FINAL REPORT

SECTION 6

ENDANGERED SPECIES ACT

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

FEDERAL AID PROJECT E-8

Status of Threatened and Endangered Fishes in Oklahoma

Leopard Darter Mark and Recapture Study

SEPTEMBER 1, 1993 - AUGUST 31, 1996

FINAL REPORT

STATE: Oklahoma Grant Number E-8

GRANT TITLE: Status of Threatened and Endangered Fishes in Oklahoma

PROJECT TITLE: Leopard Darter Mark and Recapture Study

Objective

Determine seasonal movement patterns, population abundance fluctuations, and survival rates of leopard darters (*Percina pantherina*) in tributaries of the Little River in southeastern Oklahoma.

Abstract

We evaluated seasonal migration, population abundance and survival rates of the threatened leopard darter *Percina pantherina* during 1994-1996 in Big Eagle Creek and West Fork Glover River, Oklahoma. We found evidence of only one tagged fish migrating between stream pools. A 1995 population abundance estimate of 98,441 was generated for Big Eagle Creek by using nonlinear regression techniques and mesohabitat suitability to model longitudinal distribution of leopard darters. A longitudinal trend in abundance was not detected in West Fork Glover River, so mean abundance and the mesohabitat area maps were used to generate a population estimate of 56,530 leopard darters in 1995 and 32, 614 in 1996. Annual survival rates, estimated with length-frequency histograms were 7% in Big Eagle Creek and 12% in West Fork Glover. Although we found higher abundances of leopard darters than previously reported, the variation in abundance between years, short lifespan, and apparently low migratory rates suggest the need for active management to preserve existing leopard darter populations.

Introduction

The leopard darter is a small fish endemic to the Little River drainage of southeastern Oklahoma and southwestern Arkansas (Miller and Robison 1973) and historically has been rare in collections. Before 1977, only 165 specimens had been collected from four of the six major streams of the Little River system (Robison 1978). The apparent rarity of the species led several authors (Miller 1972, Cloutman and Olmsted 1974, Robison et al. 1974, Hubbs and Pigg 1976) to recommend that it be protected. Accordingly, the U.S. Fish and Wildlife Service afforded the leopard darter threatened status in 1978 (U.S. Fish and Wildlife Service 1978).

A limiting factor for leopard darter populations is that much of the currently designated critical habitat appears unsuitable (James and Collins 1993). The preferred habitat of the species is stream pools with cobble or boulder substrate and little to no flow (Jones and Maughan 1984, James 1989). Spawning occurs in gravel riffles (James and Maughan 1989). Many streams in the drainage, however, have steep gradients, bedrock and boulder substrate, and stair-step riffles (Finnell et al. 1956, Jones 1981, Zale et al. 1994), situations that may not be well-suited for leopard darters. Downstream areas have a more gentle gradient and finer substrata, although gravel substrata that might be suitable for spawning occur sporadically (Finnell et al. 1956).

Previous work with the leopard darter has described habitat use (Jones 1981), spawning behavior and habitat (James 1989, James and Maughan 1989), growth (Jones et al. 1983), and diet (James et al. 1991). In addition, following designation of threatened status for the species, three studies found a greater abundance of darters than previously reported by Jones et al. (1984), James et al. (1991), and Zale et al. (1994). From August 1977 to July 1980, Jones and Maughan (1984) found 84 leopard darters at seven sites on the Glover River. James et al. (1991) located 835 leopard darters at six sites on Glover River from January 1986 to September 1988. Zale et al. (1994) surveyed 115 sites along the Saline, Cossatot, Rolling Fork, Mountain Fork, Robinson Fork, and upper Little rivers during 1986 and 1987 and found a total of 239 leopard darters. Although the numbers captured by Jones et al. (1984) and James et al. (1991) likely included multiple captures of individuals, abundance of leopard darters appeared greater than previously believed.

Sampling in previous studies of leopard darter abundance usually involved seining or electroshocking, but sampling of darters often is more effective through snorkeling (James 1989, Greenberg 1991). Previous estimates of leopard darter abundance were made in the Glover and Mountain Fork rivers (Jones 1981, James and Maughan 1989, Zale et al. 1994), yet typically involved depletion sampling during summer months. Capture rates tend to vary daily (personal observation), so mark-recapture studies would yield better estimates of leopard darter abundance.

An additional factor in effective management of the leopard darter is its migratory activity in association with spawning activities or repopulation of denuded areas. Large-scale movements by fish have been associated with reproduction, and some darters do migrate during spring spawning (Winn 1958, Ingersoll et al. 1984). Ingersoll et al. (1984) found that 75% of *Etheostoma flabellare*, *E. spectabile*, and *E. nigrum* that exhibited a spring spawning migration moved 30 m or more. There is also evidence that leopard darters show migration from pools into riffles associated with spawning (Jones et al. 1984, James and Maughan 1989). Degree of individual movement in relation to available spawning habitats is therefore important in relation to both spawning success and dispersal. In addition, darters often show another peak in movement during autumn months (Mundahl and Ingersoll 1983). Understanding fall movement of leopard darters will add to our understanding of their dispersal and recolonization ability.

