ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

PRODUCTION NOTE

University of Illinois at
Urbana-Champaign Library
Large-scale Digitization Project, 2007.

Evaluation of Seven Oxbow Lakes on an Unchannelized Reach of the Lower Kaskaskia River, Illinois

Progress Report

Blake A. Davis, John H. Hoxmeier, and David H. Wahl
Kaskaskia Biological Station, Illinois Natural History Survey
RR 1 Box 157
Sullivan, IL 61951

Introduction

Low-level river flood plain ecosystems are highly dynamic and complicated systems with many factors driving community structure and diversity. Many large river systems in North America are altered through channelization, impoundment, and land use which in turn alter factors that drive community structures and fish recruitment dynamics. Little research on mechanisms that drive community structure in these systems has been done in North America even though long-term fisheries data exist (Winemiller et al. 2000). Main river channels, backwater habitats, and oxbow lakes are believed to be highly integrated and interdependent systems (Winemiller et. al, 2000). As large rivers meander, erode and deposit sediments, new channels are created. When these new channels are formed, remnants of old channels are left behind and retain water. These oxbow lakes that are formed become disconnected from the main river channel hosting a wide diversity fish populations. Periodically these systems become inundated by the river causing fish migration between the main river channel and the oxbows. Oxbow lakes have been shown to be extremely important as nurseries and spawning habitats (Welcomme 1979; Hoxmeier and DeVries 1997; Winemiller 2000;). These systems can act as sources for added diversity and production to the main river channels of large rivers.

The Kaskaskia River, in Illinois, is a low-level river that flows into the Mississippi River. Many oxbow lakes were created along the river before it was impounded and channelized. None of the oxbow lakes have ever been sampled and therefore information of the composition of fish is unknown. Data on fish communities in these lakes is needed before any management recommendations can be made.

The objectives of this study were to examine fish community structure, abundance, diversity, and similarity of seven oxbow lakes on an unchannelized reach of the lower Kaskaskia River between Lake Carlyle Dam and Fayetteville, IL. Our objectives were to 1) identify what species are in these oxbows, 2) describe fish community composition in these unique systems, 3) identify factors affecting community composition of fish, and 4) examine community size structure for evidence of successful reproduction within these oxbow lakes.

Methods

Study Region– Seven lakes were chosen along an unchannelized reach of the Kaskaskia River between Fayetteville and Okawville, IL below the last impoundment (Figure 1). The Kaskaskia River originates in Champaign County, IL and flows into the Mississippi River near Moro Island. The Kaskaskia has two large impoundments (Lake Shelbyville and Carlyle Lake) and has been channelized from the Mississippi River to Fayetteville, IL. Lakes were chosen at varying distances from the river with Queens being the closest and Calamus being the farthest from the river (Table 1).

Abiotic sampling– Water levels were taken on seven lakes from 1999 to 2000. Water level markers were placed in the lakes and landowners recorded water levels weekly and during major rain events. Landowners also documented when the lakes connected to the river. Because there was incomplete data on Queens, Kehrer, Muddy, and Round lakes, water level data for these lakes was not included in this report. Water levels were graphed for Halfmoon, Clear, and Calamus because they represented varying distances from the river. Historical water level data for the Kaskaskia river at Venedy Station was also examined to compare differences in water level fluctuations from 1998 to 2000. Water level data was supplied by the U. S. Army Corps of Engineers (St. Louis District) and is presented in mean sea level (feet).

Conductivity, turbidity, and dissolved oxygen (DO) were measured on all lakes during each sampling period (spring and fall). All measurements were taken at a fixed site in the deepest part of the lake. Conductivity and DO were taken at the surface using YSI meters. Turbidity was measured with a Secchi disk.

Fish sampling– Fish were sampled twice a year during the spring and fall from 1998 to 2000. Queens was not sampled after the fall 1999 because it was often connected to the river and was not considered to be an oxbow habitat. Kehrer and Round were not sampled in fall 2000. Each lake was divided into two transects (one on each side of the lake) and electrofished for a total of 30 minutes (where possible) with an AC boom mounted electrofishing boat (9 amps/3000-4000V). If water level was too low and 30 minutes could not be attained, electrofishing was stopped (and time recorded) before transects overlapped. Each fish was measured (nearest mm) and returned to the oxbow.

