1	1	0	1	0	0	0	0	0	0	1
0	1	0	1	1	0	0	0	0	0	0	7
0	1	0	0	0	1	0	0	0	0	0	4
0	1	0	1	0	1	0	0	0	0	0	3
0	1	1	1	0	1	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0	0	0	3
0	1	0	1	1	1	0	0	0	0	0	1
0	1	0	0	0	0	1	0	0	0	0	1
0	1	1	0	0	0	1	0	0	0	0	1
0	1	0	0	1	0	1	0	0	0	0	1
0	1	1	0	1	0	1	0	0	0	0	2
0	1	1	0	0	1	1	0	0	0	0	1
0	1	0	0	1	1	1	0	0	0	0	1
0	1	0	1	1	1	1	0	0	0	0	2
0	1	0	1	1	0	0	1	0	0	0	1
0	1	0	1	0	1	1	1	0	0	0	1

Appendix C.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	1	0	0	1	1	1	1	0	0	0	1
0	1	0	0	1	0	0	0	1	0	0	1
0	1	0	0	0	1	0	0	1	0	0	1
0	1	1	1	1	0	0	1	1	0	0	1
0	1	1	1	0	0	0	0	0	1	0	1
0	1	0	0	1	0	0	0	0	1	0	2
0	1	0	0	0	1	0	0	0	1	0	1
0	1	0	0	1	1	0	0	0	1	0	1
0	1	0	0	1	0	1	0	0	1	0	1
0	1	0	1	1	1	1	0	1	1	0	1
0	1	0	1	0	0	0	1	1	1	0	1
0	1	0	0	1	0	1	0	0	1	1	1
0	1	0	0	1	0	0	1	0	1	1	1
0	0	1	0	0	0	0	0	0	0	0	398
0	0	1	1	0	0	0	0	0	0	0	15
0	0	1	0	1	0	0	0	0	0	0	3
0	0	1	1	1	0	0	0	0	0	0	3
0	0	1	0	0	1	0	0	0	0	0	4
0	0	1	1	1	1	0	0	0	0	0	1
0	0	1	0	0	0	1	0	0	0	0	2
0	0	1	0	1	1	1	0	0	0	0	2
0	0	1	1	1	1	1	0	0	0	0	1
0	0	1	0	0	0	0	1	0	0	0	1
0	0	1	1	1	1	1	1	0	0	0	1
0	0	1	0	0	0	0	0	1	0	0	2
0	0	1	1	1	1	0	1	1	0	0	1
0	0	1	1	1	0	0	0	0	1	0	1
0	0	1	1	1	1	1	0	0	1	1	1
0	0	0	1	0	0	0	0	0	0	0	287
0	0	0	1	1	0	0	0	0	0	0	52
0	0	0	1	0	1	0	0	0	0	0	27
0	0	0	1	1	1	0	0	0	0	0	10
0	0	0	1	0	0	1	0	0	0	0	8
0	0	0	1	1	0	1	0	0	0	0	7
0	0	0	1	0	1	1	0	0	0	0	9
0	0	0	1	1	1	1	0	0	0	0	3
0	0	0	1	0	0	0	1	0	0	0	2
0	0	0	1	1	0	0	1	0	0	0	2
0	0	0	1	0	1	0	1	0	0	0	2
0	0	0	1	1	1	0	1	0	0	0	2
0	0	0	1	0	0	1	1	0	0	0	6
0	0	0	1	1	0	1	1	0	0	0	2
0	0	0	1	0	0	0	0	1	0	0	5
0	0	0	1	1	0	0	0	1	0	0	3
0	0	0	1	0	1	0	0	1	0	0	1
0	0	0	1	0	0	1	0	1	0	0	1
0	0	0	1	1	0	1	0	1	0	0	1

