Can Biotelemetry Information Improve Trap-net Catch Rates of Adult White Crappie?

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Abstract: We used biotelemetry to monitor monthly adult white crappie locations and core-use-area sizes at Lyndon B. Johnson (LBJ) and Waco reservoirs in Texas over two 6-month periods (December 2000–May 2001 and November 2001–April 2002) and tested whether deploying trap nets at sites near known fish locations and at similar sites predicted to contain fish would result in increased trap-net catch per effort compared to randomly selected sites. No evidence suggested crappie preferred different depths depending upon the time of year in LBJ or Waco reservoirs. We observed fish further from shore in January compared to April in LBJ Reservoir, but all months were similar for Waco Reservoir. The majority of fish locations (>55% for both reservoirs throughout study) were further from shore than our trap nets effectively fish (21.3 m). Trap-net catch rates for the three deployment strategies (known, predicted, and random) were not significantly different in any month (November 2001–April 2002) for LBJ or Waco reservoirs. Selecting sampling sites subjectively offered no significant benefit over selecting sites randomly. However, trap nets set in deeper water (>4 m) typically caught fewer fish at both reservoirs and nets set in the upstream third of Waco Reservoir generally caught greater numbers of adults. Addressing large- and small-scale habitat variables (i.e., linear distance from dam and water depth) may be more important than actual fish locations when deciding on a trap-net deployment strategy.

Key words: crappie, biotelemetry, trap net, core-use area

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Black crappie (*Pomoxis nigromaculatus*) and white crappie (*P. annularis*) are popular sport fish in Texas (Bohnsack and Ditton 1999). Populations of either species can be difficult to manage (Boxrucker and Irwin 2002) as they commonly exhibit erratic recruitment (Mitzner 1991, Maceina and Stimpert 1998, McKeown and Mooradian 2002, Sammons et al. 2001, 2002b). Strong recruitment can result in over-crowding and stunting, whereas weak recruitment can result in over-harvest (Hooe 1991). Fisheries managers need to be able to detect changes in crappie population characteristics (i.e., abundance, recruitment, mortality) to institute appropriate management decisions.

While fisheries managers in most states use trap nets to sample for crappies based on its effectiveness compared to other gear types (Colvin and Vasey 1986, Boxrucker and Ploskey 1988, Miranda et al. 1990), analyses from trap-net data have proven problematic (Maceina et al. 1998, Maceina and Stimpert 1998, Isermann et al. 2002) because of low sampling efficiency, size bias, and poor precision. Researchers and managers have investigated improvements to trap-net design (Miranda et al. 1996, Isaaks and Miranda 1997, Besler et al. 1998) and the use of alternative sampling gears to augment trap-net data (Sammons et al. 2002*a*) in order to improve the quality of the data used for management decisions.

The Texas Parks and Wildlife Department (TPWD) conducts fall trap net sampling with random site selection to collect data on crappies following standard sampling protocol in TPWD Inland Fisheries Assessment Procedures (TPWD, Inland Fisheries, unpublished manual revised 2004). Decisions concerning crappie management in Texas are influenced by these data. Unfortunately, the current sampling strategy produces highly variable catch rate and questionable size distribution data. At some reservoirs, low trap net catches contradict creel data when the latter indicate abundant crappie.

Knowledge of seasonal and monthly adult crappie movements related to spatial and temporal variables might increase the effectiveness of trap nets if the gear could be deployed when and where crappies are more likely to be. Scientific literature describes adult crappie movement behaviors in shallow glacial lakes of a northern plains state (Guy et al. 1992, 1994) and a small (532 ha) Midwestern reservoir (Markham et al. 1991), but these habitats are dissimilar to most southern reservoirs. To date, no telemetry study has been published researching crappie movements in a southern U.S. reservoir or used telemetry data to suggest improvements to trap-net deployment methodology.

Site selection likely plays a large role in the capture success of trap nets. Factors that could influence the effectiveness of trap-net sampling for crappie include water depth, bank slope, water temperature, and orientation of net to shore (Schorr and Miranda 1995). Trap-net sampling at random locations within a reservoir may place some nets at ineffective sites (where crappies are not found). Gaining a better understanding about crappie locations utilizing biotelemetry could potentially improve sampling effectiveness by facilitating sampling at locations frequented by crappie. However, the only good test of this premise is to actually set nets utilizing this information and compare catch to nets deployed with random site selection. This study was designed to characterize adult white crappie locations utilizing biotelemetry and utilize this information to test whether we could increase trap-net sampling effectiveness. Objectives were to (1) determine monthly adult white crappie locations and core-use-area sizes and (2) compare mean trap net catch rate of white crappie among random, subjective (habitat characteristics similar to those at known white crappie locations), and known white-crappie-frequented sites in two Texas reservoirs.

