North American Journal of Fisheries Management 29:721–729, 2009

DOI: 10.1577/M08-060.1

[Article]

Capture Probability and Behavioral Response of the Robust Redhorse, a Cryptic Riverine Fish, to Electrofishing

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Abstract.—Conservation and management of riverine species, such as the robust redhorse *Moxostoma robustum*, can be hindered by incomplete understanding of their population status. Behavioral responses to sampling methods and susceptibility to capture by a particular gear type have implications for the reliability of population assessments yet are rarely evaluated. Consequently, we used radio-tagged robust redhorses in the Ocmulgee River, Georgia, to estimate capture probability when sampled with standard boat electrofishing techniques and to assess behavioral responses of individuals to single and repeated exposures to electrofishing, the recommended sampling method for this species. Transects containing one to eight radio-tagged individuals were sampled. The positions of radio-tagged individuals were recorded before electrofishing and at 1-h, 24-h, and 3–5-d intervals after sampling. We estimated robust redhorse abundance and capture probability by treating each transect as analogous to a repeated sample in time. Only one radio-tagged individual and six untagged individuals were captured after 7.46 h of effort. The radio-tagged fish did not exhibit an immediate response to boat electrofishing, but some did move from their original position after electrofishing. Mean movement was 0.15 km after 1 h, 0.19 km after 24 h, and 0.23 km after 3–5 d. However, this movement was similar to that exhibited by fish located at similar intervals during a related telemetry study without exposure to electrofishing. A mean capture probability of 0.031 with a 95% Bayesian credibility interval of 0.002–0.111 was estimated from the best-approximating model. Electrofishing is not a particularly effective method for capturing this species; therefore, inferences about population size and distribution of this or other cryptic species need to account for low detection probabilities associated with electrofishing. Alternative approaches or multiple strategies should be considered when assessing the status of such species.

The robust redhorse *Moxostoma robustum* is an imperiled riverine catostomid native to the Piedmont and upper coastal plain reaches of large Atlantic Slope rivers in Georgia and the Carolinas (Cope 1869; Bryant et al. 1996). Originally described in 1869, the species was not observed or recorded for over a century before its rediscovery in 1991 (Bryant et al. 1996). Despite being formerly abundant (Cope 1869), native populations of robust redhorses currently are known from only the Oconee River in the Altamaha River drainage of central Georgia, the Savannah River along the Georgia–South Carolina border, and the Yadkin–Pee Dee River drainage in North and South Carolina (Bryant et al. 1996; DeMeo 2001). Population estimates based on mark–recapture data from the Oconee River (Jennings et al. 2000; DeMeo 2001) and the Savannah River (Grabowski and Isely, in press) suggest only small populations of not more than 500 individuals remain in these rivers.

Robust redhorse may be considered a cryptic species by virtue of its behavior and habitat preferences. Adults spend the majority of their time in deep, fast-flowing water along the outer edge of river bends containing large woody debris (Jennings et al. 1996; Grabowski and Isely 2006; Grabowski and Jennings, in press a). These habitats are difficult to sample effectively with standard techniques such as boat-mounted electrofishers or gill nets (Bayley and Peterson 2001; Bayley and Austen 2002) and may be part of the reason why robust redhorses were "lost to science" (Grabowski and Isely 2006). Current population levels are almost certainly underestimated, perhaps substantially so, because of low catchability and violations of population estimator assumptions, such as the influence of temporary emigration on the assumption of a closed population (Kendall 1999; Grabowski and Isely, in press) or the requirement that all individuals have equal probability of capture (Pollock et al. 1990). However,

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Received March 18, 2008; accepted October 6, 2008
Published online May 14, 2009