Data Analysis– Fish data was analyzed using correlation analysis between water level fluctuations/abiotic factors and electrofishing CPUE (fish caught per half hour), percent length frequency, diversity indices, and similarity indices. Pearson's correlation analysis was used to examine the influence of water level fluctuation and abiotic factors on CPUE. Water level fluctuations were calculated by subtracting the maximum monthly water level from the minimum monthly water level. Abiotic factors were averaged across years and standard errors were calculated to get an estimate of variability. Length frequency histograms were generated using percent length frequency across years for all taxa. Percent length frequency was calculated for crappie and bluegill across years to examine potential reproduction. We looked for evidence of reproduction in 1999 by examining length frequencies. Because the river did not reconnect with the oxbows between our spring and fall sampling period, small size classes (<50mm) of bluegill and crappie present in the fall would suggest successful spawning.

Diversity was estimated using Simpsons' diversity index (S) and evenness was calculated using Pielou (J') evenness index. Diversity was calculated for all lakes in spring 1998, 1999, and 2000 to determine differences in community structure between oxbows based on lake distance from the river and wet versus dry years. Seasonal comparisons between spring and fall were made in 1998 and 1999 to look at temporal differences in wet versus dry years. Comparisons were also made between Halfmoon and Calamus across years because they represent the two spatial as well as stability extremes. Seasonal comparisons within Calamus and Halfmoon were used to examine stability of lakes based seasonal change, water level stability, and distance from the river. Similarity was estimated using Horn's quantitative similarity index across the same comparisons as the diversity indices.

Results and Discussion

Water level data– Water level in Halfmoon, Clear, and Calamus from 1999 to 2000 was variable with high levels in the spring 1999 and summer 2000 (**Figure 2**). Lowest water levels were observed from December 1999 to May 2000. During this period, Halfmoon and Clear were desicated and no fish were present. Water levels in Halfmoon and Clear were highly variable indicating less stability in these systems. Calamus had less variability and appeared to be a more stable system. Similar to the oxbows, water level in the Kaskaskia River fluctuated dramatically over the three year period. Water levels in the Kaskaskia showed a decrease from 1998 to 2000 (**Figure** 3 and 4). The river also appeared to be more stable in 1998 than 1999 or 2000 (**Figure** 4). This gives an indication that 1998 was a wetter more stable year for both the river and the oxbows. Oxbows were less stable in 1999 because of the larger differences in water level fluctuations and lower mean water levels.

Abiotic Variables– Abiotic conditions appeared relatively stable within oxbows across years (Table 1). Measurements in the spring and fall showed adequate DO for most aquatic organisms. However, DO measurements were taken during the day and may not represent oxygen levels during nighttime hours. Highly productive systems often experience a decrease in oxygen during nighttime hours because of a high biological oxygen demand. This decrease in oxygen can often lead to fish kills. In oxbows on the Brazos River in Texas, Winemiller et al. (2000) found DO levels ranged from supersaturation to extremely hypoxic levels throughout their sampling indicating stressful conditions that could drive community structures towards more tolerant species. Conductivity in the Brazos River oxbows was also high. Because of salinity in the soils along the Brazos, decreases in volume caused increased salinity imposing stresses upon these systems (Winemiller et al. 2000). Conductivity in the Kaskaskia oxbows remained relatively stable within lakes across sampling dates, indicating low salinity stress. Turbidity was very high across lakes which is typical of these highly productive systems. Clear lake had the least turbid conditions while Calamus experienced the highest turbidity of all lakes.

Pearson's correlation coefficients were used to examine a response of mean CPUE across years to abiotic factors and water level fluctuations. None of the abiotic factors measured influenced the CPUE of fish in our study (all $P>0.05$). Water level fluctuations also did not affect CPUE ($P=0.71$). The lack of significance with water level fluctuations and mean CPUE could be attributed to a small sample size ($N=3$).

Fish community structure and abundance– Overall, 35 species of fish were found across all lakes with highly variable populations within each lake. Collections were dominated by gizzard shad and bluegill with bigmouth and smallmouth buffalo, bowfin, carp, largemouth bass, and white crappie found in all lakes (Table 3). All species collected are classified as tolerant to warm water and variable DO conditions.