Methods

Study Sites

Lyndon B. Johnson (LBJ) Reservoir, a 2,580-ha mainstream impoundment of the Colorado and Llano rivers, is located approximately 97 km northwest of Austin. Mean depth is 6.7 m, maximum depth is 27.4 m, and Shoreline Development Index (SDI) (McMahon et al. 1996) is 17.9. Secchi disc depths typically range from 1.0 to 2.0 m.

Waco Reservoir is an impoundment of the North, Middle, and South Bosque rivers and is located on the west side of the city of Waco. Reservoir surface area was 2,942 ha during this study. Mean depth is 6.4 m, maximum depth is 25.9 m, and SDI is 5.0. Secchi disc depths average approximately 0.3 m.

We selected LBJ and Waco reservoirs for this study because both offered white crappie fisheries which anglers were successful targeting (according to unpublished TPWD data and anecdotal angler reports), but TPWD trap-net catch rates were poor (<2 per net-night). The disparate reservoir water clarities also offered an opportunity for our study results to be applicable to a wider list of reservoirs.

Biotelemetry

We collected white crappies for ultrasonic transmitter implantation using trap nets (both reservoirs) and hook-and-line (LBJ Reservoir) from December 2000–January 2001 and again in October 2001. We only used white crappies in this project because black crappies were rare in the study reservoirs. We attempted to collect fish from the middle section of each reservoir, but abandoned this strategy in Year 1 on Waco Reservoir due to poor success. In Year 1, all Waco Reservoir fish were collected in the North Bosque River arm of the reservoir (Fig. 1). Fish were collected and tagged in LBJ Reservoir in both year 1 and 2 (Fig. 2).

Ultrasonic transmitters (Sonotronics model IT00-4) used in

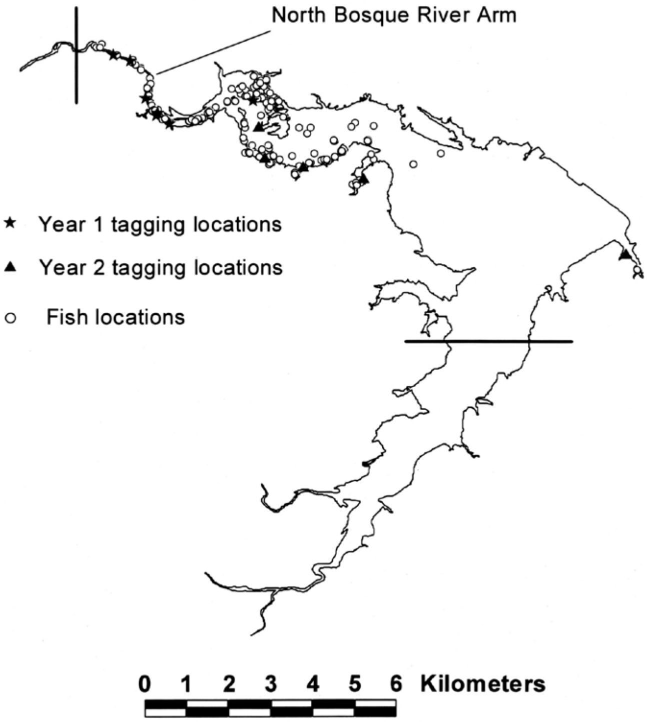

Figure 1. Transmitter implantation sites and fish locations for Waco Reservoir white crappies. Transverse lines across reservoir map indicate boundaries within which most searching activity was conducted. Searches were conducted at least once outside these boundaries.