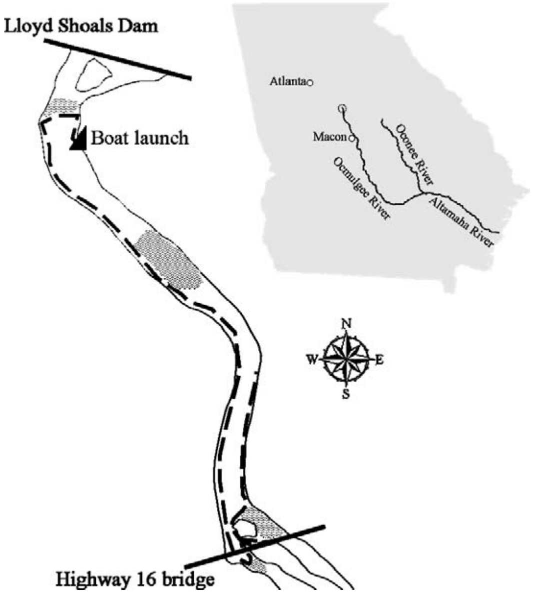

FIGURE 1.—Primary electrofishing and radiotelemetry sample area for radio-tagged robust redhorses on the Ocmulgee River, Georgia. The dashed line indicates the 1.5-km transect sampled, and the shaded areas represent shoals. The inset shows the location of the Altamaha River system within the state.

important conservation priorities and activities such as population assessments, formulating stocking recommendations, and the evaluation of recovery efforts would benefit from improved estimates of abundance that take into account this imperfect detectability (MacKenzie et al. 2005; Martin et al. 2007). Additionally, the response of robust redhorses to single or repeated sampling surveys is not known but could potentially influence capture probabilities (Fréon et al. 1993).

Our objectives were to (1) estimate the capture probability of robust redhorses sampled with standard boat electrofishing techniques proscribed by the Robust Redhorse Conservation Committee (2002), and (2) observe the movement of individuals in response to both single and repeated electrofishing and compare with that of undisturbed fish. To accomplish this, we used radio-tagged individuals that were part of a recently completed radiotelemetry study in the Ocmulgee River, Georgia (Grabowski and Jennings, in press a).

Methods

Study area.—The Ocmulgee River is approximately 400 km long and drains about 9,900 km^2 in the Piedmont and upper Coastal Plain physiographic provinces of central Georgia. The Ocmulgee and Oconee rivers are the two major tributaries that merge to form the Altamaha River. Attempts to collect robust redhorses in the Ocmulgee River and confirm the presence of a resident, native population have been largely unsuccessful (DeMeo 2001). Since 2002, robust redhorse progeny from Oconee River broodstock have been stocked into the Ocmulgee River to establish a self-sustaining population.

Our study focused primarily on a 2-km reach bounded by Lloyd Shoals Dam at river kilometer (rkm) 394.5 near the city of Jackson, Georgia, and the impassable shoals immediately downstream of the crossing of Georgia Highway 16 at rkm 392.65 (Figure 1). This section of river contains a variety of habitat types including rocky shoals, deep pools, and bends with large woody debris. Three additional surveys were made farther downstream below rkm 241.00. This downstream portion of the river was characteristic of the upper coastal plain and consisted primarily of a series of meanders with sandbars and large woody debris as the primary habitat features.

Data collection.—The fish we evaluated were part of a study examining movements and habitat use of robust redhorses stocked into the Ocmulgee River. Study fish (mean total length = 487.2 mm, SD = 8.6; mean wet weight = 1,646.1 g, SD = 91.4) were surgically implanted with radio tags and released near Lloyd Shoals Dam at rkm 393.95 on 19 April 2006 (Grabowski and Jennings, in press a). Transmitters weighed approximately 26.0 g in air and did not exceed the maximum 2.0% of the body weight of the fish as recommended by Winter (1996). Our sampling efforts were initiated near the end of the manufacturer's 1-year guaranteed transmitter battery life, which allowed fish to acclimatize to the local environment and minimized interference with the radiotelemetry study. The radio-tagged robust redhorses we used were of hatchery origin, but by the time we initiated electrofishing, they were exhibiting a behavioral pattern similar to that described for radio-tagged wild fish in other river systems (Grabowski and Isely 2006; Grabowski and Jennings, in press a; R. Hiese, North Carolina Wildlife Commission, personal communication).