Percent length frequency was used to determine population size structure for all fish collected across years and lakes (Figures 5a & b). Most lakes showed a community structure consisting of smaller fish (50-100 mm). Kehrer and Calamus showed substantial populations of adult fish

(Figure 5a). Bluegill length frequencies combined across years were also examined in all lakes (Figures 6a & b). Calamus and Kehrer had even distribution among size classes indicating healthy populations (Figure 6a). Bluegill ranged from age-0 to adults (up to 200 mm) with no gaps in size classes in both these systems. Clear also had a good representation of size classes with the exception of larger fish. Gaps in size classes in the other oxbows could be attributed to high water level fluctuations. Reductions in water level can decrease abundance of fishes that are dependent on littoral cover for refuge. Calamus and Kehrer had relatively stable water levels. Kehrer lake has more stable water levels because it is managed by the landowner and kept at a relatively constant level (Personal communication with Tom Kehrer). These stable environments could be causing less stressful conditions making these lakes suitable for growth and survival of fish. Stable water levels can allow for inundation of littoral zones creating refuge habitat for adult and forage base fish. In addition, when water levels increase, littoral habitat becomes available for spawning and refuge for age-0 fish (Paller 1997). Similar to bluegill, crappie length frequencies showed no gaps in year classes in Calamus, Kehrer, Muddy, and Clear with Calamus and Kehrer demonstrating a wider range in size classes (Figure 7a & b). This could also be attributed to stable water levels.

Reproduction was examined for 1999 because the river did not reconnect to the oxbows throughout our sampling period. Reproduction was evident in Calamus and Kehrer based on small size classes (<50 mm) of bluegill, orange-spotted sunfish, and longear sunfish found in the fall. These lakes had stable water levels which could have caused highly successful reproduction. These young-of-year were found through electrofishing which targets larger size classes of fish.

Because of this gear bias and the inefficiency in obtaining smaller fish, other lakes need to be examined through seining (which targets smaller fish) to look for reproduction.

Diversity and similarity comparisons– During 1998 there was high diversity across all oxbow lakes in the spring. This high diversity and similarity could be attributed to late flooding in the spring. Winemiller et al. (2000) found migration of main channel fish into oxbows during flood events causes homogeneity of fish species between lakes. The flooding in 1998 occurred about two weeks before our sampling which should have allowed fish species in these lakes to mix.. In 1999, these lakes experienced substantial decreases in diversity which could be caused by flooding early in the year and a dry spring (Figure 3). Paller (1997) also found that lowering water levels in Par Pond decreased abundances and diversity of fish. These highly variable communities appear to be random in composition which could be driven by these highly fluctuating water levels.

Spring diversity values for Queens, Halfmoon, and Muddy were highly variable indicating highly unstable systems (Table 3). However, Calamus, Kehrer, Round, and Clear had similar diversity values across years suggesting more stable systems. Kehrer, Calamus, and Round all had high diversities with low variability from spring to fall 1998 indicating stability (Table 4). Although Round, Clear, and Halfmoon have high diversity values, seasonal similarity indices were low (Table 4) suggesting highly different fish communities between the spring and fall. These differences in fish communities in Round, Clear, and Halfmoon demonstrate unstable systems throughout the year which appears to be caused by high water level fluctuations. Even though water level data does not exist for Round, extremely low water levels were observed during sampling periods. Halfmoon was completely dessicated in 1999 and Clear was too low to sample in 1998. These unstable water levels could be driving unpredictable community structure. Calamus and Kehrer had high similarities between seasons for both years. Calamus and Kehrer had more stable water levels that could be allowing for communities to reach equilibrium. In Texas newer, deeper oxbows had more stable populations (Winemiller et al. 2000). This was attributed to higher volumes of water causing less fluctuations in salinity. These populations experienced less stress causing higher diversity and therefore becoming more stable. In the Kaskaskia River system, low water levels could be affecting reproduction as well as causing intra- and interspecific competition.

Management Implications and Conclusions

The lower flood plain section of the Kaskaskia River is a unique and diverse system. Community structure in the oxbow lakes in this system appear to be driven by water level stability. Stable water levels in Calamus and Kehrer appear to allow for fish communities to be stable and are suitable habitats for reproduction and rearing of fish. Increases in water level have been found to increase young-of-year recruitment (Miranda et al. 1984; Paller 1997). Miranda et al. (1984) also found that increasing volume disperses food resources and reduces availability of food resources to young-of-year fish. This reduction in availability causes a decrease in condition and can affect over winter survival of age-0 fish. However, Paller (1997) found that reductions in water level can remove refuge seeking forage fish through predation and reduce populations of age-0 fish.