Methods

Location of Study Sites

During the fall of 1993, we visited 21 locations in the upstream Glover and Mountain Fork rivers, McCurtain County, Oklahoma to examine their potential as study sites. Locations were initially selected from areas known to contain leopard darters, but additional sites were also examined because of access from county or logging roads. Three sites were selected in Big Eagle Creek, a tributary of the Mountain Fork River, and three sites were selected in West Fork Glover River. These sites were used for population sampling through the fall of 1994, but one site was abandoned after it was altered by reconstruction of a low water crossing. An additional site was completely overgrown with water willow (*Justicia* sp.) during the summer of 1994, preventing any sampling for leopard darters. Continuing difficulties with sampling in restricted sites and questions regarding our ability to extrapolate results to unsampled areas led us to develop a method to map and classify quality of mesohabitat for the purpose of expanding population estimates. Methods for our new technique are detailed in the section for population abundance estimation.

Evaluation of Visible Implant Tags

A surrogate species, the slenderhead darter *Percina phoxocephala*, was selected for a visible implant tag retention/mortality experiment. Thirty slenderhead darters were collected from the Salt River, Osage County, Oklahoma in December 1993. In January 1994, ten slenderhead darters were anesthetized in a 150 ppt solution of MS-222 and tagged with visible implant tags on the cheek slightly posterior to the eye.

Poor performance of visible implant tags led to exploration of two other tagging methods. In April 1994, seven slenderhead darters were injected with latex paint. Four were tagged at the anterior insertion of the anal fin, and three were tagged on the caudal peduncle. In May 1994, ten slenderhead darters were injected with an elastomer tag (Northwest Marine Technology, Inc.).

Seasonal Migration Study

During fall 1994 to spring 1995, movement between mark-recapture study sites 5-7 km apart was taken as evidence of migration. No evidence was found, so a permanent movement study site was selected during the summer of 1994. The site, located in Big Eagle Creek, was approximately 400 m long and consisted of two large pools separated by a glide, a run, and two riffles. We examined potential autumnal movements in September 1994. The entire study site was searched for several days, and most observed leopard darters were captured, tagged, and released as close as possible to their original location. Resampling trips were conducted through November 1994, and captured darters were examined for evidence of movement between pools within the sampling site.

A spring movement study was initiated in February 1995. In contrast to the autumn study, unmarked darters were marked during resampling trips. The resampling trips continued through April 1995. During the fall of 1995, construction was started on a new bridge over the lower pool of the movement study site. Scouting trips were conducted from the fall of 1995 through late winter of 1996 to locate a new study site. Low flow during the entire period limited access to many locations and also reduced our ability to determine suitability of some sites if higher flow were to occur in the spring. A replacement site was selected in March 1996. The site was about 250 m long and contained one large and several small pools separated by narrow riffles. Sampling was conducted similar to the previous spring study with resampling trips continuing through late April 1996.

Population Abundance and Survival Rate Estimation

To create a base map of West Fork Glover River and Big Eagle Creek, we digitized the boundaries of both streams from aerial photographs. During canoe trips, mesohabitat types (McCain et al. 1990) were identified and drawn on the base maps of Big Eagle Creek and West Fork Glover River in, respectively, June 1995 and May 1996. Transect sampling was conducted in all mesohabitat types, and spacing of transects was based on mean stream width (MSW). If MSW was <5 m then transects were placed three MSWs apart, but if MSW was ≥5 m, transects were placed two MSWs apart (Simonson et al. 1994). Four equally spaced points were measured along each transect, and suitability of habitat at each of the points was determined. Usable values for depth, current velocity and substrate were identified as the central 95% of the frequency distribution (Thomas and Bovee 1993) for each variable observed in an earlier study of habitat use by leopard darters (James 1989). Usable values for water depth were 25 to 90 cm. Usable current velocity was 0 to 28 cm/s and usable substrate was gravel, cobble, and boulder. We applied these criteria to all sampling points to derive a habitat suitability rating for each point. If all three variables (depth, velocity, and substrate) at a sampling point were usable, habitat was defined as usable. If any of the variables were unusable, habitat at that point was defined as unusable (after Thomas and Bovee 1993). After deriving a suitability rating for each sampling point, we re-classified mesohabitat types based on frequency of usable and unusable sampling points taken in that type. The selection criterion for an optimal mesohabitat type was that ≥50% of the points measured within that type were usable. If 30-49% of the sampling points within a mesohabitat type were usable, the type was classified as suitable, and mesohabitat types with <30% usable sampling points were classified as unsuitable. The mesohabitat maps then were used to generate a stratified sampling design for selection of sampling sites in each stream during the summers of 1995 and 1996.

