Variability in Haul Seine Retention Rates and its Effects on Abundance and Size Structure Estimates of Black Crappie and Sunfish Populations

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Abstract: Gear catch efficiencies have a large effect on data collected to describe fish populations and communities used by managers to make informed decisions. We measured the retention rate of black crappie (*Pomoxis nigromaculatus*) and sunfish (*Lepomis* spp.) from a seeding experiment composed of 10 haul seines pulled at three lakes. Approximately 50 individuals of each group were marked and placed into closed haul seines, and fish recovery rates were measured. Retention rates ranged between 0.34 and 0.94 for black crappie and 0.38 and 0.89 for sunfish. Akaike's Information Criterion was used to select between alternative generalized linear models of recapture probability using site-specific environmental and sampling measurements as covariates. Our top ranked model for black crappie incorporated heterogeneity in fish retention across lakes with different sample area sizes, while the best model for sunfish included covariates for lake, size of sample area, and sample effort. Nonparametric bootstrap (with replacement) estimates of mean retention rate across sites were 0.57 (90% confidence interval [CI] = 0.48–0.66) for black crappie and 0.63 (90% CI = 0.55–0.71) for sunfish. We observed increased retention rates of larger fish for both groups, indicating higher capture probabilities. This information may be useful for adjusting haul seine catches used to estimate absolute abundance and size structure on black crappie and sunfish populations.

Key words: Centrarchidae, capture probability, catch efficiency, natural lakes

Journal of the Southeastern Association of Fish and Wildlife Agencies 2:72–79

Catch data are frequently used to estimate size structure, density, and relative abundance estimates of fish populations. However, variations in catch efficiency may result in inaccurate estimation of population metrics (Lyons 1986, Allen et al. 1992). Catch efficiency is defined as the proportion of targeted fish captured in the sample area (Rozas and Minello 1997), and is also referred to as gear efficiency or capture probability. Understanding the catch efficiency of a gear is important for understanding how catches are related to what actually exists in the population. If catch efficiencies can be estimated, then corresponding catch data can be corrected to reduce this source of variability and provide more accurate estimates of fish population and community composition (Kjelson and Colby 1977, Pierce et al. 1990, Lauretta et al. 2013).

Catch efficiency has been shown to vary by targeted fish species, size of fish, sampled habitat, size of sampling area, season, and experience of the sampling crew (Kjelson and Johnson 1974, Kjelson and Colby 1977, Kjelson and Johnson 1978, Weinstein and Davis 1980, Lyons 1986, Charles-Dominique 1989, Parsley et al. 1989, Pierce et al. 1990, Allen et al. 1992, Holland-Bartels and Dewey 1997, Rozas and Minello 1997, Bayley and Herendeen 2000, Steele et al. 2007). Since catch efficiency is variable, it is necessary to estimate the mean and variation in catch efficiency of particular gears so that catch data can be appropriately adjusted to make more accurate inferences regarding fish population metrics and community dynamics (Rozas and Minello 1997). When adjusting catch data to estimate absolute abundance and density, it is also important to have catch efficiency estimates across a range of measured sampling conditions to obtain an understanding of the predominant factors that influence catch efficiency.

Two factors that reduce catch efficiency are gear avoidance and gear escapement (Kjelson and Colby 1977, Charles-Dominique 1989). Gear avoidance refers to individuals that dodge an active sampling gear, never actually being captured by the gear. Gear escapement refers to individuals that are captured by the gear, but manage to escape before being recovered. Although it is difficult to directly estimate gear avoidance in most cases, an estimate of gear escapement can be made relatively easily when using surrounding and encircling gears (e.g., beach seines, haul seines, purse seines, etc.), where a seeded population can be added and the rate of recovery observed. This can be accomplished by placing a known number of measured and marked individuals into the enclosed area and evaluating the recovery of those individuals (Rozas and Minello 1997). The proportion of marked fish recovered in the sample provides a direct estimate of the retention rate or recovery rate, which has been used as an upper estimate of catch efficiency (Charles-Dominique 1989, Wessel and Winner 2003).