Further study into effects of water level fluctuations needs to be examined to determine success of age-0 fish in these oxbows. The diversity in these systems could be an invaluable contribution to the main river system. Further study into the contribution to the main river channel is also needed. Oxbow lakes have been shown to be used as spawning and nursery habitats for main channel river fish (especially centrarchids) and this diversity could be important to the contribution in river systems.

Water level fluctuations in these oxbows needs to be examined further to determine if stable reproductive populations can be attained. Increased water level has been shown to increase spawning and production of young-of-year fish (Miranda et al.1984; Paller 1997). Maintenance of stable water levels (avoidance of dessication) could create spawning populations that could benefit the diversity and contribution to the main river channel. Water levels within this reach of the Kaskaskia are manipulated through natural and anthropogenic effects. Channelization below this reach could be drawing levels in the river and groundwater sources down causing the dessication in these systems. Flood control upstream (Carlyle Dam) could also be causing low water levels. Through proper water level management, these systems could become more productive.

In conclusion, more information needs to be gathered to determine the impacts of water level fluctuations upon these oxbows. Evaluation of contributions to the main channel river should also be evaluated. Because of flood control upstream of these oxbows limits creation of new oxbows, these lakes need to be maintained. These habitats are invaluable resources in terms of fish production and need to be preserved.

References

Miranda, E. L., W. L. Shelton, and T. D. Bryce. 1984. Effects of Water Level Manipulation on Abundance, Mortality, and Growth and Young-of-Year Largemouth Bass in West Point Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 4:314-320.

Paller, M. H. 1997. Recovery of a Reservoir Fish Community From Drawdown Related Impacts. North American Journal of Fisheries Management 17:726-733.

Hoxmeier, R. J. H., and D. R. DeVries. 1997. Habitat Use, Diet, and Population Structure of Adult and Juvenile Paddlefish in the Lower Alabama River. Transactions of the American Fisheries Society 126:288-301.

Welcomme, R. L. 1979. *The fisheries ecology fo floodplain rivers.* London, Longman Press.

Winemiller, K. O., S. Tarim, D. Shormann, and J. B. Cotner. 2000. Fish Assemblage Structure in Relation to Environmental Variation among Brazos River Oxbow Lakes. Transactions of the American Fisheries Society 129:451-468.

Acknowledgments

We thank the following landowners for granting access, sharing information, and compiling water level data for these oxbows: Jennifer Malacame, Jim McDonald, Tom Kehrer, Joan Powers, Landowners OKAW (Original Kaskaskia Area Wilderness), Inc., Venedy Sportsman Club, and West End Sportsman Club. We would also like to thank Glen Scheatz for his efforts in coordinating landowner permission for use of boat ramp access and water level data collection. We are also thankful to the U. S. Army Corps of Engineers (St. Louis District) for providing water level data from 1998 to 2000 for the Kaskaskia River. Funding was provided by the Southwestern Illinois Resource Conservation and Development, Inc. with the help of Ed Weilbacher. We are also thankful to Derek Aday for his assistance in writing this report.

Table 1. Summary of spatial and abiotic characteristics of seven oxbow lakes on the unchannelized reach of the Kaskaskia River below Carlyle dam. Distance is measured in feet from river. Values (mean ± 1 SE)of abiotic factors are averaged across years. DO, Secchi, and Conductivity were taken at the surface during each spring and fall at the deepest location of each lake.

Lake	Distance from River (feet)	DO (ppm)		Conductivity (μhos)		Secchi (m)	
		Mean	SE	Mean	SE	Mean	SE
Queens	165	4.71	0.41	288.5	10.50	0.18	0.03
Round	633	7.25	1.83	227.0	14.60	0.22	0.07
Halfmoon	1300	7.21	1.20	230.7	14.70	0.27	0.10
Kehrer	1343	8.14	0.97	138.3	4.40	0.31	0.05
Muddy	1450	6.92	1.49	246.0	15.10	0.13	0.01
Clear	4550	5.45	1.35	130.0	15.80	0.42	0.16
Calamus	5650	8.65	0.49	182.5	11.80	0.12	0.01

Table 2. Mean CPUE (fish caught per half hour) of all fish species collected in each of the seven oxbow lakes on the Kaskaskia River across years (1998 to 2000).