Since abundance estimates had been difficult to obtain previously, we biased our sampling toward optimal habitat in both streams. Efforts were made to stratify by segment and mesohabitat suitability, with sampling locations selected randomly from all available sites meeting the stratification requirements. Low summer flow and poor accessibility limited our sampling to the upper and lower third of several long segments in both streams. If we were unable to sample a site because of low water or poor visibility, the nearest location from the same suitability category was chosen. Mesohabitat units that were 500 m^2 or smaller were completely sampled. In larger units, we chose an area that could be sampled effectively by two people. A sample consisted of two snorkelers each searching the entire area at least 3-4 times. In areas containing leopard darters, we sampled until no additional darters were sighted for a period of 30 minutes. Darters with captured with two hand-held 5-inch dip nets and were kept in a 5-gallon bucket until sampling was completed. Approximately 1/4 gallon of water in the bucket was replaced with fresh water every 5-10 minutes. In addition, during periods when temperatures were extremely high or the bucket could not be placed in a shaded area, we halted sampling after a 1-hour period to prevent mortality of the captured darters. All captured darters were anesthetized with MS-222, marked with an elastomer tag, and released after recovering equilibrium. The tag was generally placed on one side of the first dorsal fin. Recapture runs were made for an additional two days during which all unmarked darters were marked and released. A Schnabel abundance estimate and density value were determined for each sampling location.

In Big Eagle Creek, we detected a longitudinal gradient in both habitat and darter abundance. The size and frequency of units of suitable mesohabitat increased in the downstream direction as did the density of leopard darters. We used the relationship between habitat and abundance to generate nonlinear regression models to assist in prediction of abundance in unsampled areas. Distance to the center of each mesohabitat unit was determined using Geographic Information Systems procedures and was used in the regression models with density as the dependent variable. Although our samples showed an exponential trend, we assumed that densities would reach an asymptote, resulting in a logistic curve with the equation, $D = [1 + e^{-(\beta 0 + \beta 1 x)}]^{-1}$, where D is density, x is distance from the top of the stream, β_0 is the intercept, and β_1 is slope. Separate equations were generated for optimal and suitable mesohabitat in Big Eagle Creek. We used the equations along with distance from the upstream terminus for each mesohabitat unit to predict densities in unsampled areas. These densities were then multiplied by the area of each unit of mesohabitat to calculate an abundance estimate for the entire stream. The 95% confidence limits for the slope and intercept of the two regression equations were used to calculate confidence bounds for abundance in Big Eagle Creek. The resulting numbers were not true confidence limits. but we consider them to be best and worst-case estimates.

Mesohabitat and darter abundance did not show a longitudinal trend in West Fork Glover River. We chose to use mean values of abundance along with the mesohabitat type of each area to generate abundance estimates for the stream. A complete sample from all three mesohabitat suitabilities was not available in 1995, and no fish were found in suitable or unsuitable mesohabitat in 1996. We assumed that no fish would have been found in these areas in 1995 either. so abundance estimates were calculated separately for both years. We used one standard deviation from the mean to calculate upper and lower 95 % confidence limits (CL) for overall abundance.

We initially planned to estimate survival rates during long-term capture histories of individually marked leopard darters. Since the visible implant tags were not appropriate for the study, we estimated survival from year-class abundances made annually at several locations in both streams. Two locations in Big Eagle Creek were sampled in summer 1994, but we were unable to locate adult leopard darters for a population estimate in summer 1995. The migration study site in Big Eagle Creek was sampled intensively in September 1994 and a length-frequency histogram was generated for the population. Population estimates were also made in several locations in Big Eagle Creek in August 1995, and a length-frequency histogram was generated for fish from all sites. A break between size classes was observed at 60 mm standard length (SL) in the August 1995 Big Eagle Creek histogram and also in histograms for West Fork Glover. We assumed that the individuals <60 mm SL in September 1994 were newly recruited and compared their abundance to the abundance of individuals ≥60 mm SL (age 1+) in 1995. High turbidity prevented population sampling in West Fork Glover River in 1994. Samples were made in August 1995 and July 1996, however, and length-frequency histograms were generated for both periods. In addition, since previous work with leopard darters indicated a lifespan of about 18 months (James et al. 1991), we considered survival to spring spawning to be especially critical. Again, we attempted to compare mark-recapture population estimates to calculate survival, but were unable to generate estimates during both post-recruitment and pre-spawning periods. However, length-frequency histograms were available from the migration study site in September 1994 (post-recruitment) and February 1995 (pre-spawning). We used the length-frequency histograms to calculate survival rate of adults prior to spawning.

Results

Evaluation of Visible Implant Tags

Retention of visible implant tags was 100% overnight but dropped to 70% after one week and 40% after two weeks. All tags were lost within one month. Three of the slenderhead darters injected with latex paint died within one week, and the remaining tags were not evident after one to two months. Four of the ten darters tagged with elastomer injections died within one month of a cause unrelated to tagging. The remaining tags were still visible three months later. In addition, tagged leopard darters in the field have been recaptured as long as six to eight months after injection of the elastomer tag.

Seasonal Migration Study

Sixty-four leopard darters were marked and released in the downstream-most of two pools during the 1994 autumnal movement study. An additional 29 were marked and released in the upstream-most pool, and six were marked and released in the glide between the two pools. During six resampling trips, a total of 65 leopard darters was captured. Only 11 of the captures had been marked previously, and none of the recaptured individuals had migrated out of the pool in which they were originally captured.