Haul seines were first used as a commercial fishing gear in the United States in the mid 1800s, and have been components of numerous commercial fisheries since the early 1900s (Dequine 1950, Joseph 1972, DeVries and Ross 1983). Commercial harvest with haul seines includes marine, anadromous, and freshwater species (Guthrie et al. 1973, Langford et al. 1978, DeVries 1980, Schramm et al. 1985). Haul seines have also been used to collect biological, population, and community data on fish (Huish 1958, DeVries 1980, Tuten et al. 2011) and as a tool for fish management programs (Horel 1966, Godwin et al. 1993). Kjelson and Johnson (1974) estimated the retention rate of haul seines by marking nine different species of marine fish and placing them in sample areas at different phases of the sampling operations, which resulted in relatively low retention rates of 31% to 54%. More recently, Tuten et al. (2010) compared haul seine and otter trawl catches of black crappie (*Pomoxis nigromaculatus*) and suggested that haul seines may provide a more accurate representation of population size structure than otter trawls but recommended more research on gear selectivity issues.

The objective of this study was to measure retention rates for haul seine catches of black crappie and sunfish (i.e., bluegill [*Lepomis macrochirus*] and redear sunfish [*L. microlophus*]) in three Florida freshwater lakes, as well as across sampling habitats and fish length classes. We aimed to provide a more comprehensive understanding of factors that affect haul seine catch efficiency to determine if and how future haul seine catch data of black crappie and sunfish can be adjusted to produce more accurate estimates of population traits.

Methods

Study systems included lakes Istokpoga, Newnans, and Lochloosa. Lake Istokpoga is a 12,188-ha eutrophic lake in Highlands County, Florida, with an average lake depth of 1.6 m (Florida LAKEWATCH 2009). Lakes Newnans and Lochloosa are hypereutrophic systems located in Alachua County, Florida, and are 2632 and 2306 ha, respectively. Newnans Lake has an average depth of 1.4 m and Lochloosa Lake has an average depth of 1.7 m (Florida LAKEWATCH 2009). All three lakes are known to produce dynamic black crappie fisheries and are part of Florida Fish and Wildlife Conservation Commission's (FWC) Freshwater Fisheries Long-term Monitoring Project. These lakes were included based on their differences in substrate types; Newnans Lake is covered with a layer of flocculent sediment averaging 2.5-m thick (Nagid et al. 2001, Environmental Consulting and Technology 2002), Lake Istokpoga has a higher amount of sandy areas available, and Lochloosa Lake is intermediate between the two.

Retention rate estimates were made for both black crappie and sunfish with mark-recapture trials using methods similar to those described by Wessel and Winner (2003). Experimental animals for mark-recapture trials were collected with electrofishing and trawls one day prior to haul seining. Experimental animals were measured and then marked with a plastic tipped Hallprint dart tag (55-mm long) or pelvic fin clip for identification purposes. Marked fish were placed in floating pens and held overnight until haul seining occurred the following day. The minimum size of black crappie used for mark and recapture was 150 mm TL, based on observations by Tuten et al. (2010) that black crappie fully recruited to a haul seine with mesh size similar to the one used in this study at 145 mm TL. Experimental sunfish stocked into haul seines were greater than or equal to 130 mm TL based on unpublished data collected by the FWC.

A haul seine (384-m long, 50.8-mm stretch mesh, 100 meshes deep) was used to sample 10 open water sites among the three lakes. Four samples were collected on Lake Istokpoga in fall 2011, and three samples were collected from each of lakes Lochloosa and Newnans in fall 2012 and 2013, respectively (Table 1). The method for operating the haul seine consisted of first driving a metal stake firmly into the substrate with at least 0.6 m of the stake remaining above the surface. A staff connected to the lead and float lines at

Table 1. Retention rates for the number of black crappie and sunfish stocked into each haul seine and measurements of sample area, effort, average depth, and average sediment thickness for each sample at lakes Istokpoga, Lochloosa, and Newnans, Florida.