	Calamus	Clear	Halfmoon	Kehrer	Muddy	Queens	Round
Bigmouth Buffalo *Ictiobus cyprinella*	15.2	6.8	1.0	11.4	4.1	1.0	6.0
Black Buffalo *Ictiobus niger*	2.0	-	1.0	6.3	2.0	-	1.0
Black Bullhead *Amelurus melas*	-	1.2	-	-	-	-	-
Black Crappie *Pomoxis nigromaculatus*	6.0	-	6.5	2.0	2.0	-	10.0
Blackstripe Topminnow *Fundulus notatus*	-	1.2	3.0	2.5	-	-	-
Bluegill *Lepomis macrochirus*	36.2	16.7	41.3	44.2	3.6	25.5	42.8
Bluegillxredear	-	-	-	1.0	-	-	-
Bluntnose Minnow *Pimephales notatus*	-	-	-	-	-	1.0	-
Bowfin *Amia calva*	4.6	5.5	2.5	1.8	3.3	2.0	2.3
Brook Silverside *Labidesthes sicculus*	1.0	-	-	2.7	1.0	2.0	-
Carp *Cyprinus carpio*	5.0	5.7	5.5	4.3	5.7	5.0	4.8
Central Mudminnow *Umbra limi*	1.0	-	-	-	-	-	-
Channel Catfish *Ictalurus punctatus*	-	-	-	-	1.7	2.0	-
Flier *Centrarchus macropterus*	1.0	5.8	2.0	-	-	-	-
Freshwater Drum *Aplodinotus grunniens*	1.0	-	-	1.0	10.3	6.3	-
Gizzard Shad *Dorosoma cepedianum*	15.8	14.3	22.5	17.4	82.2	-	5.0
Golden Redhorse *Moxostoma erythrurum*	-	2.0	1.0	-	-	-	-
Golden Shiner *Notemigonus crysoleucas*	-	5.5	-	-	-	-	-
Grass Pickerel *Esox americanus*	-	-	3.0	-	-	37.3	-
Green Sunfish *Lepomis cyanellus*	-	1.0	1.5	1.0	1.0	2.0	-
Largemouth Bass *Micropterus salmoides*	2.0	3.4	13.7	3.8	1.0	1.0	2.3
Longear Sunfish *Lepomis megalotis*	1.0	-	-	1.0	-	-	-
Orange Spotted Sunfish *Lepomis humilis*	3.0	-	1.0	2.7	2.0	5.0	1.0
Pirate Perch *Aphredoderus sayanus*	3.0	4.0	-	-	-	-	-
Quillback *Carpiodes cyprinus*	1.0	-	-	-	3.0	-	-
Redear Sunfish *Lepomis microlophus*	1.0	1.5	-	1.0	-	2.0	2.0
Shortnose Gar *Lepisosteus platostomus*	-	-	-	-	1.0	3.0	-
Smallmouth Buffalo *Ictiobus bubalus*	1.5	1.0	3.0	2.5	1.0	7.0	3.0
Spotted Gar *Lepisosteus osseus*	1.5	2.0	2.0	-	1.0	-	-
Sunfish *Centrarchidae spp.*	-	-	-	-	-	1.0	-
Warmouth *Lepomis gulosus*	8.0	9.3	4.0	3.3	-	4.0	9.0
White Bass *Morone chrysops*	-	-	-	1.0	1.0	1.0	-
White Crappie *Pomoxis annularis*	29.8	6.6	11.0	9.4	3.7	4.3	4.5
Yellow Bass *Morone mississippiensis*	1.0	-	-	-	1.0	-	-
Yellow Bullhead *Amelurus natalis*	-	-	-	-	1.0	-	-

Table 3. Simpson's Diversity index (S) and Pielou's evenness index (J') for seven oxbow lakes on the Kaskaskia River for spring 1998, 1999, and 2000. Values > 0.500 indicate high diversity and evenness.

	Spring 1998		Spring 1999		Spring 2000	
Oxbow	S	J'	S	J'	S	J'
Queens	0.867	0.877	0.176	0.237		
Halfmoon	0.780	0.757	0.333	0.650		
Muddy	0.828	0.772	0.385	0.414	0.762	0.812
Kehrer	0.770	0.755	0.648	0.629	0.834	0.847
Calamus	0.804	0.765	0.695	0.652	0.807	0.813
Clear	0.851	0.917	0.861	0.856	0.861	0.850
Round	0.923	0.942	0.795	0.876		

Table 4. Seasonal (spring and fall) diversity (S), evenness(J'), and similarity (Horn's) comparisons of four lakes on the Kaskaskia River for 1998 and 1999. Values >0.500 indicate high diversity and evenness. Values for Horn's similarity coefficient: < 0.500 are "dissimilar", 0.500-0.700 are "somewhat similar", >0.700 are "similar".