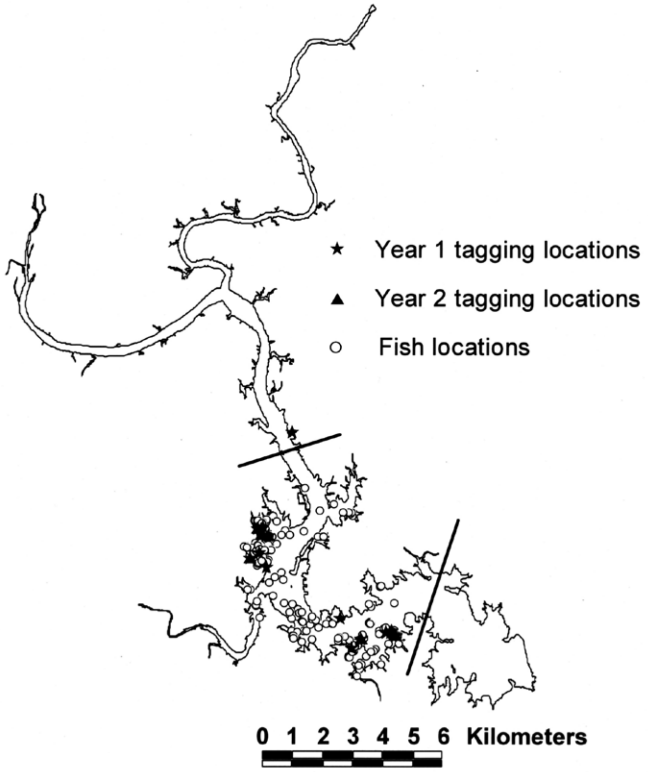

Figure 2. Transmitter implantation sites and fish locations for LBJ Reservoir white crappies. Transverse lines across reservoir map indicate boundaries within which most searching activity was conducted. Searches were conducted at least once outside these boundaries.

this study measured 39 x 12.5 mm, weighed 4 g in water, and contained a six-month lithium battery. We used an ultrasonic receiver (Sonotronics model USR-96) and directional hydrophone to locate transmitter signals. We targeted white crappies >320 g for transmitter implantation. Fish weighing <320 g would violate the 1.25% transmitter weight in water/fish weight in air ratio (Winter 1996).

White crappies were surgically implanted with transmitters at or adjacent to (<200 m) collection sites. Transmitters were implanted according to procedures developed by Hart and Summerfelt (1975) with special modifications for this species (Guy et al. 1994). Surgical skin staples (Mulford 1984, Swanberg et al. 1999) were used to close incisions. Fish were released immediately following surgery to avoid additional handling stress. At least seven days were allowed for fish to recover from surgery before tracking was initiated. Tracking was conducted twice monthly in January 2001–May 2001 and November 2001–April 2002 in each reservoir. Because most fisheries agencies sample crappies with trap nets in either spring or fall (Colvin and Vasey 1986, Boxrucker and Ploskey 1988, McInerny 1988), tracking periods were designed to include these seasons. Because adult white crappies move mostly between dusk and dawn (Markham et al. 1991, Guy et al. 1994) and trap nets are set overnight, tracking was limited to a 16-hour period (1700–0900 hours). Each tracking trip consisted of one of two possible eight-hour tracking periods (1700–0059 hours or 0100–0859 hours). The first tracking trip was during the 1700–0059-hours period and subsequent trips alternated between tracking periods.

Searching for transmitter-bearing white crappie began near tagging locations and proceeded until the first fish was located. After located, the tracker recorded identification and location information on the fish. Location of fish included: latitude and longitude using an Eagle AccuNav Sport GPS (global positioning system), depth at fish location using a Lowrance 65X sonar unit, and shortest distance to shore using a Bushnell 1000 yardage pro range finder. The maximum detection distance of the receiver was 1 km. However, the effective range of the telemetry equipment was often reduced by underwater obstructions (reservoir bottom contours, flooded timber, bridge pilings, etc.). After identification and location information was recorded, the tracker attempted to locate other fish in the area.

Trap Netting

Trap-net sampling was conducted at each reservoir concurrently with Year-2 telemetry surveys using three site selection strategies: 1) nets placed near known white crappie locations (i.e., known) based on telemetry data, 2) nets placed in areas predicted to contain white crappie but not containing transmitter-bearing fish (i.e., predicted), and 3) nets placed at random sites (i.e., random). Predicted sites were chosen by plotting transmitter-bearing fish locations on a reservoir map, then subjectively selecting sampling sites based on similarities (i.e., water depth, bank slope, reservoir habitat [i.e., boat houses, flooded timber/brush], and reservoir area [i.e., point extending into cove, back of cove, main-reservoir shoreline, etc.]) with fish location sites. Reservoir maps were digitized using 7.5-minute quadrangles (7.5 min^2 = approximately 7.2 ha). Coordinates representing the geographical centers for grids overlapping reservoir shorelines were randomly selected to serve as random stations. Trap nets were randomly set as near to selected coordinates as possible, provided that they could be set perpendicular to shore, and water depth was sufficient to cover the net. New sampling sites were selected for each deployment strategy each month.