Electrofishing was conducted on 23 February, 2 March, 8 March, 5 April, and 19 June 2007. Eight transects were sampled during this study; they ranged in length from 0.50 to 2.24 km in length and contained between one and eight radio-tagged robust redhorse (Table 1). Transect selection was based primarily upon practical concerns, such as ensuring conditions were such to work safely, presence of radio-tagged fish in relatively close proximity to one another (<5.0 rkm), and proximity to an access point that could be used by both the tracking and

TABLE 1.—Sample data for radio-tagged and untagged robust redhorses and other catostomid species collected in electrofishing transects in the Ocmulgee River, Georgia, during 2007.

	Transect			Numbers of robust redhorses			Number captured			
Sample date	Start at (river kilometer)	Length (km)	Effort (h)	Radio-located	Tagged captures	Untagged captures	Notchlip redhorse	Spotted sucker	Brassy jumprock	Quillback
23 Feb	393.95	2.24	0.77	8	0	2	4	10	0	0
23 Feb	240.95	0.75	0.40	1	0	0	0	0	0	0
23 Feb	236.57	1.00	1.07	1	0	0	0	1	0	1
23 Feb	233.98	0.50	0.40	1	0	0	0	1	0	0
2 Mar	393.95	2.24	1.51	7	0	2	6	15	12	0
8 Mar	393.95	2.24	1.51	6	0	0	0	11	8	0
5 Apr	393.95	1.49	1.05	4	1	0	0	0	0	0
19 Jun	393.95	1.50	0.75	2	0	2	0	8	5	0

electrofishing boats. Before electrofishing was initiated, radio-tagged robust redhorses were located by boat via an ATS R2100 programmable scanning radio receiver (Advanced Telemetry Systems, Isanti, Minnesota) with a loop antenna. The location of the fish was estimated by disconnecting the coaxial cable from the antennae and using it to pinpoint the position of the tagged fish to within 1 m (as described by Grabowski and Jennings, in press a). Upon locating a fish, its position was recorded with a 12-channel, Wide Area Augmentation System-enabled, hand-held global positioning unit (Garmin International, Inc., Olathe, Kansas). Fish position was converted from latitude and longitude to river kilometer via ArcGIS 9.2 (Environmental Systems Research Institute, Redlands, California).

After all radio-tagged robust redhorses within a transect had been located, the tracking boat returned to the ramp and rendezvoused with the electrofishing boat. The electrofishing crew was made aware of the length of the transect and the number of fish present but was not told of their positions. The electrofishing crew then sampled the defined area for at least 0.19 h of pedal time per river kilometer, which is the minimum effort suggested to establish whether robust redhorses are present in an area (also used as a guideline for mark–recapture surveys; Robust Redhorse Conservation Committee 2002). The electrofishing boat was outfitted with a Smith-Root Type VI-A electrofisher (Smith-Root, Inc., Vancouver, Washington) set at 600 V, 60-Hz DC, and a 6–7-ms pulse width. The voltage and pulse width settings were altered as necessary to maintain a 4–5-A output. The tracker followed the electrofishing boat at a safe distance and monitored fish response during sampling, noting any movement of radio-tagged fish as the electrofishing boat passed their previously recorded position. Because of safety concerns, the tracking boat was not able to pinpoint the location of the fish during electrofishing and was only able to detect large movements such as across the river channel or to a different fallen tree. The electrofishing crew collected all catostomids that surfaced around the boat. Each was identified to species and enumerated. All captured fish were allowed to recover and released alive. After the electrofishing crew completed sampling, the tracker relocated the position of each individual as described above. The tracker also returned to relocate these fish 24 h and 3–5 d later.