	1998 Seasonal Comparisons			1999 Seasonal Comparisons		
Oxbow	S	J'	Horn's	S	J'	Horn's
Clear	-	-	-	0.852^{S}	0.859^{S}	0.329
	-	-	-	0.624^{F}	0.805^{F}	-
Kehrer	0.770^{S}	0.755^{S}	0.832	0.648^{S}	0.629^{S}	0.875
	0.778^{F}	0.705^{F}	-	0.692^{F}	0.628^{F}	-
Round	0.923^{S}	0.322^{S}	0.535	0.795^{S}	0.876^{S}	0.716
	0.942^{F}	0.392^{F}	-	0.852^{F}	0.885^{F}	-
Calamus	0.824^{S}	0.803^{S}	0.785	0.695^{S}	0.652^{S}	0.784
	0.792^{F}	0.713^{F}	-	0.736^{F}	0.709^{F}	-
Halfmoon	0.708^{S}	0.757^{S}	0.471	-	-	-
	0.785^{F}	0.720^{F}	-	-	-	-

Table 5. Diversity (S), evenness (J'), and similarity (Horn's) comparisons on Halfmoon and Calamus lakes across years and seasonally (spring and fall) across years. Fish species were totaled for the spring and fall 1998, spring 1999, and fall 2000. Values >0.500 indicate high diversity and evenness. Values for Horn's similarity coefficient: < 0.500 are "dissimilar", 0.500-0.700 are "somewhat similar", >0.700 are "similar".

	Calamus/Halfmoon across years			Calamus/Halfmoon Seasonally		
Oxbow	S	J'	Horn's	S	J'	Horn's
Calamus	0.834	0.688	0.816	0.823^{S}	0.733^{S}	0.906
				0.817^{F}	0.729^{F}	
Halfmoon	0.759	0.634	0.816	0.743^{S}	0.724^{S}	0.697
				0.730^{F}	0.640^{F}	