Ten trap nets (0.9-m x 1.8-m frames, 18.3-m leads, and 13-mm bar mesh) were set for each of three sampling strategies each month (N_{total} = 30). Thirty sets were distributed equally into two 15-net sets, typically conducted on successive days. One exception to this rule occurred at Waco Reservoir in November because inclement weather allowed the deployment of only 15 of the 30 nets (N_{known} = 1, $N_{\text{predicted}}$ = 7, N_{random} = 7). Each trap net was set in the evening and collected the following morning, constituting one unit of effort. White crappies were removed from the nets, measured to the nearest mm TL, and subsequently released at the site. Additional information collected at each trap-net site included GPS location, Secchi depth (cm), and water depth (m) at cod end of net.

Data Analysis

We tested whether water depth at marked white crappie locations and distance from shore changed by month using Proc Mixed (SAS 1999). The distance-from-shore data were $\log_{10}$-transformed because of some extreme observations. Multiple observations from each fish were represented as longitudinal data, with each fish serving as a subject. Kenward-Rogers approximation was used to estimate degrees of freedom for hypothesis tests and models were fit using the restricted maximum-likelihood method (SAS 2002). We tested whether variance was homogenous in the different months and examined a variety of likely covariance structures (e.g., independence/variance components, compound symmetric, and spatial power) based on our understanding of the processes that would create the dependences (SAS 2002, Littell et al. 2000). When modeling the spatial power covariance construct, we used days since released as the measure of distance. Model fit for nested models was assessed using a likelihood ratio test and non-nested models using Akaike's Information Criteria. On those occasions where a single fish was observed several times on a single trip, the average (depth or distance) was used in the analysis. When the analysis suggested significant difference in depth or distance, we estimated appropriate pairwise differences and tested these differences using a Tukey adjustment to control our Type I error. Stationary transmitters were excluded from analysis. Transmitters were considered stationary when all successive signal locations were separated by ≤30 m until battery failure. We selected 30 m as our threshold because this distance would encompass both the GPS unit's accuracy (15 m) and boat positioning precision (approximately 15 m).

ANOVA was used to compare mean trap-net CPUE among sampling site categories by month for adult white crappie ≥280 mm. We chose 280 mm to represent the lower limit of the adult size category because this demarcation approximated the length of the smallest crappie implanted with a transmitter in this study. Tukey-Kramer HSD Multiple Range Tests were used to determine which means differed significantly. Trap-net catch data were not normally distributed and consequently were transformed to logarithms [i.e., $\log_{10}(X + 1)$]. As ANOVA is robust to minor violations of the normality assumption, normality following transformations was assessed visually. All tests were considered significant at $\alpha \leq 0.05$.

Individual white crappie locations were classified into one of three distinct patterns: 1) singular core-use, 2) multiple core-use, and 3) nomadic pattern with no identifiable core-use. A fourth category included fish with insufficient location sample sizes to describe a distinct pattern. Core-use area sizes were calculated using the Convex Polygon Method (Winter 1977, Fish and Savitz 1983). An observation-area curve or cumulative increase in area was drawn to determine when sufficient locations were observed to adequately describe a stable core-use area. Core-use areas were described when the observation curve increased by <1% (Odum and Kuenzler 1955). Movement distances outside core-use areas were calculated from the movement location to the closest point along the perimeter of the core-use polygon.

Table 1. Summary of data for white crappie implanted with ultrasonic transmitters in LBJ and Waco reservoirs, Texas, 2001–2002.