	Black crappie		Sunfish					
Sample number	Number stocked	Retention rate	Number stocked	Retention rate	Sample area (ha)	Effort (min)	Average depth (m)	Average sediment thickness (m)
Lake Istokpoga								
1	49	0.41	50	0.38	0.98	60	1.52	0.01
2	50	0.34	51	0.61	1.12	90	2.21	0.02
3	50	0.54	50	0.56	1.12	80	2.07	0.03
4	50	0.48	50	0.72	0.97	85	2.18	0.02
Lochloosa Lake								
1	51	0.71	51	0.57	0.78	60	2.33	0.11
2	55	0.60	63	0.83	0.69	120	2.45	0.04
3	40	0.40	64	0.47	0.66	75	2.50	0.02
Newnans Lake								
1	49	0.94	56	0.89	1.59	100	2.47	0.61
2	55	0.62	54	0.56	0.55	125	2.55	0.29
3	48	0.63	56	0.73	1.24	120	2.39	0.61

the end of the seine was pushed into the substrate against the stake and tied to the top of the stake at the water surface. A powered boat deployed the remainder of the seine by moving in a counterclockwise direction to form a circle and bring the haul seine back against the stake, which enclosed the sample area. Once the seine was fully laid out, the boat pulled the seine at an angle intended to keep it firmly against the stake while another crewmember worked the seine between the stake and a metal rod held in the crewmember's hand. The boat continued to pull the seine until the mouth of a pocket located near the staff was pulled between the metal rod and stake, concentrating fish inside the pocket. The mouth of the pocket was opened between two boats and fish in the pocket were removed with dip nets.

A GPS unit (3- to 5-m accuracy) was used to track the deployment of the net for each haul seine sample in order to obtain an estimate of the total area covered (ha) by each sample. After the haul seine was laid out, measurements of water depth (m) and substrate thickness (m) were recorded from at least 10 locations dispersed within the enclosed area. Water depth was measured with a depth pole, and was considered as the depth when the pole initially had resistance from substrate. Substrate thickness was considered as the difference between the water depth and the depth to hard bottom, measured by pushing the depth pole firmly through softer substrate until reaching hard bottom. Thus, sampling locations with harder substrates had substrate thicknesses measured close to 0 m.

After the physical measurements of the haul seine sample area were recorded, marked black crappie and sunfish (goal of at least 50 for each group) were stocked throughout the enclosed sample area. The haul seine was then immediately pulled (fished) until reaching the pocket. Total effort (min) from the start of fishing the seine until reaching the pocket was recorded for each sample. Fish were removed from the pocket, and all black crappie and sunfish caught were inspected for an external tag or fin clip. Total length was measured for all recaptured fish. Each stocked individual was assigned a fate of recaptured (success) or not recaptured (failure). All sampling was conducted using the same primary personnel throughout the study.

Mark-recapture data were analyzed using the binomial probability density function, with each haul seine treated as individual experimental trials. Retention rate and associated variance was estimated from the binomial probability mass function given the number of trials and observed successes, with an associated log-likelihood (LL) calculated as:

$$\mathrm{LL}(\mathrm{p}|M,R) = \mathrm{LN}[M!/R!(M-R!)] + R \times \mathrm{LN}(p) + (M-R) \times \mathrm{LN}(1-p)$$

where p is the probability of success (retention rate), M is the number of marked fish released at a site (trials), and R is the number of marked fish recaptured in the sample (successes). The maximum likelihood estimate of p is equal to R/M, with an associated binomial variance. Individual sites were considered replicate experiments, from which a total log-likelihood was estimated as the sum of the log-likelihood of individual replicates:

$$\mathrm{TotalLL} = \mathrm{LL}(\mathrm{site}_1) + \mathrm{LL}(\mathrm{site}_2) + \ldots + \mathrm{LL}(\mathrm{site}_k)$$

where k is equal to the total number of sites.

Akaike's Information Criterion (AIC, Akaike 1973) was used to test the following *a priori* hypotheses of heterogeneity in haul seine retention rates of black crappie and sunfish:

1) Retention rate is constant across study sites and systems (r constant),

2) Retention rate varies by study system (r heterogeneous across three lakes),

3) Retention rate varies across study sites (r heterogeneous across 10 sites)

AIC values were calculated based on the model log-likelihood and number of retention rate parameters of each alternative model:

$$\mathrm{AIC} = 2(K) - 2(\mathrm{TotalLL})$$

where K is equal to the number of retention rate parameters.