Appendix C.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	0	0	1	0	1	1	0	1	0	0	2
0	0	0	1	1	0	0	1	1	0	0	1
0	0	0	1	0	1	0	1	1	0	0	2
0	0	0	1	0	0	1	1	1	0	0	1
0	0	0	1	1	0	1	1	1	0	0	1
0	0	0	1	0	1	1	1	1	0	0	1
0	0	0	1	1	0	0	0	0	1	0	3
0	0	0	1	0	1	0	0	0	1	0	2
0	0	0	1	0	0	1	0	0	1	0	1
0	0	0	1	1	1	1	0	0	1	0	1
0	0	0	1	0	0	1	1	0	1	0	1
0	0	0	1	0	0	0	0	1	1	0	1
0	0	0	1	1	0	0	0	1	1	0	1
0	0	0	1	0	1	0	0	1	1	0	1
0	0	0	1	0	0	0	0	0	0	1	1
0	0	0	1	1	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0	0	0	1	1
0	0	0	1	0	0	1	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	1	1
0	0	0	1	0	0	1	0	1	0	1	1
0	0	0	1	1	1	0	1	1	0	1	1
0	0	0	1	0	1	1	0	0	1	1	1
0	0	0	0	1	0	0	0	0	0	0	366
0	0	0	0	1	1	0	0	0	0	0	27
0	0	0	0	1	0	1	0	0	0	0	24
0	0	0	0	1	1	1	0	0	0	0	9
0	0	0	0	1	0	0	1	0	0	0	5
0	0	0	0	1	1	0	1	0	0	0	1
0	0	0	0	1	0	1	1	0	0	0	3
0	0	0	0	1	0	0	0	1	0	0	8
0	0	0	0	1	1	0	0	1	0	0	4
0	0	0	0	1	0	1	0	1	0	0	2
0	0	0	0	1	1	1	0	1	0	0	4
0	0	0	0	1	0	0	1	1	0	0	1
0	0	0	0	1	1	1	1	1	0	0	1
0	0	0	0	1	0	0	0	0	1	0	7
0	0	0	0	1	1	0	0	0	1	0	2
0	0	0	0	1	0	1	0	0	1	0	4
0	0	0	0	1	1	1	0	0	1	0	1
0	0	0	0	1	0	1	1	0	1	0	1
0	0	0	0	1	0	0	0	1	1	0	1
0	0	0	0	1	1	0	0	1	1	0	1
0	0	0	0	1	0	0	1	1	1	0	1
0	0	0	0	1	1	1	1	1	1	0	1
0	0	0	0	1	0	0	0	0	0	1	2
0	0	0	0	1	1	0	0	0	0	1	4
0	0	0	0	1	1	1	0	0	0	1	1

Appendix C.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	0	0	0	1	0	1	0	1	0	1	1
0	0	0	0	1	1	0	1	1	0	1	1
0	0	0	0	1	1	1	1	1	0	1	1
0	0	0	0	1	0	1	0	0	1	1	1
0	0	0	0	0	1	0	0	0	0	0	192
0	0	0	0	0	1	1	0	0	0	0	21
0	0	0	0	0	1	0	1	0	0	0	6
0	0	0	0	0	1	1	1	0	0	0	5
0	0	0	0	0	1	0	0	1	0	0	14
0	0	0	0	0	1	1	0	1	0	0	6
0	0	0	0	0	1	0	1	1	0	0	4
0	0	0	0	0	1	1	1	1	0	0	1
0	0	0	0	0	1	0	0	0	1	0	4
0	0	0	0	0	1	1	0	0	1	0	3
0	0	0	0	0	1	0	0	1	1	0	1
0	0	0	0	0	1	1	0	1	1	0	1
0	0	0	0	0	1	0	1	1	1	0	1
0	0	0	0	0	1	0	0	0	0	1	1
0	0	0	0	0	1	1	0	0	0	1	2
0	0	0	0	0	1	0	1	0	0	1	1
0	0	0	0	0	1	1	1	0	0	1	1
0	0	0	0	0	1	0	0	0	1	1	1
0	0	0	0	0	1	1	0	0	1	1	1
0	0	0	0	0	1	0	0	1	1	1	1
0	0	0	0	0	0	1	0	0	0	0	560
0	0	0	0	0	0	1	1	0	0	0	35
0	0	0	0	0	0	1	0	1	0	0	21
0	0	0	0	0	0	1	1	1	0	0	15
0	0	0	0	0	0	1	0	0	1	0	16
0	0	0	0	0	0	1	1	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0	3
0	0	0	0	0	0	1	0	1	1	0	3
0	0	0	0	0	0	1	1	1	1	0	6
0	0	0	0	0	0	1	0	0	0	1	9
0	0	0	0	0	0	1	1	0	0	1	3
0	0	0	0	0	0	1	0	1	0	1	3
0	0	0	0	0	0	1	1	1	0	1	2
0	0	0	0	0	0	1	0	0	1	1	1
0	0	0	0	0	0	1	0	1	1	1	2
0	0	0	0	0	0	0	1	0	0	0	406
0	0	0	0	0	0	0	1	1	0	0	61
0	0	0	0	0	0	0	1	0	1	0	21
0	0	0	0	0	0	0	1	1	1	0	10
0	0	0	0	0	0	0	1	0	0	1	21
0	0	0	0	0	0	0	1	1	0	1	10
0	0	0	0	0	0	0	1	0	1	1	7
0	0	0	0	0	0	0	1	1	1	1	6