During the first two trips of the spring 1995 movement study, a total of 45 leopard darters was captured, including 17 recaptures from fish marked during the first marking trip (spring 1995) and two recaptures of individuals marked the previous fall. All captured individuals were found in the downstream pool; no leopard darters were observed in the upstream pool. A total of 13 leopard darters, including seven recaptures, was captured during resampling trips later in the spring. Of the seven recaptured fish, one had moved from the glide down into the lower pool, a minimum distance of 52 m. All other recaptures showed no evidence of migration.

Fewer fish were found during the movement study in the spring of 1996. During March and April, 12 leopard darters were captured or sighted. Only one recapture was made, and no evidence of migration was found. No spawning activity was observed.

Population Abundance and Survival Rate Estimation

Approximately 21 kilometers were mapped in both Big Eagle Creek and West Fork Glover River. Big Eagle Creek was completely mapped and classifed in June 1995. A total of 208 mesohabitat units of 10 different types were identified (Table 1). Transect sampling was conducted in 48 (23%) of the mesohabitat units. Based on mean depth, current velocity, and substrate characteristics, the mesohabitat types backwater pool, midchannel pool, secondary channel pool, and glide were classified as optimal habitat for leopard darters. Lateral scour pools and runs were classified as suitable, and the remaining types, cascade, low gradient and high gradient riffles, were classified as unsuitable. Sampling sites for population estimates were selected from the maps classified according to mesohabitat, with a bias toward sampling optimal habitat. For the summer 1995 sampling, we selected seven optimal habitat sites, four suitable habitat sites, and three unsuitable habitat sites. Population abundance and density estimates were generated for each site (Table 2), and the values were used to generate the regression equations. The equation for optimal habitat was $D = [1 + e^{-(-5.08 + 0.00027x)}]^{-1}$ and the equation for suitable habitat was $D = [1 + e^{-(-16.43 + 0.00094x)}]^{-1}$. Using the equations along with the mesohabitat area estimates, we calculated an overall abundance estimate of 98,441 for Big Eagle Creek. The upper confidence bound was 236,706 and the lower bound was 12,604.

West Fork Glover River was mapped and classified in May 1996. A total of 118 mesohabitat units of seven different types were identified (Table 1). We conducted transect sampling in 34 (29%) of the mesohabitat units. Midchannel pools, glides, runs, and step runs were classified as optimal mesohabitat. Suitable mesohabitat included low gradient riffles, and unsuitable mesohabitat included cascades, high gradient riffles, and a single backwater pool with bedrock substrate. Only five mark-recapture estimates, all from optimal mesohabitat, were made in 1995. In 1996, we used the maps to select seven optimal sampling sites, five suitable sites, and two unsuitable sites. Abundance and density estimates were generated for each site and the mean density estimate was calculated for each year (Table 3). Mean ($\pm$ 1 SD) density per square meter was 0.104 ± 0.074 for 1995, and 0.070 ± 0.072 for 1996. Using these values along with the area of optimal mesohabitat in the West Fork Glover, we calculated an abundance of 56,530 (95% CL = 16,307 and 96,754) in 1995 and 32,614 (95% CL = 0 and 77,186) in 1996.

The length-frequency histograms for the summers of 1994 and 1995 in Big Eagle Creek (Fig. 1) indicated that 74 of the 95 leopard darters were young-of-year. Only 5 of the 117 leopard darters in 1995 were age 1+ adults, giving an annual survival rate of 7% from 1994 to 1995. However, pre-spawning survival appeared much higher (Fig. 2). Forty-one adults were located in February 1995, indicating an over-winter survival rate of 55%. Annual survival rate in West Fork Glover River from 1995 to 1996 appeared slightly higher than in Big Eagle Creek (Fig. 3). Ninety-eight young-of-year were collected in 1995, and 12 age 1+ adults were collected in 1996, resulting in a survival rate of 12%.

Discussion

Our first major task in this project was to assess seasonal movement patterns of the leopard darter. Although we were hindered by bridge construction at our initial study site, the main difficulty we encountered was our inability to uniquely mark individual leopard darters. The original plan of using visible implant tags would also have allowed us to determine seasonal dispersion and home range patterns with little additional effort. If we had been able to mark individuals, our understanding of movement patterns would have been greatly enhanced. The lack of individual marks also hindered our assessment of survival rates and to some extent our determination of population abundance estimates.

Annual survival rates of the leopard darter were 7% in Big Eagle Creek and 12% in West Fork Glover River. The pre-spawning survival rate in Big Eagle Creek appeared higher, however, and our estimate of 55% survival from September 1994 to February 1995 was higher than the July-September mean survival rates calculated by James (1991) for 1987 (40%) and 1988 (42%). Recruitment in 1996 (Figure 3) in West Fork Glover River seemed much lower than in the previous year, however, so the pre-spawning survival rate for 1995-1996 may have been much lower.