Based on the selected heterogeneity model, 90% upper and lower confidence intervals (CI) of retention rates were estimated for black crappie and sunfish using a nonparametric bootstrap. For this analysis, we resampled (with replacement) our retention rate estimates 1000 times to produce a distribution of retention rate estimates. Confidence intervals were bounded by the 5th and 95th percentiles of the sample means. The bootstrap was calculated for haul seine sample sizes ranging from 1 to 10 sites, to determine how the CI width (i.e., CI width = upper CI – lower CI) decreased with increased sample size.

We used a generalized linear model assuming a binomial distribution to determine which individual site covariates best explained the observed variation in black crappie and sunfish retention rates. Individual haul seines were considered the sample unit and covariates used for the analysis included lake and site specific habitat and sampling measurements (i.e., average depth, sediment thickness, area sampled, and effort). Model selection based on AIC was used to determine the best model for estimating black crappie and sunfish retention rates. Retention rates of black crappie and sunfish for all 10 haul seine samples were plotted along with AIC model average estimates and 90% confidence intervals for the relevant site specific covariates.

Simple linear regression was used to describe changes in retention rates with an increase in length for both black crappie and sunfish. Stocked fish were placed into 1-cm size classes, starting with the minimum length used for each experimental group. Due to common occurrences of low sample sizes and missing cm groups within individual samples, individuals within the same cm group from each of the 10 haul seine samples were combined. Length groups containing less than three fish after pooling the data were not used in the linear regression models. The 90% prediction intervals were plotted and regressions were considered significant at $P \leq 0.10$.

Results

Haul seines enclosed areas varying between 0.55 and 1.59 ha among samples and lakes, and required between 60 and 125 min of effort to reach the pocket (Table 1). We sampled limnetic zones of the lakes with average depths that varied between 1.52 and 2.55 m. The majority of the sample sites at lakes Istokpoga and Lochloosa had relatively hard bottom, with measurement of soft substrate thickness varying between 0.01 and 0.11 m. Newnans Lake had the softest substrates of all sites we sampled, with measurements of substrate thicknesses varying between 0.29 and 0.61 m. Retention rates varied between 0.34 and 0.94 for black crappie and 0.38 and 0.89 for sunfish (Table 1).

Analysis of AIC scores indicated the best model incorporated heterogeneity across haul seine sites and lakes. Estimates of mean retention rates across all sites measured were 0.57 for black crappie and 0.63 for sunfish. Variance in mean retention decreased with increased sample size, resulting in width reduction of the 90% CI from 0.60 to 0.18 units for black crappie and from 0.51 to 0.16 units for sunfish as the number of sample sites increased from 1 to 10 (Figure 1). There were large decreases in the CI widths for black crappie and sunfish when sample size increased from one to four, but the decline lessened considerably as the number of samples increased from 4 to 10 haul seines (Figure 1). Based on these results, the optimal sample size to reduce variance is four, after which the return in precision per sampling effort is considerably less.

Mean retention rates (± SE) of black crappie were highest at Newnans Lake (0.70 ± 0.039), followed by Lochloosa Lake (0.66 ± 0.044), and then Lake Istokpoga (0.42 ± 0.036). Retention rates appeared to increase with size of the sample area, but showed little correlation to effort, sediment thickness, or average depth (Figure 2). The best model for black crappie accounted for variation in fish retention rates between different lakes along with the size of the sample area (Table 2). The AIC weight of this model was 0.233, while the next top two candidate models included sediment thickness and effort and had AIC weights of 0.157 and 0.111, respectively. However, the additional parameters from these models were non-significant (sediment thickness: $P = 0.32$, effort: $P = 0.51$). Samples in Lochloosa Lake had the highest mean retention rate of sunfish (0.77 ± 0.037), followed by Lake Istokpoga (0.61 ± 0.039), and then Newnans Lake (0.54 ± 0.06). Retention rates increased with the size of the sample area, as well as with effort (Figure 2). The best model for sunfish included lake, sample area, and amount of effort as covariates and had an AIC weight of 0.394 (Table 2). The next best models included depth and sediment thickness and had AIC weights of 0.178 and 0.145, respectively. Again, significance tests revealed that only lake ($P = 0.05$), sample area ($P = 0.01$), and effort ($P = 0.01$) were significant covariates, where average depth ($P = 0.56$) and average sediment thickness ($P = 0.94$) were both non-significant in their respective models.