Appendix C.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	0	0	0	0	0	0	0	1	0	0	397
0	0	0	0	0	0	0	0	1	1	0	54
0	0	0	0	0	0	0	0	1	0	1	25
0	0	0	0	0	0	0	0	1	1	1	17
0	0	0	0	0	0	0	0	0	1	0	573
0	0	0	0	0	0	0	0	0	1	1	96
0	0	0	0	0	0	0	0	0	0	1	650

Appendix D.—Mark and recapture records of 6,510 male walleye at Rathbun Lake. Fish were marked with Visual Implant Tags, 1990-00. Leftmost column of 1's represent the year tagging occurred. Thereafter a 0 represents fish, which were not captured, and a 1 represents a captured fish. N indicates the total number of individual fish with a unique recapture history.

90	91	92	93	94	95	96	97	98	99	00	N
1	0	0	0	0	0	0	0	0	0	0	218
1	1	0	0	0	0	0	0	0	0	0	31
1	1	1	0	0	0	0	0	0	0	0	14
1	1	0	1	0	0	0	0	0	0	0	3
1	0	1	1	0	0	0	0	0	0	0	2
1	1	1	1	0	0	0	0	0	0	0	10
1	0	1	0	1	0	0	0	0	0	0	2
1	1	1	0	1	0	0	0	0	0	0	1
1	0	0	1	1	0	0	0	0	0	0	1
1	1	0	1	1	0	0	0	0	0	0	2
1	1	1	1	1	0	0	0	0	0	0	4
1	1	0	1	0	1	0	0	0	0	0	1
1	1	0	0	1	1	0	0	0	0	0	1
1	1	0	1	1	1	0	0	0	0	0	1
1	1	1	1	1	1	0	0	0	0	0	3
1	1	0	1	1	1	1	0	0	0	0	1
1	1	0	1	0	1	1	1	0	0	0	1
1	1	1	0	1	1	1	1	0	0	0	1
1	1	1	0	1	1	0	0	1	0	0	1
1	0	0	1	1	0	1	0	1	0	0	1
1	1	0	0	1	1	0	1	1	0	0	1
1	1	1	1	1	1	0	1	1	0	0	1
1	1	0	0	1	1	1	1	1	0	0	1
1	0	1	0	1	1	1	0	0	1	0	1
1	1	1	0	1	1	0	0	0	1	1	1
1	1	1	1	1	0	1	1	1	1	1	1
0	1	0	0	0	0	0	0	0	0	0	345
0	1	1	0	0	0	0	0	0	0	0	90
0	1	0	1	0	0	0	0	0	0	0	11
0	1	1	1	0	0	0	0	0	0	0	31
0	1	0	0	1	0	0	0	0	0	0	3
0	1	1	0	1	0	0	0	0	0	0	7
0	1	0	1	1	0	0	0	0	0	0	7
0	1	1	1	1	0	0	0	0	0	0	14
0	1	1	0	0	1	0	0	0	0	0	1
0	1	1	1	0	1	0	0	0	0	0	1
0	1	0	1	1	1	0	0	0	0	0	5
0	1	1	1	1	1	0	0	0	0	0	9
0	1	1	1	1	0	1	0	0	0	0	2
0	1	0	0	0	1	1	0	0	0	0	2
0	1	0	1	0	1	1	0	0	0	0	1