Population abundance estimates for leopard darters in both streams tended to be much higher than previously reported. Although upstream sites in Big Eagle Creek with optimal mesohabitat had few or no leopard darters, the downstream sites had estimates ranging from 104 to 195 or 0.256 to 0.656 leopard darters per square meter. Our estimates in West Fork Glover River varied from 1995 to 1996, but our highest estimate was 0.214 fish/m^2. The highest density reported for a single site in the Glover River drainage by Jones et al. (1984) was 0.0165 fish/m^2, and the highest density reported by James et al. (1991) for the same drainage was 0.065 fish/m^2. Our population abundance estimates could be strengthened, however, by the ability to track individuals over time. Our design was similar to a two-stage design proposed earlier by Hankin and Reeves (1988). Although variance in the first-stage (extrapolation) is large compared to variance in the second-stage (estimation of abundance within sites), we feel that variation in the second-stage could be reduced by using more powerful abundance estimate techniques (i.e., Jolly-Seber). However, we feel the addition of mesohabitat classification and stratified random sampling allowed us to reduce first-stage variation, the major source of variation in stream-wide analyses (Hankin and Reeves 1988)

Our data from West Fork Glover River showed some variation between years. The period from summer 1995 to summer 1996 had extremely low rainfall, and we suspect that leopard darters were highly stressed and may have suffered heightened mortality. For example, we had success locating individuals prior to spawning in 1995 and observed spawning activity from late February through April. Individual fish in the 1995 recruitment were large enough (40 mm SL) to safely tag by early July. In contrast, in 1996 we located few individuals and no spawning activity was observed through April. Most recruited individuals were <40 mm SL until late July, indicating a late spawn. In addition, our capture efforts on the first day of sampling at site 14 (Table 2) of Big Eagle Creek yielded 38 fish in approximately one hour in 1995. We returned to the same location in 1996 to capture leopard darters for another project and were only able to locate two fish in about one and a half hours of effort. We also found evidence that the fish were highly stressed and susceptible to infection. During our sampling efforts in one location in West Fork Glover River in May 1996, we captured 22 leopard darters, 14 of which had fungal growth on their fins and in some cases on their gills. Given the short lifespan (James et al. 1991) of the leopard darter, harsh environmental conditions in any one year may have major effects on leopard darter populations.

Recommendations

1. We recommend the use of mesohabitat classification with a stratified random sampling scheme to characterize habitat quality and leopard darter abundance in the Glover and Mountain Fork mainstems.

2. Once tagging technology (i.e., PIT tags) has advanced to allow individual tagging of leopard darters, we recommend further efforts be made to assess seasonal movement, dispersion and home range patterns, and survival rates.

3. We recommend conducting further research into the potential inter-annual variation in abundance and survival of leopard darters and examining factors contributing to the variation.

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Table 1. Classification of mesohabitat type suitability in Big Eagle Creek and West Fork Glover River, Oklahoma. Ratings are based on percentage of transect points classified as suitable or unsuitable. The total area for each mesohabitat type is for each entire stream.

Mesohabitat type	Total Number of Mesohabitat Units	Number of Units Sampled	Percent Suitable	Percent Unsuitable	Suitability Classification	Total Area (ha)
Big Eagle Creek						
Low Gradient Riffle	68	15	25	75	Unsuitable	7.67
High Gradient Riffle	26	5	28	72	Unsuitable	4.24
Cascade	7	3	0	100	Unsuitable	0.44
Secondary Channel Pool	1	1	58	42	Optimal	1.02
Backwater Pool	3	2	59	41	Optimal	1.02
Lateral Scour Pool	12	4	45	55	Suitable	2.67
Midchannel Pool	45	9	57	43	Optimal	34.47
Glide	13	4	73	27	Optimal	3.56
Run	32	5	30	70	Suitable	8.95
Step Run	1	0	0	0	NA	0.16
Total	208	48				64.20
West Fork Glover River						
Low Gradient Riffle	50	10	47	53	Suitable	7.74
High Gradient Riffle	2	2	29	71	Unsuitable	0.13
Backwater Pool	1	1	100	0	Unsuitable	0.11
Midchannel Pool	37	9	45	55	Optimal	44.90
Glide	12	5	64	36	Optimal	3.51
Run	19	6	77	23	Optimal	5.88
Step Run	1	1	50	50	Optimal	0.06
Total	118	34				62.33

Table 2. Population abundance and density estimates of leopard darters in Big Eagle Creek, Oklahoma, during 1995.

Site #	Mesohabitat Quality	Search Area (m^2)	Abundance Estimate (number of fish)	Density Estimate (fish/m^2)
1	Unsuitable	159	0	0
2	Unsuitable	272	0	0
3	Unsuitable	120	0	0
4	Suitable	429	0	0
5	Suitable	174	0	0
6	Suitable	941	2	0.001
7	Suitable	495	34	0.069
8	Optimal	336	0	0
9	Optimal	602	0	0
10	Optimal	600	0	0
11	Optimal	945	11	0.012
12	Optimal	348	111	0.319
13	Optimal	406	104	0.256
14	Optimal	297	195	0.656

Table 3. Population abundance and density estimates of leopard darters in West Fork Glover River, Oklahoma, during 1995 and 1996.