Data analysis.—We calculated absolute movement and displacement of each individual at 1–2 h, 24 h, and 3–5 d postelectrofishing. Displacement was the difference between the initial fish position and its position upon relocation. Negative values for displacement indicated downstream movement, and upstream movement was represented by positive values. Absolute movement was simply the absolute value of displacement (Grabowski and Isely 2006; Grabowski and Jennings, in press a). We evaluated the directionality of the displacement with Student's *t*-test to evaluate whether mean displacement differed from zero. A one-way repeated-measures analysis of variance was used to compare the absolute movement and displacement of individuals exposed to one, two, three, and four sampling events. Radio-tagged robust redhorses, including individuals used in this study, were relocated using the methods described above over a 1-year period (see Grabowski and Jennings, in press a). Over the course of this year, individuals were relocated twice with a 24-h period 85 times and twice within a 3–5-d period 262 times. These data, which were collected before the exposure of any of the fish to electrofishing, were used as a reference data set to evaluate changes in movement patterns associated with electrofishing. Absolute movement and displacement were calculated for each of these individuals during these periods, and a paired Student's *t*-test was used to compare these values with those from the fish exposed to electrofishing. A significance level α of 0.05 was used for all of the abovementioned tests.

We wanted to estimate the probability of capturing a robust redhorse with boat electrofishing equipment and the abundance of untagged robust redhorses in the study transects. For radio-tagged robust redhorses, we estimated the capture probability (p) for each sampling transect (i) as:

$$\hat{p}_i = c_i / N_i,$$

where N_i is the known number of radio-tagged robust redhorses in transect i and c_i is the number of radio-tagged fish captured in transect i. One method for estimating the abundance of untagged robust redhorses is to adjust the number of untagged fish catch by the estimated capture probability (see Thurow et al. 2006). This approach, however, ignores the potentially useful information from the capture histories of the untagged robust redhorses. Fish abundance and capture probability can be estimated from repeat fish collection samples with the technique for estimating abundance from repeated samples (Royle and Nichols 2003). We treated each transect as analogous to a repeated sample from a sample site and estimated mean abundance (L) and capture probability as:

$$L(w) = \binom{T}{w}\left[1-(1-r)^{k_i}\right]^{w}\left[(1-r_i)^{k}\right]^{(T-w)}\frac{e^{-\lambda}\lambda^{k_i}}{k_i!},$$

where w is the number of observed detections in T total transects, λ is the mean of a Poisson distribution of the assumed robust redhorse abundance, r is the capture probability of untagged robust redhorses, and the likelihood is evaluated with respect to k (the number of untagged robust redhorses in transect i).

To accommodate the complex model structure, we used Markov chain Monte Carlo (MCMC), as implemented in BUGS software version 1.4 (Spiegelhalter et al. 2006) to jointly fit the model estimating capture probabilities of tagged and untagged robust redhorses and the mean abundance of redhorses in sample transects. All models were fit based on 500,000 iterations with 250,000 burn-in (i.e., the first 250,000 MCMC iterations were dropped) and diffuse priors. We evaluated the relative fit of four candidate models: (1) capture probabilities differed between tagged and untagged fish ($\hat{p}_i \neq \hat{r}_i$), (2) capture probabilities of tagged and untagged fish were equal ($\hat{p}_i = \hat{r}_i$), (3) mean robust redhorse abundance was a function of transect length, and (4) mean robust redhorse abundance was constant among transects (irrespective of transect length). The relative fit of models was assessed using deviance information criterion (DIC; Spiegelhalter et al. 2002), with lower values indicating better approximating models. We considered models with ΔDIC values less than 5 as plausible and reported their parameter estimates and 95% Bayesian credibility intervals, which are analogous to 95% confidence intervals (Spiegelhalter et al. 2002).

Results

A total of 7.46 h of effort was expended during electrofishing. A mean of 0.66 h (SD = 0.22) of effort was spent per kilometer of transect, which was 1.5–5.7 times greater than the amount of effort recommended by sampling guidelines outlined for this species (Robust Redhorse Conservation Committee 2002). Although the eight transects sampled (each on a different day) each contained from one to eight radio-tagged robust redhorses (as verified by radiotelemetry just before electrofishing began), only one radio-tagged robust redhorse and six untagged individuals were captured during all sampling days combined (Table 1). An additional 82 catostomids were captured: 10 notchlip redhorses *Moxostoma collapsum*, 46 spotted suckers *Minytrema melanops*, 25 brassy jumprocks *Moxostoma* sp. cf. *lachneri* (species not yet described), and 1 quillback *Carpiodes cyprinus* (Table 1).