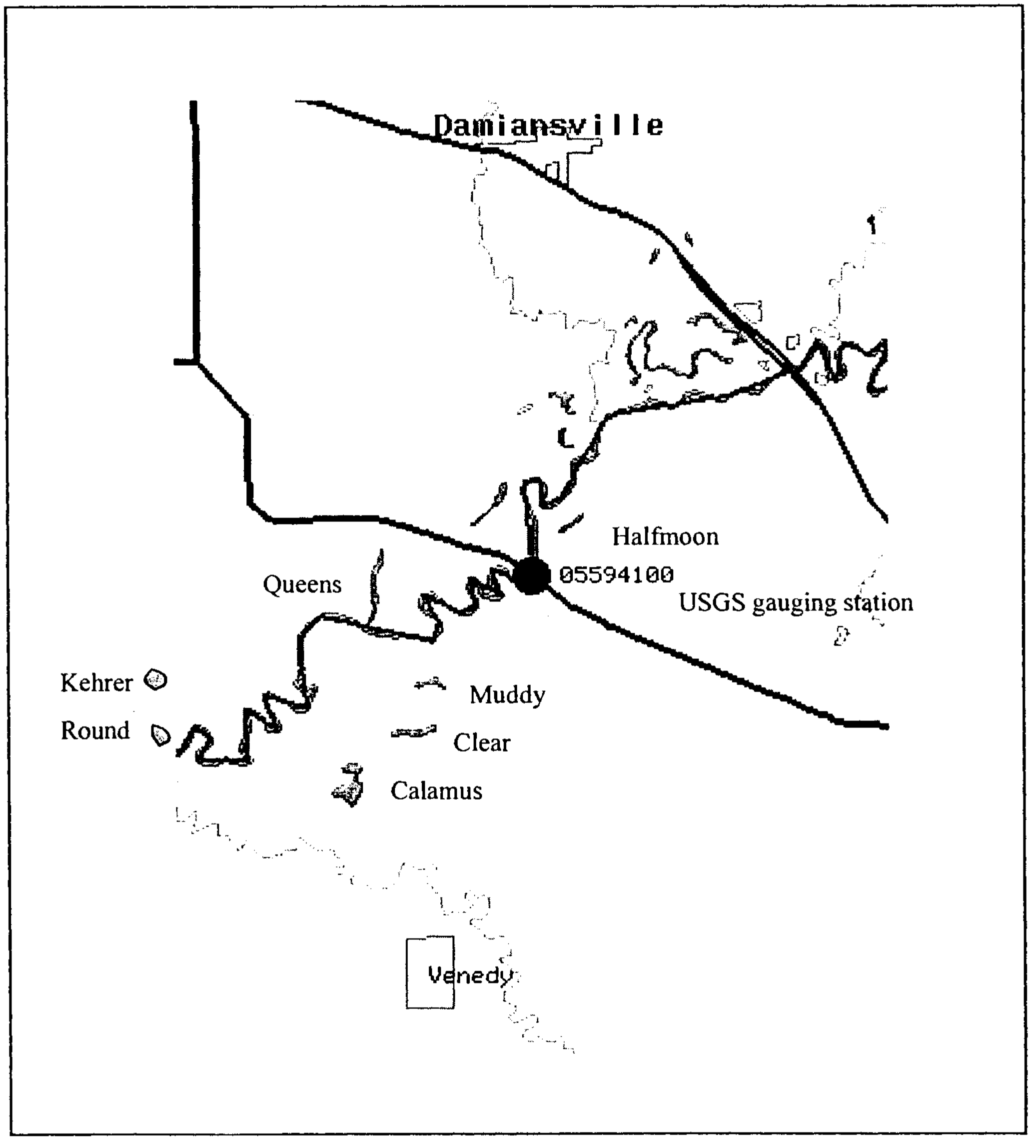

Figure 1. Map of the Kaskaskia River floodplain study region showing the location of oxbow lakes that were surveyed in the spring and fall from 1998 to 2000.