Site #	Mesohabitat Quality	Search Area (m^2)	Abundance Estimate	Density Estimate (fish/m^2)
		1995		
1	Optimal	338	42	0.120
2	Optimal	588	7	0.012
3	Optimal	163	12	0.074
4	Optimal	459	47	0.102
5	Optimal	529	113	0.214
		1996		
1	Unsuitable	584	0	0
2	Unsuitable	306	0	0
3	Suitable	155	0	0
4	Suitable	241	0	0
5	Suitable	780	0	0
6	Suitable	720	0	0
7	Suitable	1280	0	0
7	Optimal	232	37	0.160
8	Optimal	840	2	0.002
9	Optimal	219	36	0.164
10	Optimal	300	11	0.040
11	Optimal	384	0	0
12	Optimal	113	3	0.026
13	Optimal	235	7	0.030

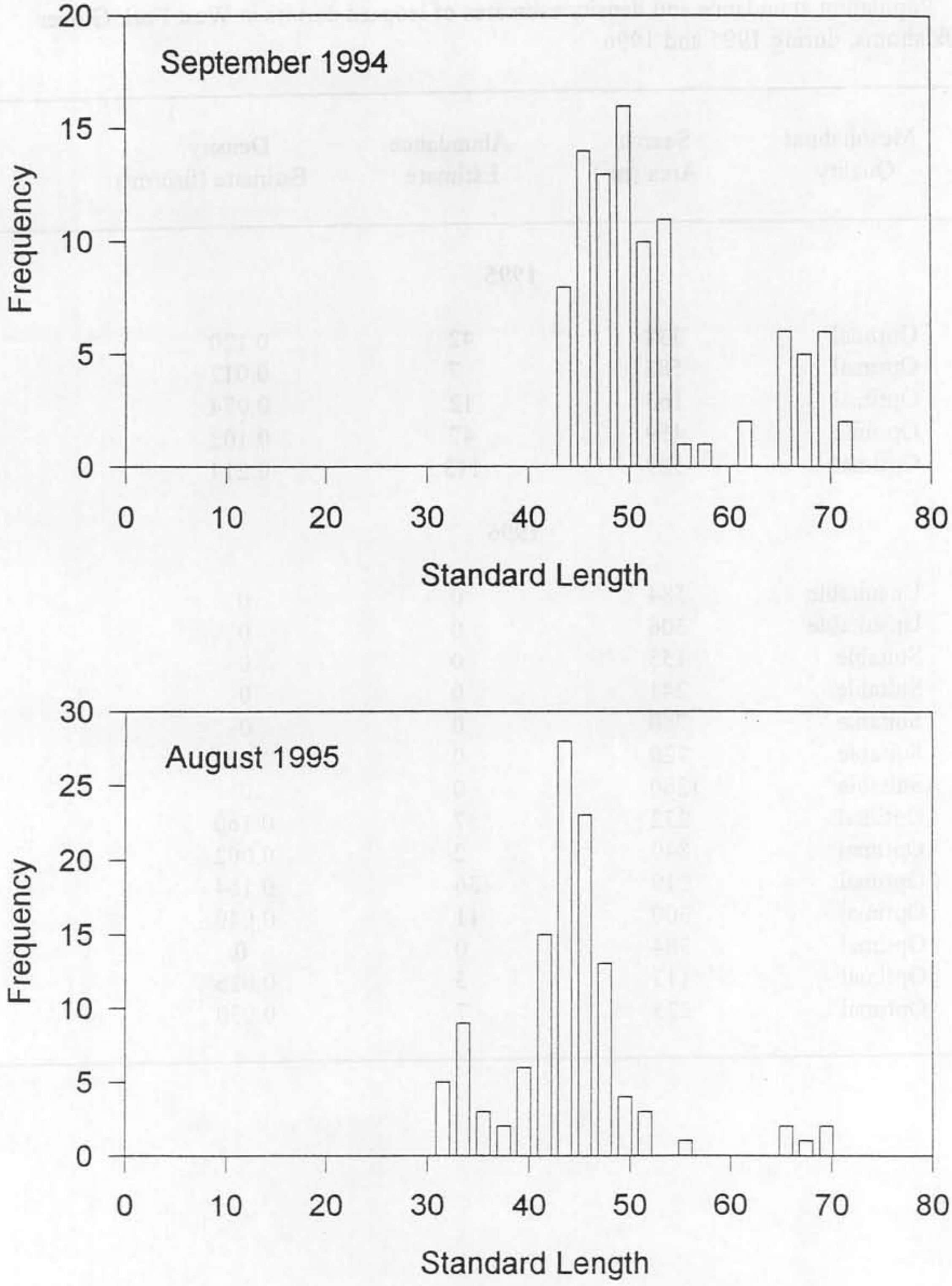
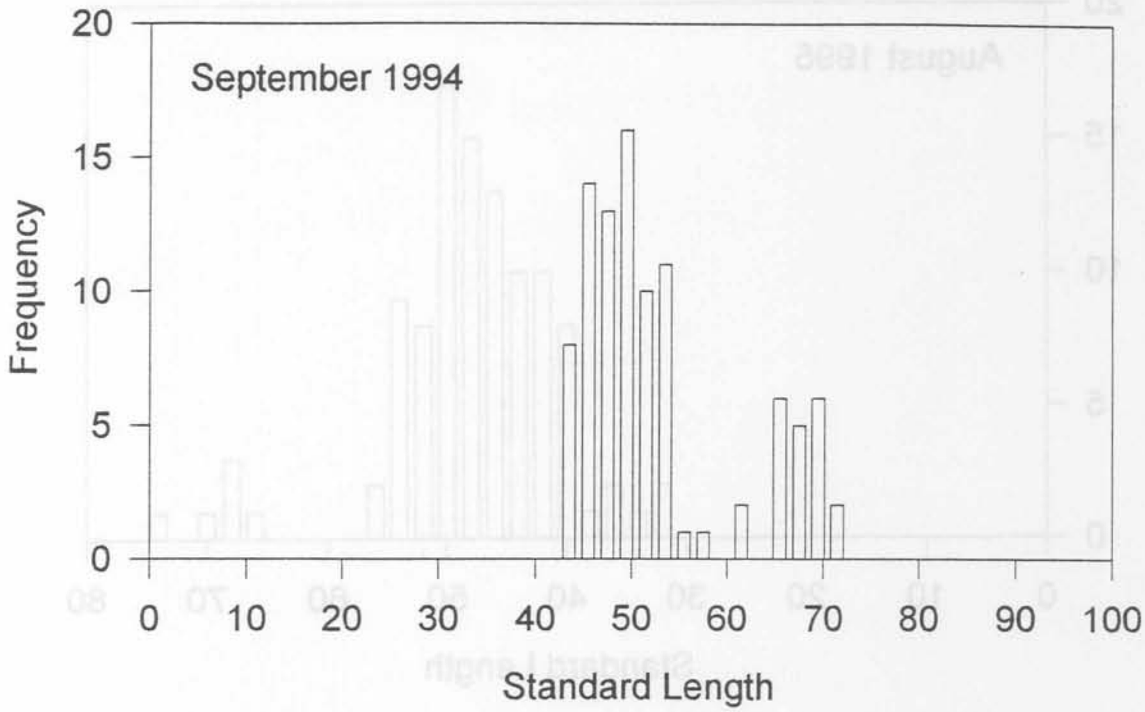