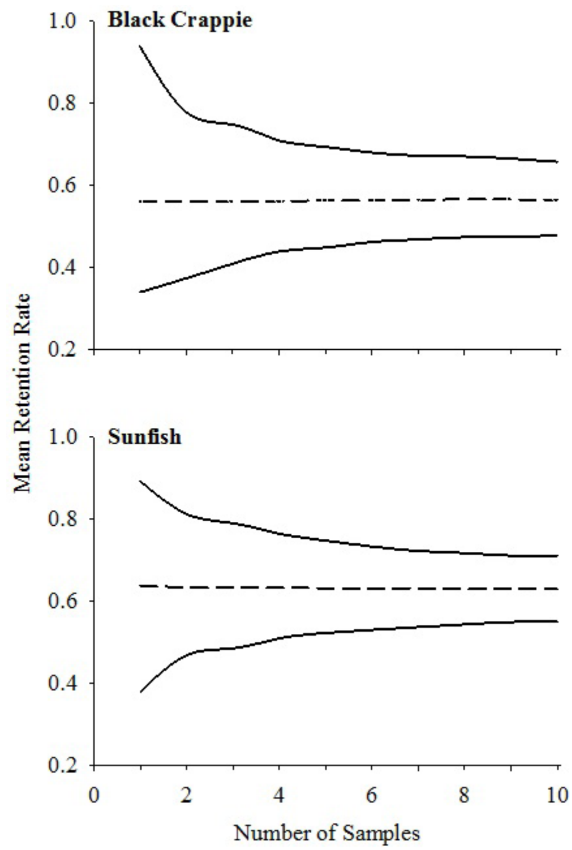

Figure 1. Mean retention rates (dashed lines) and associated 90% prediction intervals (solid lines) for black crappie and sunfish when sampling with 1 to 10 haul seines.

We observed increased retention rates with an increase in fish length for both black crappie ($P < 0.001$) and sunfish ($P = 0.036$, Figure 3). There was a higher increase in retention rate per corresponding increase in fish length for black crappie ($\beta = 0.0255$) than for sunfish ($\beta = 0.0162$). This suggests that retention of black crappie and sunfish increased by 2.5% and 1.6%, respectively, with a corresponding increase in cm group.

Table 2. Comparisons and AIC (Akaike's Information Criteria) selection criteria of the top 10 retention rate models for black crappie and sunfish using covariates for lakes and site specific habitat and sample data.

Model	Number of parameters	AIC	Delta AIC	AIC weight
Black Crappie				
Lake + area	4	71.6	0.0	0.233
Lake + area + sediment thickness	5	72.4	0.8	0.157
Lake + area + effort	5	73.1	1.5	0.111
Lake + area + sediment thickness + effort	6	73.5	1.9	0.091
Lake + area + depth	5	73.5	2.0	0.088
Lake + area + sediment thickness + depth	6	74.0	2.4	0.070
Lake + area + effort + depth	6	75.0	3.4	0.042
Lake + effort	4	75.4	3.8	0.035
Lake + area + sediment thickness + effort + depth	7	75.4	3.9	0.034
Depth + sediment thickness + effort	4	76.3	4.7	0.022

Model	Number of parameters	AIC	Delta AIC	AIC weight
Sunfish				
Lake + area + effort	5	64.8	0.0	0.394
Lake + area + effort + depth	6	66.4	1.6	0.178
Lake + area + effort + sediment thickness	6	66.8	2.0	0.145
Lake + effort + sediment thickness	5	68.0	3.1	0.082
Lake + area + sediment thickness + effort + depth	7	68.3	3.5	0.068
Lake + effort + depth + sediment thickness	6	68.4	3.6	0.065
Area + effort + depth	4	70.2	5.3	0.027
Area + effort + depth + sediment thickness	5	70.4	5.6	0.024
Area + effort	3	73.2	8.4	0.006
Area + depth	3	73.9	9.0	0.004