Radio-tagged robust redhorses did not seem to exhibit an immediate response to the electrofishing. Movement was detected only 2 times out of the 30 possible electrofishing encounters with radio-tagged individuals. The signal for the single captured radio-tagged fish did increase in strength as the fish was brought to the surface and netted. Movement was observed for another radio-tagged fish that was initially occupying shallow water (1.0 m) in the proximity of the shoals at the upstream limit of the transect (Figure 1) on 8 March 2007. This fish moved across the river channel several times before taking up a position about 0.1 km downstream where the water was 2.0 m deep and contained large woody debris. Changes in signal strength or other indications of movement were not noted for any of the remaining individuals while electrofishing was in progress.

Some movement was observed when the tracker relocated fish at the conclusion of electrofishing. Within 1–2 h after electrofishing, approximately 71% of radio-tagged robust redhorses were occupying positions within a mean distance of 0.15 km (SE = 0.05, range = 0.00–0.80 km) of their location before electrofishing. However, this movement was not directional as demonstrated by the mean displacement not differing from zero (t_{21} = −0.02, P = 0.99). A similar pattern was observed upon relocating radio-tagged robust redhorses 24 h and 3–5 d after electrofishing. Individuals had moved mean distances of 0.19 km (SE = 0.05) from their original position after 24 h and 0.23 km (SE = 0.14) after 3–5 d. However, this movement also was not directional

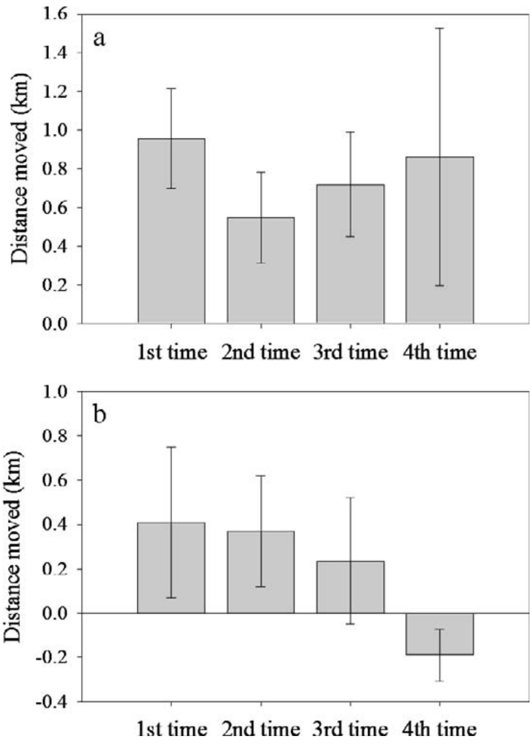

FIGURE 2.—Mean (±SE) **(a)** absolute movement and **(b)** displacement of radio-tagged robust redhorses in the Ocmulgee River, Georgia, over 3–5-d periods after their first, second, third, and fourth exposures to electrofishing. Positive values for displacement indicate upstream movement, and negative values indicate downstream movement.