	LBJ Reservoir		Waco Reservoir	
Biotelemetry statistics	**Year 1**	**Year 2**	**Year 1**	**Year 2**
Number of white crappie tagged	28	29	29	30
Mean length (mm TL)	297	290	315	298
Mean weight (g)	374	312	485	388
% ≥ transmitter-weight/fish-weight ratio	54	41	100	83
Mean water temperature (C) at surgery	11.3	23.2	11.4	19.9
Number and % of located mobile tags	22 (78)	8 (27)	21 (72)	6 (20)
Number and % of stationary tags	1 (4)	15 (52)	1 (3)	17 (57)
Number and % of missing tags	5 (18)	6 (21)	7 (24)	7 (23)

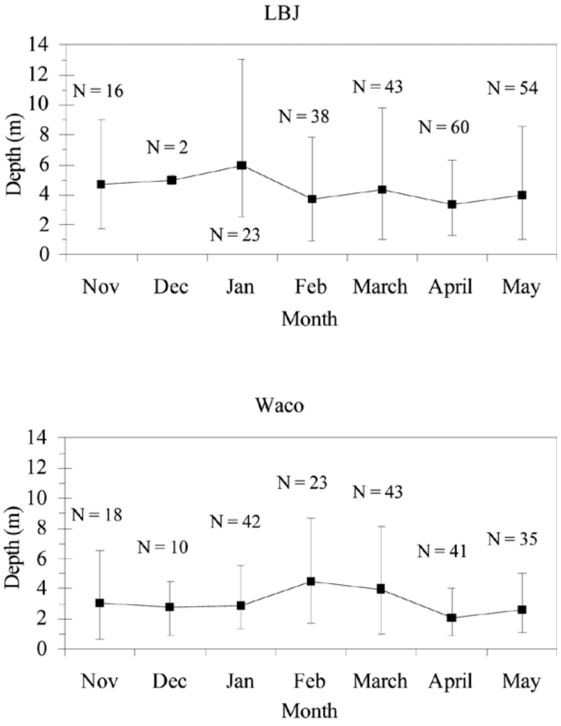

Figure 3. Mean depth, by month, at fish location for adult white crappies monitored in LBJ and Waco reservoirs January 2001–May 2001 and November 2001–April 2002. Data were pooled among years for similar months. Vertical lines represent the lower 10% and upper 90% quantiles.

Results

Biotelemetry

A total of 116 white crappies, averaging 300 mm (range = 267–374) and 390 g (range = 242–683), were implanted with ultrasonic transmitters in LBJ and Waco reservoirs over the course of the two-year study (Table 1). During model fitting, we found that Compound Symmetric and Spatial Power covariance models, with the Month-specific variances provided almost identical fit based on the AIC. The Null Model likelihood ratio test was highly significant (P=0.0003), suggesting either of these was a better fit than the uncorrelated Variance Components model. As both provided similar fits, and identical conclusions, we chose the Spatial Power model during the reporting of the results, as that structure makes more sense conceptually. Using that model, we found no evidence to suggest crappies preferred different bottom depths depending upon the month of year (P [$F_{5,30} > 1.03$] = 0.416) in LBJ Reservoir (Fig. 3). However, fish were more dispersed in January (i.e., fish located at many different depths), and more concentrated in April (i.e., fish depths closer to the mean of 3.4 m). Fish were further from shore in January than in April (adjusted P = 0.029) in LBJ

Reservoir, but distances in all other months were similar (Fig. 4).

For Waco Reservoir, we again found that Compound Symmetric and Spatial Power covariance models, with the Month-specific variances provided almost identical fit based on the AIC, and the Null Model likelihood ratio test was highly significant (*P*=0.0001), suggesting either of these was a better fit than the uncorrelated Variance Components model. Using the spatial power model, we observed no ($P[F_{6,19} > 2.59] = 0.056$) differences in fish depth across months (Fig. 3). Fish were more dispersed, by depth, in February and March, and least so in April. Fish distance from shore was highly variable within months for Waco Reservoir (Fig. 4), and no months were significantly different ($P = 0.058$).

Two patterns of movement, site-specific (i.e., core-use and multiple core-use) and nomadic, were observed. Five (23%) fish in LBJ Reservoir established identifiable core-use areas with a mean size of 5.3 ha (SE = 2.5, Range = 0.5–14.2 ha). Four (18%) fish frequented consistent areas, but did not meet the observational-area curve criterion. No fish in LBJ Reservoir exhibited detectable multiple core-use areas. Four (18%) fish exhibited nomadic behavior. The fish exhibiting the greatest mobility traveled 4.8 km between furthest locations. Nine (41%) fish were located too infrequently to ascertain distinct behavior patterns. Fish that established core-use areas would briefly move long (mean = 2.9 km, SE = 0.25, N = 2) or short (mean = 0.9 km, SE = 0.23, N = 3) distances, but would often return.