Figure 1. Length frequency histograms of leopard darters for Big Eagle Creek, Oklahoma.



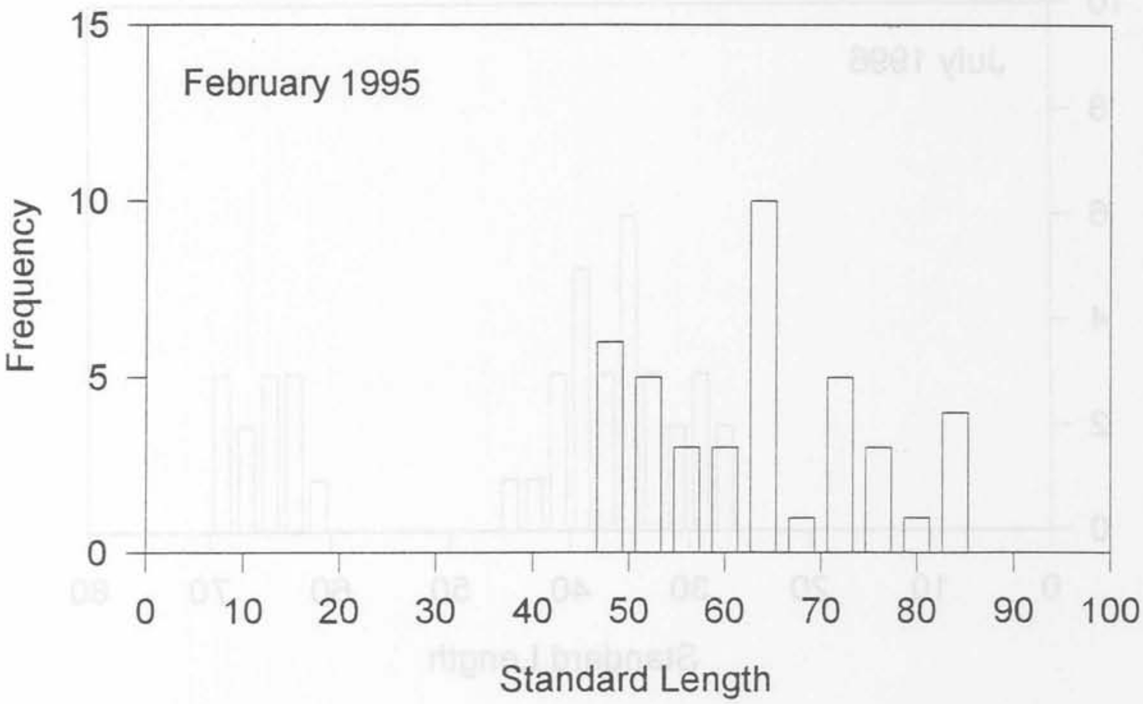


Figure 2. Pre-spawning survivorship of leopard darters in Big Eagle Creek, Oklahoma.