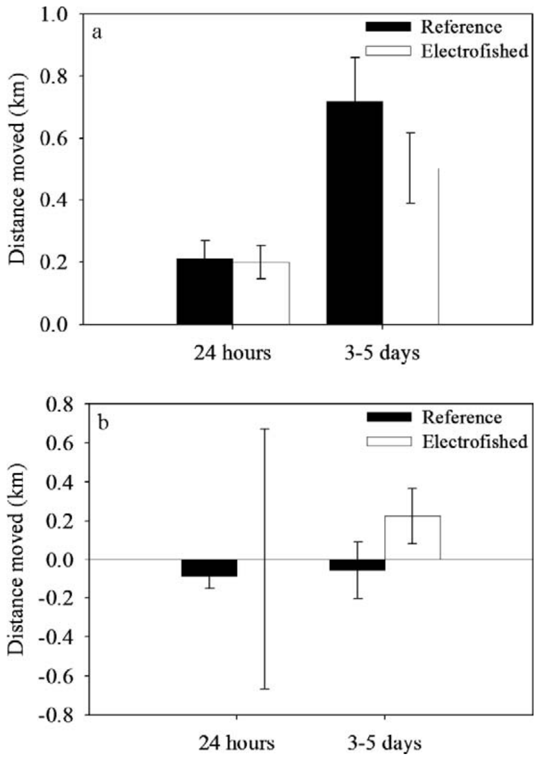

FIGURE 3.—Mean (±SE) **(a)** absolute movement and **(b)** displacement of radio-tagged robust redhorses in the Ocmulgee River, Georgia, at 24 h and at 3–5 d after exposure to electrofishing (dark bars), as compared with the reference group (unshaded bars), which were relocations at 24 h and 3–5 d after an initial radiotelemetry location, periods when there was no electrofishing (as obtained in a 1-year radiotelemetry study of these individuals; Grabowski and Jennings, in press a).

during either time interval ($t_{30} \leq 1.58$, $P \geq 0.12$). The single recaptured radio-tagged individual was released at the boat ramp. This fish returned to within 200 m of the position from which it was captured and remained in that location for approximately 3 weeks before being detected upstream in the tailrace of Lloyd Shoals Dam.

Multiple exposures to electrofishing did not seem to alter the behavior of radio-tagged robust redhorses (Figure 2); over the course of the study, seven individuals were exposed to electrofishing twice, five were exposed three times, and three were exposed four times. During these subsequent exposures, the activity levels of these fish, expressed as the sum of absolute movement and displacement over the 3–5-d monitoring periods, were similar to their initial exposure, both for absolute movement ($F_{3,12} = 0.49$, $P = 0.70$) and displacement ($F_{3,12} = 0.62$, $P = 0.62$).

Ultimately, the behavior of radio-tagged robust redhorses seemed to be minimally affected by boat-mounted electrofishing (Figure 3). During the course of a year-long telemetry study in the Ocmulgee River (Grabowski and Jennings, in press a), radio-tagged fish, including individuals used in this study, were relocated 85 times over the 24 h after prior radiotelemetry location and 262 times over the 3–5-d period when fish were not exposed to electrofishing. The absolute movement of individuals during the 24 h after electrofishing ($t_{83} = 0.13$, $P = 0.90$) and 3–5 d after electrofishing ($t_{144} = 1.19$, $P = 0.12$) was similar to the movement patterns of undisturbed fish over similar time intervals, as was the displacement of individuals during the 24 h ($t_{69} = -1.00$, $P = 0.32$) and 3–5 d ($t_{110} = -1.37$, $P = 0.17$) after electrofishing.

Model selection criteria indicated support for two of the candidate models. The best-approximating model for estimating robust redhorse capture probability and abundance had modeled capture probabilities as equal between tagged and untagged fish and had modeled mean abundance as equal across transects (Table 2).

TABLE 2.—Mean deviance ($\bar{D}$), deviance at mean parameter values ($\hat{D}$), effective number of parameters (pD), deviance information criterion (DIC), and ΔDIC for the candidate models for estimating robust redhorse capture probability (P), and the abundance of untagged robust redhorses (N) in transects in the Ocmulgee River, Georgia. Parameter symbols in bold were modeled as a constant.

Model	$\bar{D}$	$\hat{D}$	pD	DIC	ΔDIC
P*, *N	27.670	25.947	1.724	29.394	0.000
P(tagged, untagged), ***N***	27.850	23.875	3.975	31.825	2.432
P(tagged, untagged), *N*(transect length)	25.170	15.903	9.267	34.437	5.044
P, *N*(transect length)	26.810	19.157	7.653	34.463	5.070

The second-best approximating model differed from the best by modeling capture probabilities as differing between tagged and untagged fishes. Estimates of capture probabilities from the best-approximating model averaged 0.031 (95% Bayesian credibility interval = 0.002–0.111). In contrast, capture probability estimates from the second-best-fitting models were 0.062 for tagged and 0.055 for untagged fish. The standard deviations for these were relatively large and suggested that these estimates were unreliable. Mean robust redhorse abundance estimates per transect were 86.3 for the best model and 179.7 for the second-best model (Table 3). However, the standard deviations were relatively large and suggest that these values be interpreted with caution.