Seven (35%) Waco Reservoir fish established identifiable core-use areas with a mean size of 11.7 ha (SE = 2.7, Range = 3.0–22.5 ha). Four (20%) fish did not meet the observational-area curve criterion despite frequenting fairly consistent locations. However, changing our observational-area curve criterion from 1% to 5% to include these data resulted in a similar mean core-use size (8.7 ha, SE = 2.2, Range = 0.9–22.5 ha). One (5%) fish in Waco Reservoir appeared to establish multiple core-use areas, the first during the winter (0.7 ha) and the second during spring (3.9 ha). However, neither of these areas contained enough locations to meet the observational-area curve criterion for describing a distinct area size. Two (10%) fish demonstrated nomadic behaviors, and six (30%) fish were located too infrequently to identify any site-selection behavioral patterns. The fish exhibiting the greatest mobility traveled 5.6 km between furthest locations. One (<1%) fish migrated to a new area in the spring (3.0 km, N = 1), and five (25%) fish moved (mean = 2.5 km, SE = 0.6, N = 5) briefly away from established core-use areas. Maximum distances traveled from transmitter-implanting locations were 6.8 km and 6.3 km for LBJ and Waco reservoirs, respectively. However, one transmitter-bearing white crappie was caught by an angler from Waco Reservoir 8.8 km from the nearest transmitter-implanting location.

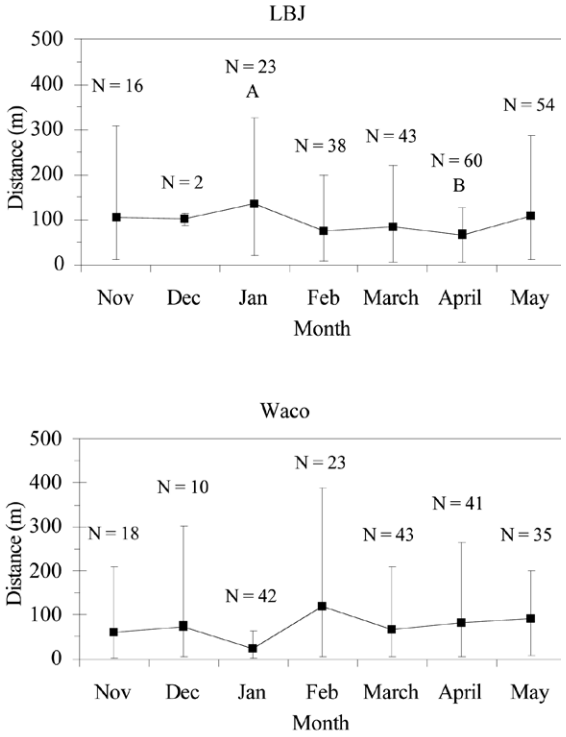

Figure 4. Mean distance from shore, by month, at fish location for adult white crappies monitored in LBJ and Waco reservoirs January 2001–May 2001 and November 2001–April 2002. Data were pooled among years for similar months. Vertical lines represent the lower 10 and upper 90% quantiles. Values for months with different letters are significantly different.

Trap Netting

Trap-net catch rates of white crappie (>280 mm) were not improved using alternate deployment strategies at LBJ or Waco reservoirs (Fig. 5). Mean white crappie CPUE for the three deployment strategies were not significantly different in any month for LBJ or Waco reservoirs ($P > 0.083$ for all months).

Discussion

Characterizing adult white crappie locations in these study reservoirs was difficult. Fish exhibited individualistic behaviors which led to high variation in water depths and off-shore distances within months. Even within tracking trips, individual fish would often move considerable distances, changing depths and distances from shore. Guy et al. (1994) and Markham et al. (1991) found that adult white crappie movements were greatest during dawn and dusk periods from April through October and June through August, respectively. The two tracking periods in our study encompassed the high movement periods of both dawn and dusk hours which could have contributed to the variability observed.