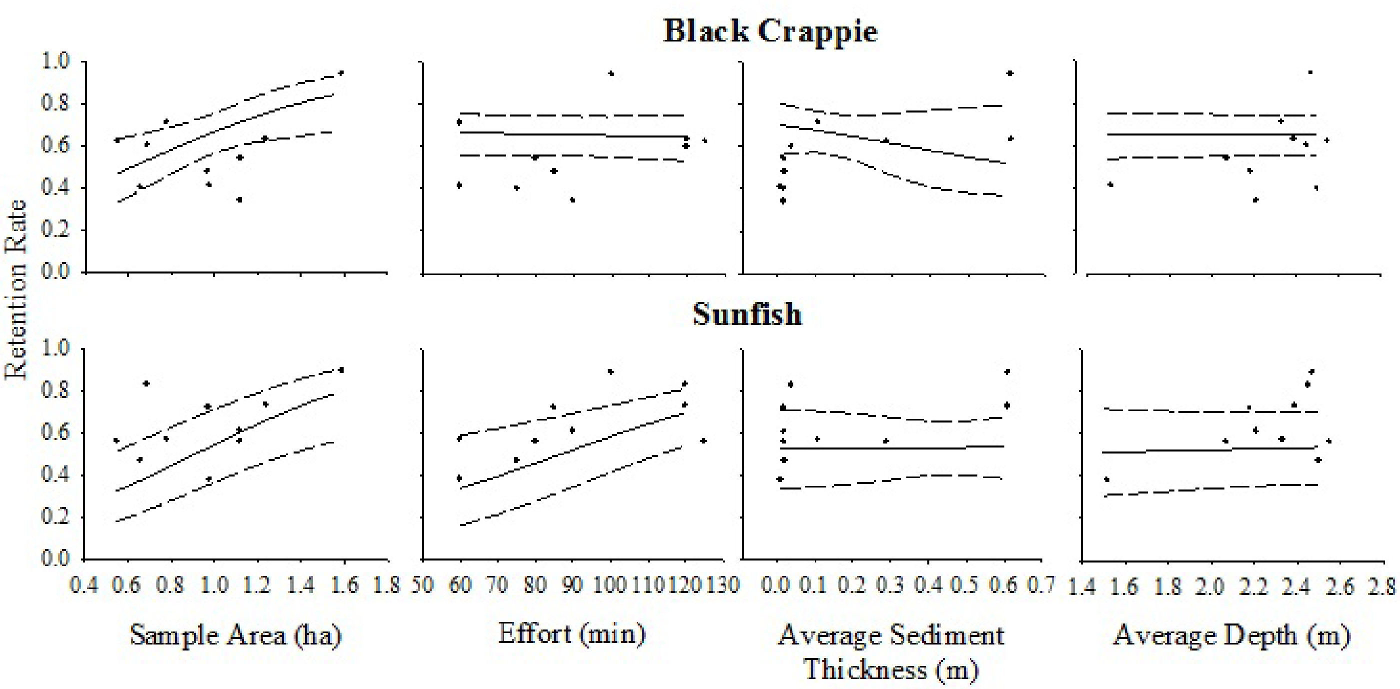

Figure 2. Retention rate estimates of black crappie and sunfish from 10 haul seine samples with different site specific habitat and sampling measurements including sample area, effort, average sediment thickness, and average depth. The solid line is the AIC (Akaike's Information Criteria) model averaged estimate and the dashed line represents the 90% confidence interval of the estimate. Model estimates from Lochloosa Lake are shown for black crappie and Lake Istokpoga for sunfish.