Discussion

Robust redhorses exhibited little, if any, response to boat-mounted electrofishing sampling activities. Most fish did not exhibit large responsive movements during or after single or repeated electrofishing sampling events. This lack of response was unexpected because the species has been observed to be somewhat wary and sensitive to disturbance, at least under captive conditions (D. Wilkins, South Carolina Aquarium, personal communication). Observations in streams and smaller rivers have indicated that other catostomids are wary and can be difficult to approach when not spawning (Jenkins and Burkhead 1993; T. B. Grabowski, personal observation). The observed similarity of behavior between fish exposed to sampling activities, the reference data set of the movement of individuals over similar periods, and the consistent behavior of individuals exposed to multiple exposures seem to suggest the fish were not being affected by the electric field. Unfortunately we lacked data to make a direct comparison between our reference and experimental fish in their movement during 1-h intervals, the period when such differences might be most likely to occur. However, the movements of robust redhorses 1 h after exposure to electrofishing are comparable to those made of undisturbed, radio-tagged robust redhorses in the Savannah River at similar time intervals (Grabowski and Isely 2006). These Savannah River fish exhibited mean hourly absolute movement of 0.13 rkm (SE = 0.02, range = 0.0–6.7 rkm, $N = 548$) and mean hourly displacement of −0.02 rkm (SE = 0.03, range = −6.7 to 3.2 rkm, $N = 548$; T.B. Grabowski, unpublished data). From a practical standpoint, the magnitude of these movements would seem to suggest that robust redhorses exposed to electrofishing are no more likely to violate closure assumptions during sampling than are unexposed individuals. Further research should validate whether habitat complexity or depth affect the magnitude of movement during or after electrofishing.

There are several possible explanations for the observed lack of response of radio-tagged robust redhorses in the Ocmulgee River. Robust redhorses occupy relatively deep water, typically more than 2.0 m (Grabowski and Isely 2006; Grabowski and Jennings, in press a). As such, they may be out of reach of the electric field generated by a boat-mounted electrofisher, particularly if they are on or near the river bottom (Reynolds 1996). Alternatively, they may be stunned by the electricity but may not readily float to the surface, possibly because they become entangled in cover. Robust redhorses are rarely, if ever, found far from cover as demonstrated by this and other radiotelemetry studies (Grabowski and Isely 2006; Grabowski and Jennings, in press a; R. Hiese, North Carolina Wildlife Commission, personal communication). The lack of movement we observed may be a

TABLE 3.—Parameter estimates, standard deviation (SD), and 95% credibility intervals for the confidence set of models of robust redhorse abundance and capture probability in the Ocmulgee River, Georgia.

Parameter	Estimate	SD	Credibility interval
Best model			
Untagged fish abundance	86.34	135.8	6–532
Probability of capture	0.031	0.030	0.002–0.111
Second-best model			
Untagged fish abundance	179.7	242.8	2–873
Probability of capture			
Tagged fish	0.062	0.042	0.008–0.167
Untagged fish	0.055	0.093	0.001–0.351

result of some individuals becoming entrapped in structurally complex refuges and thus prevented from rising to the surface.

Regardless, the implication to conservation efforts is that electrofishing does not seem to be a particularly effective method for capturing robust redhorses. Their capture probabilities are considerably lower than those reported for smallmouth bass *Micropterus dolomieu* (Odenkirk and Smith 2005; Dauwalter and Fisher 2007) and other common sport fish (e.g., largemouth bass *Micropterus salmoides*, bluegills *Lepomis macrochirus*, and crappies *Pomoxis* spp.) as well as nongame fishes (e.g., common carp *Cyprinus carpio*, gizzard shad *Dorosoma cepedianum*, or threadfin shad *Dorosoma petenense*; Bayley and Dowling 1990, 1993; Bayley and Austen 2002). Many of these studies have suggested that catostomids, such as redhorses, may be underrepresented in samples taken with boat-mounted electrofishers. Bayley and Austen (2002) report a mean capture probability of 0.03 for catostomids captured with a boat-mounted electrofisher in Midwestern lakes. They found that only ictalurid catfishes had a lower capture probability (mean = 0.0018) than catostomids out of 11 common warmwater taxa. The capture probability we reported for robust redhorses (mean = 0.031, 95% Bayesian credibility interval = 0.002–0.111) is comparable to that reported for catostomids by Bayley and Austen (2002), despite the deeper water, higher current velocities, and potentially lower conductivity in the present study. The low sample sizes of robust redhorses in our study suggests a high level of uncertainty regarding the precise probability of capturing robust redhorses with electrofishing gear; however, the capture probability is probably low based on our study and the observations of others. Further research to refine these models would be useful, but our results suggest that the effort recommended for the standard electrofishing mark–recapture surveys used to monitor populations of this species is insufficient and greater effort must be expended to ensure more accurate estimates than are available currently.