Appendix D.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	1	1	1	0	1	1	0	0	0	0	2
0	1	0	0	1	1	1	0	0	0	0	1
0	1	0	1	1	1	1	0	0	0	0	4
0	1	1	1	1	1	1	0	0	0	0	6
0	1	1	1	1	1	0	1	0	0	0	3
0	1	0	1	1	0	1	1	0	0	0	1
0	1	0	0	1	1	1	1	0	0	0	2
0	1	0	1	1	1	1	1	0	0	0	1
0	1	1	1	1	1	1	1	0	0	0	5
0	1	0	1	1	0	0	0	1	0	0	1
0	1	1	1	1	1	0	0	1	0	0	1
0	1	0	1	1	1	1	0	1	0	0	1
0	1	1	1	1	1	1	1	1	0	0	2
0	1	1	1	1	1	0	0	0	1	0	1
0	1	1	0	1	1	0	0	1	1	0	1
0	1	1	0	1	0	0	1	1	1	0	1
0	1	0	1	1	1	1	1	1	1	0	1
0	1	1	1	1	0	1	1	1	0	1	1
0	1	1	1	1	1	1	1	1	1	1	1
0	0	1	0	0	0	0	0	0	0	0	372
0	0	1	1	0	0	0	0	0	0	0	37
0	0	1	0	1	0	0	0	0	0	0	12
0	0	1	1	1	0	0	0	0	0	0	24
0	0	1	0	0	1	0	0	0	0	0	2
0	0	1	0	1	1	0	0	0	0	0	2
0	0	1	1	1	1	0	0	0	0	0	8
0	0	1	0	0	0	1	0	0	0	0	4
0	0	1	1	0	0	1	0	0	0	0	1
0	0	1	0	1	0	1	0	0	0	0	3
0	0	1	1	1	0	1	0	0	0	0	3
0	0	1	0	1	1	1	0	0	0	0	1
0	0	1	1	1	1	1	0	0	0	0	5
0	0	1	1	1	0	0	1	0	0	0	1
0	0	1	1	1	1	0	1	0	0	0	1
0	0	1	1	1	0	1	1	0	0	0	2
0	0	1	1	1	1	1	1	0	0	0	1
0	0	1	1	0	1	0	0	1	0	0	1
0	0	1	0	0	1	1	0	1	0	0	1
0	0	1	1	0	1	1	0	1	0	0	1
0	0	1	1	1	1	1	0	1	0	0	2
0	0	1	0	0	0	0	1	1	0	0	1
0	0	1	1	1	0	0	1	1	0	0	1
0	0	1	1	1	1	1	1	1	0	0	3
0	0	1	0	0	0	0	0	0	0	1	2
0	0	1	0	1	0	0	0	0	0	1	1
0	0	1	1	0	1	0	0	0	0	1	1

Appendix D.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	0	1	1	1	1	1	1	0	1	1	1
0	0	0	1	0	0	0	0	0	0	0	315
0	0	0	1	1	0	0	0	0	0	0	90
0	0	0	1	0	1	0	0	0	0	0	18
0	0	0	1	1	1	0	0	0	0	0	42
0	0	0	1	0	0	1	0	0	0	0	6
0	0	0	1	1	0	1	0	0	0	0	2
0	0	0	1	0	1	1	0	0	0	0	6
0	0	0	1	1	1	1	0	0	0	0	3
0	0	0	1	0	0	0	1	0	0	0	2
0	0	0	1	0	1	0	1	0	0	0	1
0	0	0	1	1	1	0	1	0	0	0	2
0	0	0	1	1	0	1	1	0	0	0	2
0	0	0	1	0	1	1	1	0	0	0	1
0	0	0	1	1	1	1	1	0	0	0	3
0	0	0	1	0	0	0	0	1	0	0	2
0	0	0	1	1	0	0	0	1	0	0	2
0	0	0	1	1	0	0	0	1	0	0	1
0	0	0	1	0	1	0	0	1	0	0	2
0	0	0	1	1	1	0	0	1	0	0	3
0	0	0	1	1	1	0	1	1	0	0	2
0	0	0	1	0	0	1	1	1	0	0	1
0	0	0	1	0	1	1	1	1	0	0	1
0	0	0	1	1	1	1	1	1	0	0	7
0	0	0	1	0	0	0	0	0	1	0	1
0	0	0	1	1	0	0	0	0	1	0	1
0	0	0	1	0	0	1	0	0	1	0	1
0	0	0	1	1	1	1	0	0	1	0	2
0	0	0	1	1	1	0	1	0	1	0	1
0	0	0	1	1	1	1	1	0	1	0	1
0	0	0	1	0	1	1	0	1	1	0	1
0	0	0	1	0	0	0	1	1	1	0	1
0	0	0	1	0	1	0	1	1	1	0	1
0	0	0	1	0	1	1	1	1	1	0	1
0	0	0	1	1	1	1	1	1	1	0	1
0	0	0	1	0	1	0	0	0	0	1	1
0	0	0	1	1	0	1	0	1	0	1	1
0	0	0	1	1	1	1	1	1	0	1	1
0	0	0	1	0	0	0	1	1	1	1	1
0	0	0	1	1	1	0	1	1	1	1	1
0	0	0	0	1	0	0	0	0	0	0	274
0	0	0	0	1	1	0	0	0	0	0	30
0	0	0	0	1	0	1	0	0	0	0	4
0	0	0	0	1	1	1	0	0	0	0	15
0	0	0	0	1	0	0	1	0	0	0	9
0	0	0	0	1	1	0	1	0	0	0	3
0	0	0	0	1	0	1	1	0	0	0	1