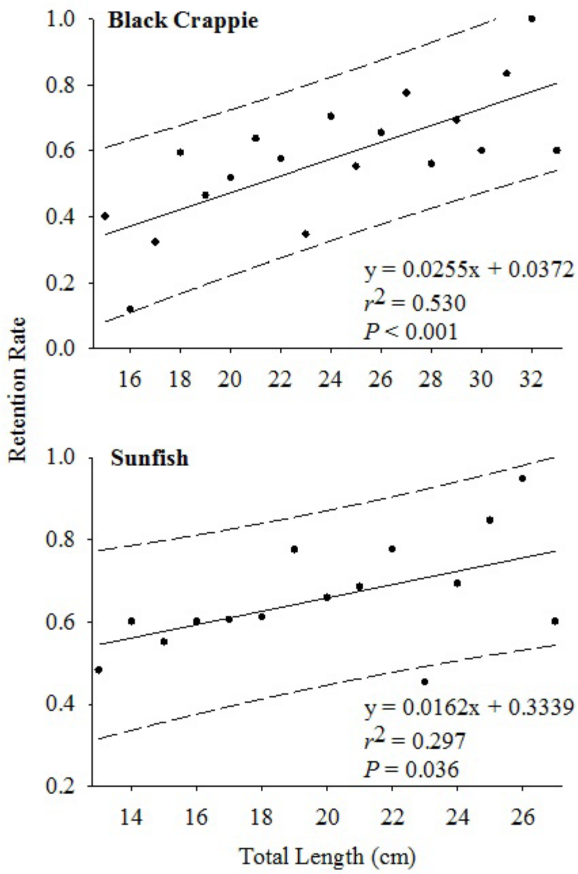

Figure 3. Retention rate at length (1-cm groups) for black crappie and sunfish in haul seines. Long dashed lines represent the 90% predictive interval for the regressions. Linear regression functions, r^2 values, and *p*-values are labeled for each plot.

Discussion

Our results showed that haul seine retention rates for black crappie and sunfish tended to vary by site and increase with fish length. High variation in fish retention among sites is common when using encircling gears to collect fishes. Wessel and Winner (2003) reported that retention rates varied between 9% and 100% among sites for marked pinfish (*Lagodon rhomboides*) released into purse seines. Retention rates of three species of marked freshwater fish released into enclosed beach seines varied between 35% and 100% (Pierce et al. 1990). Lauretta et al. (2013) likewise observed high variability of catchabilities for 12 taxa with bag seines at two Florida rivers where the mean was 61.9% with a 95% CI that ranged from 22.5% to 93.3%. Variable catchabilities of encircling gears such as haul seines should be accounted for when using them to estimate abundance and density of fishes. At the very least, confidence intervals associated with a mean should be used when adjusting data. Holland-Bartels and Dewey (1997) found adjusted seine data from the Mississippi River to be more accurate than unadjusted data when considering fish assemblage and abundance estimates, but also found adjusted data to overestimate the abundance half of the time. Large variations in fish densities among hauls seine samples that co-occur with known variations in retention rates have the potential to cause absolute abundance and density estimates from adjusted raw data to be more inaccurate than unadjusted catch data. Thus, while we provided a mean retention rate and 90% confidence interval based on our observations, we express caution in their use for adjusting haul seine catch data in future projects.

We observed that fish retention rates increased with fish length for both black crappie and sunfish, suggesting that haul seines were more effective for capturing larger individuals. For this analysis, we only included individuals that were fully recruited to the gear. If all lengths were included, the observed relations may have instead been logistic, with a sharp increase in retention rates from the small fish collected to the length at recruitment, and thereafter a liner relationship to the largest fish collected. Tuten et al. (2010) previously questioned the accuracy of haul seine catches for representing size structures of black crappie populations after observing a higher proportion of larger individuals in haul seines when compared to otter trawls. Our results indicate that haul seine catches do not accurately reflect true size structures of black crappie and sunfish populations, but are instead more selective of larger sized fish. The slopes observed in the linear regressions developed during this study can be used to adjust future length frequencies developed from haul seine catch data, to more accurately estimate size structures of black crappie and sunfish populations in Florida lakes.