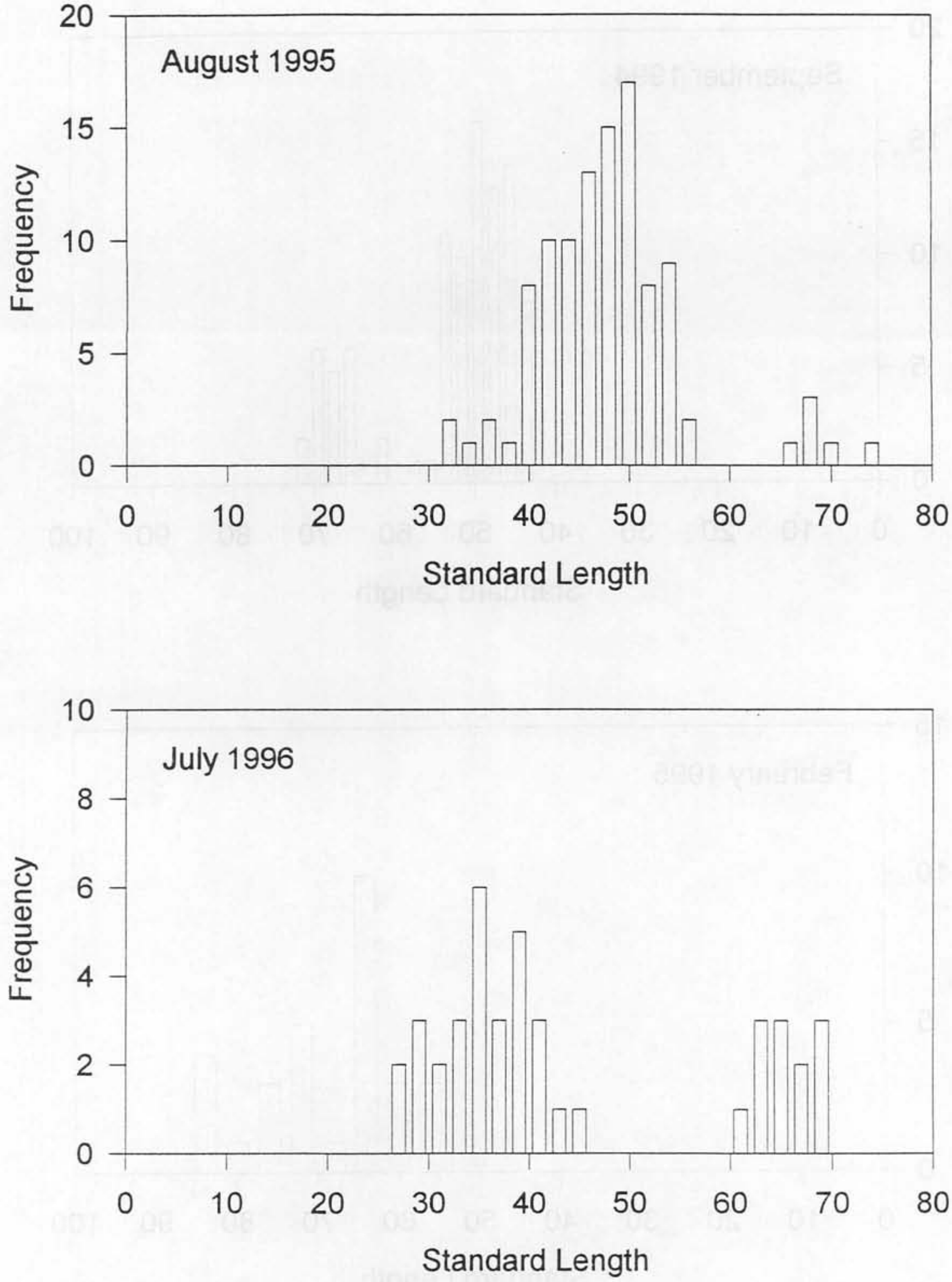


Figure 3. Length frequency histograms for West Fork Glover River, Oklahoma.

Appendix

Population abundance sampling sites in Big Eagle Creek and West Fork Glover River during 1994

Stream	Site Number	Legal Description
Big Eagle Creek	1	T1N R25E Sec. 10
Big Eagle Creek	2	T1N R25E Sec. 30
Big Eagle Creek	3	T1S R25E Sec. 20
West Fork Glover River	1	T1S R22E Sec. 25
West Fork Glover River	2	T2S R23E Sec. 6
West Fork Glover River	3	T2S R23E Sec. 7