Appendix D.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	0	0	0	1	1	1	1	0	0	0	6
0	0	0	0	1	0	0	0	1	0	0	2
0	0	0	0	1	1	0	0	1	0	0	2
0	0	0	0	1	0	1	0	1	0	0	1
0	0	0	0	1	1	1	0	1	0	0	3
0	0	0	0	1	1	0	1	1	0	0	1
0	0	0	0	1	0	1	1	1	0	0	1
0	0	0	0	1	1	1	1	1	0	0	3
0	0	0	0	1	1	1	0	0	1	0	1
0	0	0	0	1	1	0	1	0	1	0	2
0	0	0	0	1	1	1	1	0	1	0	3
0	0	0	0	1	1	0	0	1	1	0	1
0	0	0	0	1	1	1	0	1	1	0	2
0	0	0	0	1	1	1	1	1	1	0	2
0	0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	1	1	0	0	0	1	1
0	0	0	0	1	0	1	0	1	0	1	1
0	0	0	0	1	1	1	1	1	0	1	2
0	0	0	0	1	0	1	0	0	1	1	1
0	0	0	0	1	1	0	1	0	1	1	1
0	0	0	0	1	0	1	0	1	1	1	1
0	0	0	0	1	1	1	1	1	1	1	2
0	0	0	0	0	1	0	0	0	0	0	196
0	0	0	0	0	1	1	0	0	0	0	31
0	0	0	0	0	1	0	1	0	0	0	9
0	0	0	0	0	1	1	1	0	0	0	19
0	0	0	0	0	1	0	0	1	0	0	6
0	0	0	0	0	1	1	0	1	0	0	2
0	0	0	0	0	1	0	1	1	0	0	7
0	0	0	0	0	1	1	1	1	0	0	5
0	0	0	0	0	1	0	0	0	1	0	4
0	0	0	0	0	1	1	0	0	1	0	2
0	0	0	0	0	1	0	1	0	1	0	1
0	0	0	0	0	1	1	1	0	1	0	5
0	0	0	0	0	1	1	0	1	1	0	2
0	0	0	0	0	1	0	1	1	1	0	3
0	0	0	0	0	1	1	1	1	1	0	5
0	0	0	0	0	1	0	0	0	0	1	2
0	0	0	0	0	1	1	0	0	0	1	2
0	0	0	0	0	1	0	1	0	0	1	2
0	0	0	0	0	1	1	1	1	0	1	1
0	0	0	0	0	1	1	1	0	1	1	2
0	0	0	0	0	1	1	1	1	1	1	3
0	0	0	0	0	0	1	0	0	0	0	608
0	0	0	0	0	0	1	1	0	0	0	109
0	0	0	0	0	0	1	0	1	0	0	25
0	0	0	0	0	0	1	1	1	0	0	49

Appendix D.—Continued.

90	91	92	93	94	95	96	97	98	99	00	N
0	0	0	0	0	0	1	0	0	1	0	8
0	0	0	0	0	0	1	1	0	1	0	3
0	0	0	0	0	0	1	0	1	1	0	6
0	0	0	0	0	0	1	1	1	1	0	18
0	0	0	0	0	0	1	0	0	0	1	5
0	0	0	0	0	0	1	1	0	0	1	5
0	0	0	0	0	0	1	0	1	0	1	2
0	0	0	0	0	0	1	1	1	0	1	7
0	0	0	0	0	0	1	0	0	1	1	1
0	0	0	0	0	0	1	1	0	1	1	8
0	0	0	0	0	0	1	0	1	1	1	4
0	0	0	0	0	0	1	1	1	1	1	12
0	0	0	0	0	0	0	1	0	0	0	643
0	0	0	0	0	0	0	1	1	0	0	159
0	0	0	0	0	0	0	1	0	1	0	36
0	0	0	0	0	0	0	1	1	1	0	39
0	0	0	0	0	0	0	1	0	0	1	12
0	0	0	0	0	0	0	1	1	0	1	14
0	0	0	0	0	0	0	1	0	1	1	17
0	0	0	0	0	0	0	1	1	1	1	35
0	0	0	0	0	0	0	0	1	0	0	436
0	0	0	0	0	0	0	0	1	1	0	63
0	0	0	0	0	0	0	0	1	0	1	36
0	0	0	0	0	0	0	0	1	1	1	60
0	0	0	0	0	0	0	0	0	1	0	550
0	0	0	0	0	0	0	0	0	1	1	246
0	0	0	0	0	0	0	0	0	0	1	714