We observed heterogeneity of retention rates across individual sites for both black crappie and sunfish. The diversity was mediated mostly by lake and size of the sample area for black crappie, and lake, size of the sample area, and amount of effort necessary to complete the sample for sunfish. Retention rates for both black crappie and sunfish increased along with the size of the sample area. This was unexpected considering that the size of the sample area may impact the sampling efficiency: larger areas sampled may be more prone to increased drag on the seine and have higher probabilities of seine being snagged on foreign objects (Bayley and Herendeen 2000, Steele et al. 2007). However, larger sample areas can also make it less likely for fish to escape when the net is lifted to get over objects or through thick sediment. Another surprising result was that retention rates of sunfish increased with sample effort, despite the fact that higher effort usually occurred at the more difficult, hard to fish sample sites. Furthermore, the amount of effort necessary for a particular sample should increase the amount of time fish have to escape from the seine. We failed to find significant impacts on retention rates from average water depths and sediment thickness. However, Pierce et al. (1990) and Parsley et al. (1989) both found substrate to influence retention rates of fish when using seines, which would be expected given that substrate type and thickness can impact drag on the seine and how effectively it fishes. Ultimately, we collected a relatively low sample size (i.e., $n = 10$) with low variability in some habitat characteristics among sites. We expect that further evaluation with an increased sample size and variability in habitat characteristics among sites may produce some different results.

Another factor that may impact the results and variability of haul seine retention rates is the experience of the sampling crew. We used the same primary crew throughout the duration of this study; therefore, we were unable to assess this variable. Haul seines are large and cumbersome, fished from boats in relatively deep, offshore areas of water, and require techniques that are learned through extensive experience. Our sampling crew was relatively inexperienced, and had operated the gear independently less than 10 times before this study. Multiple studies have shown that experience of the sampling crew can have significant impacts to catches when using a variety of sampling gears such as trawls, purse seines, and electrofishing (Hardin and Connor 1992, Robins et al. 1998, Ruttan and Tyedmers 2006). For example, Ruttan and Tyedmers (2006) suggested that a significant "skipper effect" on purse seine catches was due to differences in tactical skills, where some skippers were better able to set purse seines around schools of fish and also better managed their crews when setting the nets. While the high variation in retention rates we observed in this study is similar to the variation reported for other studies that evaluated encircling gears (Charles-Dominique 1989, Pierce et al. 1990, Wessel and Winner 2003, Lauretta et al. 2013), we expect that retention rates would be higher and less variable if using samples collected by commercial fishers, who use the gear regularly. Thus, our retention rate estimates may not be appropriate for adjusting data collected from haul seines that are fished by commercial fishers, and further estimates may be necessary.

Our haul seine retention rate estimates were made using the recapture of marked fish that were originally captured and kept in floating pens for close to 24 h before being used in the seeding experiments. We frequently observed high mortality in the pens due to stress and handling of the fish from the day before. Similar to other studies that have used seeding experiments to estimate capture efficiencies (Jacobs and Swink 1982, Bayley and Austen 1990), we discarded deceased individuals and only used marked individuals that were alive after being held in the pens overnight. Once the marked individuals were removed from the pens and placed into our closed sampling areas, we immediately started fishing the haul seine to limit additional stress. While we took precautions to use live and healthy fish in our seeding experiments, we expect that some of the marked fish we stocked may have been more stressed than a native (unmarked) fish that was never captured or handled in the first place. Thus, our estimates may not directly reflect retention rates of native fish, because vulnerabilities of marked fish may have been higher.

The product of this study provides a better understanding of haul seine gear efficiency and can be useful to future projects that use haul seines to estimate absolute abundances and size structures of black crappie and sunfish. We observed similar mean estimates and ranges for haul seine retention rates of black crappie and sunfish. However, numerous studies have found capture efficiencies for the same encirclement gear to be highly variable among different species (Lyons 1986, Parsley et al. 1989, Allen et al. 1992, Lauretta et al. 2013), and our results should not be used to adjust haul seine catches of other fish species. We stress the importance of being cautious if using these results to adjust raw catch data, and suggest that further evaluation using an increased sample size or more experienced sampling crew may lead to a different outcome.

Acknowledgments

We appreciate Zach Martin and Matt Young for volunteering to help in the field. We also appreciate the help from Gary Byerley, Gigi DelPizzo, Dan Dorosheff, Brian Hilton, Steve Hooley, Eddie Leonard, Cheree Steward, Nick Trippel, and other Florida Fish and Wildlife Conservation Commission employees who helped with field work. We would also like to thank Erin Leone for statistical help and Dick Krause for his review.

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