The estimates generated by our model are considerably higher than what we expected. However, this does not necessarily render then biologically impossible. These estimates would not seem unreasonable for the other catostomid species captured during this experiment. Several catostomid species were captured at a high enough frequency to suggest that density estimates of 80–180 fish/rkm would not seem unreasonable for a catostomid species. The focus area of our electrofishing surveys was close to one of the robust redhorse release points for the stocking program on the Ocmulgee River, which as of 2005 had stocked approximately 13,000 individuals ranging from age 0 to young adults (age 5; J. Evans, Georgia Department of Natural Resources, personal communication). Consequently, the robust redhorse densities may have been elevated if individuals were slow to disperse after release (Grabowski and Jennings, in press a). Finally, robust redhorses are morphologically unique among catostomids on the Atlantic Slope because of their well-developed crushing molariform pharyngeal teeth (Bryant et al. 1996; Marcy et al. 2005). Presumably these structures enable robust redhorses to consume hard-shelled invertebrates such as gastropods and freshwater mussels (Bryant et al. 1996; Marcy et al. 2005). The Ocmulgee River has been invaded by the Asiatic clam *Corbicula fluminea*, which seems to occur at high densities within our study area (T.B. Grabowski, personal observation). The local abundance of a potential food source may support high densities of robust redhorses. Obviously, this is highly speculative but does suggest a need to refine population density estimates and further illustrates the uncertainties associated with estimating the population size of difficult-to-capture organisms.

Accounting for the behavioral reactions of fish to sampling gear (Fréon et al. 1993) and the capture probability of a species, particularly those that are rare or difficult to sample, is an important component of study design. Failing to do so will probably result in consistent underestimates of population size. Although a conservative approach is desirable in the management of threatened or endangered species, underestimating population size can be a hindrance to recovery. For example, in the case of robust redhorses, some combination of behavioral responses and habitat selection seem to render the species difficult to capture. Low capture probability results in high sample variance, which lowers data quality and ultimately influences conservation decision-making (Peterson and Rabeni 1995). However, determining the success of stocking programs, estimating the status of known populations or establishing the presence or absence of this species in other Atlantic Slope drainages is heavily dependent upon electrofishing surveys (DeMeo 2001, Robust Redhorse Conservation Committee 2002). This theme is common among the conservation programs for imperiled catostomids throughout North America (Cooke et al. 2005) and perhaps other cryptic riverine species. There are potential remedies that resource managers can incorporate to account for low capture probabilities: employing alternative gear types to which the target species may be more vulnerable, increasing gear efficiency by using radio-tagged fish as guides (Grabowski and Jennings, in press b), and approaching the problem differently (e.g., use of occupancy models; MacKenzie et al. 2003, 2006; Royle and Dorazio 2006).

Acknowledgments

The authors thank M. Abney, W. Clark, R. Cull Peterson, J. Evans, K. Filer, R. Parr, C. Shea, and K. Woodward for their assistance in the field. Funding for this study was provided by Georgia Power Company. This manuscript benefited from the comments and suggestions provided by O. P. Olafsson, C. R. Ruetz III, and three anonymous reviewers. Cooperating agencies for the Georgia Cooperative Fish and Wildlife Research Unit are the U.S. Geological Survey, the University of Georgia, Georgia Department of Natural Resources, and the Wildlife Management Institute. Reference to trade names does not imply endorsement by the U.S. government.

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