Seasonal movements in our study likely overlapped months. We believe movements related to spawning activities occurred in

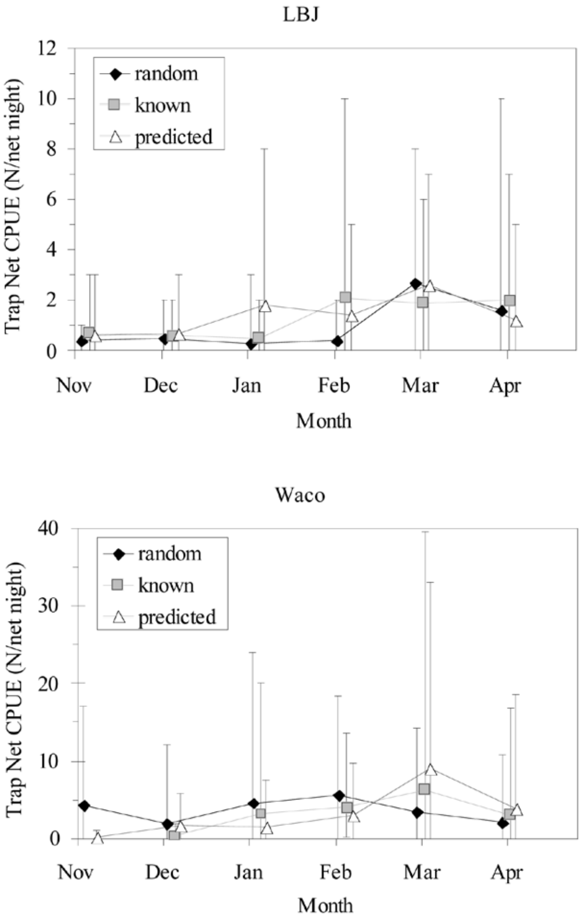

Figure 5. Mean trap net catch of white crappie > 280 mm by deployment strategy, November–April at LBJ and Waco reservoirs. Deployment strategies were random, known (nets placed near known crappie locations), and predicted (nets placed in areas predicted to hold crappie but not containing transmitter-bearing fish). Vertical lines represent the lower 10% and upper 90% quantiles. Note the difference between y-axis scales.

March and April in the study reservoirs. White crappies in Midwestern and Southeastern U.S. reservoirs may begin spawning at water temperatures >16 C, spawning peaks between 20 and 22 C, and continues for a protracted period ranging from 27 to 56 days (Hammers 1990, Mitzner 1991, Travnichek et al. 1996, Sammons et al. 2001). Based on water temperatures in the study reservoirs, and if the above temperature relationships held true, peak spawning occurred in our study near the first week of April. However, the protracted duration of spawning activities likely resulted in fish moving in and out of shallower, nearer-shore locations at different times during March and April.

Reservoir morphometry and topography were more heterogeneous in our study reservoirs than in the shallow, glacial lake (SDI = 1.6, size = 117 ha, maximum depth = 2.4 m) described in another white crappie telemetry study (Guy et al. 1994). Greater heterogeneity in reservoir shape and depths could also explain the high variability in depths and distance from shore observed in this study.

Knowledge of Waco Reservoir morphometric heterogeneity and transmitter-implanting locations are required to better explain characterizations of fish location data there. For January, we could only make inferences for water depth at fish location and fish distance from shore for the very upper end of Waco Reservoir (which consisted of mainly the North Bosque River channel). Most fish locations were determined for Year-1 fish which were implanted with transmitters in that immediate location. Most of these fish did not disperse out of the narrow river channel until February. This explains the small mean and variance for depth and distance for January at Waco Reservoir.

Transmitter-bearing fish exhibited variable degrees of site fidelity. Mean core-use areas for LBJ (5.3 ha, Range = 0.5–14.2 ha) and Waco (13.1, Range = 5.7–22.5 ha) reservoirs were similar to median monthly home ranges (15.8 ha, Range = 0.1–85.0 ha) reported for white crappie of similar size in a South Dakota glacial lake (Guy et al. 1994). Incorrect categorization of small home ranges as stationary transmitters could have skewed our results, but we suspect this was unlikely. Our telemetry encompassed seasonal and diel periods associated with elevated white crappie movement (Markham et al. 1991, Guy et al. 1994). Stationary transmitters did not vary outside our detection threshold for the remainder of the battery life in stark contrast to fish exhibiting small core-use areas that displayed obvious mobile characteristics. We did not include daytime (0900–1700) telemetry. Although it is possible that fish could have moved during the day and returned to the same spot at night, prior studies indicate white crappies move most at dusk and dawn (Markham et al. 1991, Guy et al. 1994).

Individual white crappies in our study used broad areas of the reservoir, traveling up to 8.8 km from their transmitter-implanting locations. Although some fish used well-defined core-use areas, several exhibited nomadic behavior and were seldom found within several hundred meters of previous locations. Guy et al. (1994) mentioned that some white crappies did not establish preferred home ranges, but used the entire 117-ha lake.

Water temperature most likely influenced post-surgery survival of white crappie. In October 2001, transmitter-bearing fish were released into water 8.5–11.9 C warmer than during the surgery period (December 2000–January 2001) of the previous year. The greater proportion of stationary transmitters in Year 2 may have been related to increased post-surgery mortality or transmitter loss as a result of higher water temperatures. Adult bluegills (*Lepomis macrochirus*) surgically implanted with radio transmitters suffered elevated rates of mortality and transmitter loss at 20 C (10% and 15%, respectively), compared to those at 6 C (0% for both), over an eight-week period (Knights and Lasee 1996). Established rules for transmitter-weight to fish-weight ratios were occasionally broken in this study because obtaining large (>320 g) white crappie was difficult. However, the use of slightly undersized fish was consistent among years for each reservoir. We could not detect any differences in mortality or tag retention rates between fish weighing more or less than 320 g. In addition, information exists to challenge rules concerning these ratios (Brown et al. 1999).

Subjectively choosing trap net sites, either in locations known to have held transmitter-bearing fish or at sites similar to those, offered no improvement over randomly-selecting sites in any month. White crappie CPUE was highly variable, making the detection of actual differences difficult. However, a survey consisting of only 10 trap nets reflects a realistic effort required for some Texas reservoirs (TPWD, Inland Fisheries, unpublished manual revised 2004). Two factors exist that could have effected white crappie catch rates. First, fewer mobile white crappies were available during Year 2 when fish locations were used to assist with planning concomitant trap-net sets. We were forced to use Year-1 fish locations to supplement recommendations for known and predicted sites. Because of the one-week lag between locating fish and setting trap nets and given the opportunity for fish movement, our confidence in placing nets in the immediate vicinity of transmitter-bearing fish would have been low even if mortality/transmitter-loss had been low. Second, and perhaps most important, transmitter-bearing white crappie would often be located in reservoir areas that were not conducive for trap nets to fish effectively (i.e., far from shore, near steeply sloping banks, or near rapid bottom contour changes). TPWD standardized sampling protocol requires the use of trap nets measuring approximately 21.3 m long from the start of the lead to the cod end, yet the majority of transmitter-bearing fish were located >21.3 m from shore, even during spring months when fish typically move shallow to spawn. The fact that a higher percentage of Waco Reservoir crappie locations were within 21.3 m of the shore may provide a clue as to why trap-net CPUE was greater at this reservoir as compared to LBJ. This study raises questions about the effectiveness of shoreline trap nets to effectively sample a fish population comprised of individuals that routinely reside further than a trap-net length from shore.

Improving the efficiency of trap netting in Texas will likely require addressing factors other than random versus subjectively-chosen site selection. Prior research has addressed trap-net catch variables related to season (Boxrucker and Ploskey 1988); mesh size (Besler et al. 1998); and shoreline slope, water depth, and water temperature (Schorr and Miranda 1995). We observed that trap nets set in water <4 m deep tended to catch more fish. Augmenting white crappie data using alternative trap-net designs (Miranda et al. 1996, Isaaks and Miranda 1997) or gear types (Sammons and Bettoli 1998; Allen et al. 1999; Sammons et al. 2002*a*; Mike Wood, Louisiana Department of Wildlife and Fisheries, personal communication) also showed promise. Trap nets set according to the TPWD procedures (TPWD, Inland Fisheries, unpublished manual revised 2004) have proven more effective in relatively shallow, turbid reservoirs. Future research should focus on developing a gear that will fish effectively further from shore (>21.3 m) or adjacent to more heterogeneous reservoir bottom contours and testing these against standard gears.

Some white crappies establish relatively small core-use areas and are not highly mobile, while others were nomadic. Passive sampling trap nets likely select for the nomadic component of the white crappie population. An active sampling gear may be needed to compliment trap nets in order to capture a more representative white crappie sample. Allen et al. (1999) found that otter trawls were more effective at sampling black crappie in Florida lakes than were trap nets, especially for individuals >250 mm. Sammons and Bettoli (1998) described the use of a boat-towed neuston net to sample larval white and black crappies in a Tennessee reservoir. Incorporating prior and future research into an integrated suite of potential sampling tools will assist agency personnel with the challenging task of managing white crappie populations.

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