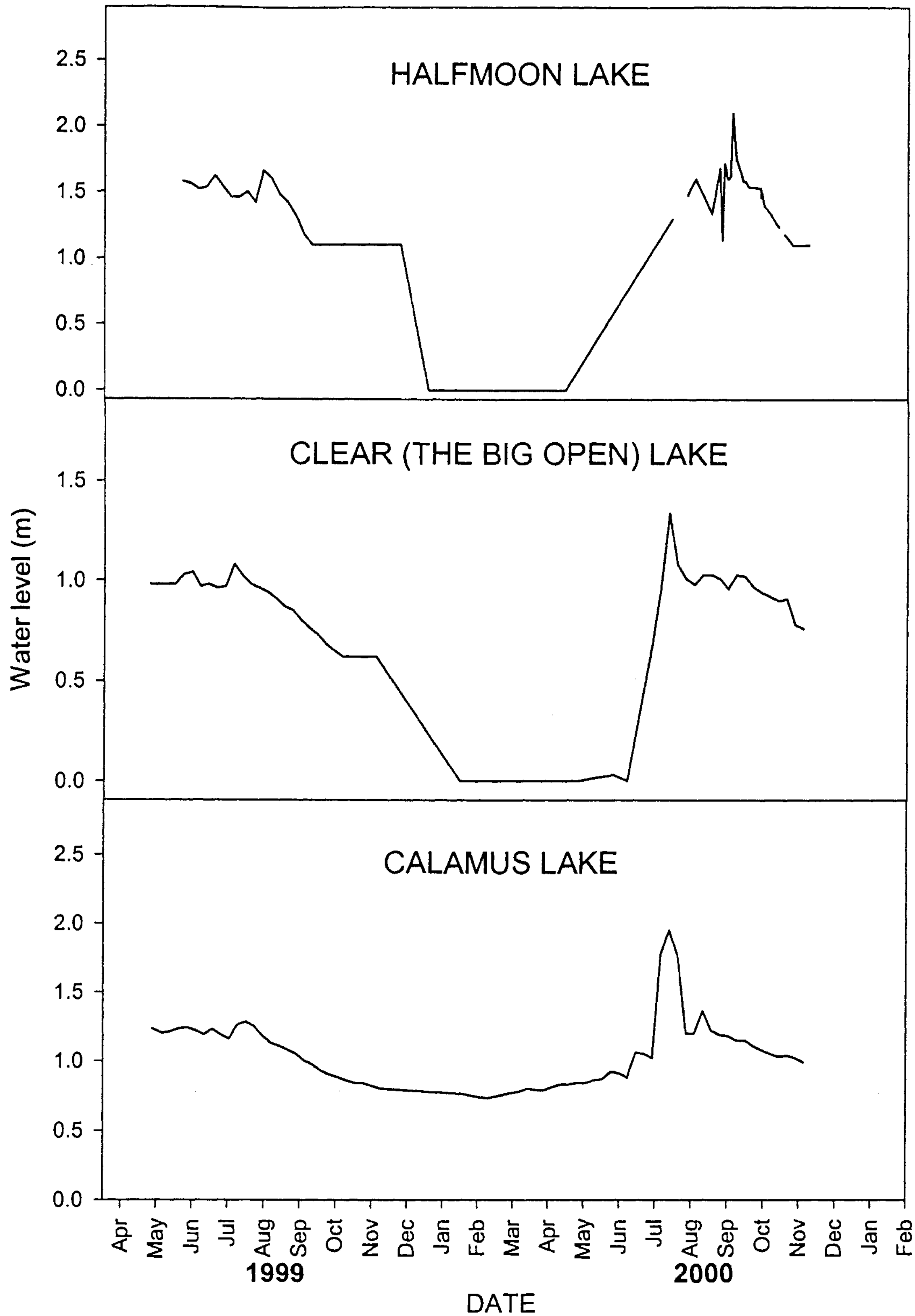

Figure 2. Recorded water levels (meters) for Halfmoon, Clear, and Calamus lakes from spring 1999 to fall 2000. Measurements were recorded by landowners based on gauges placed in each lake.

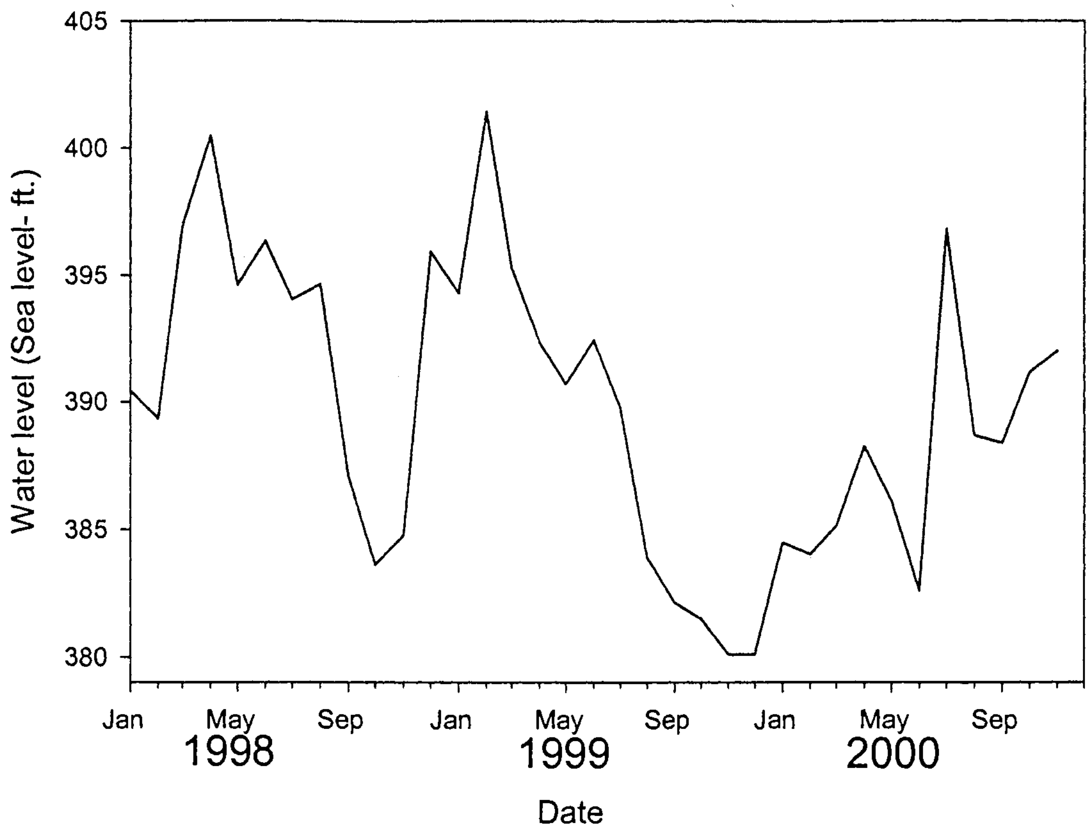

Figure 3. Mean monthly water levels (feet sea level) for the Kaskaskia River recorded at Venedy gauging station from 1998 to 2000. Water levels were supplied by the Army Corps of Engineers (St. Louis District).

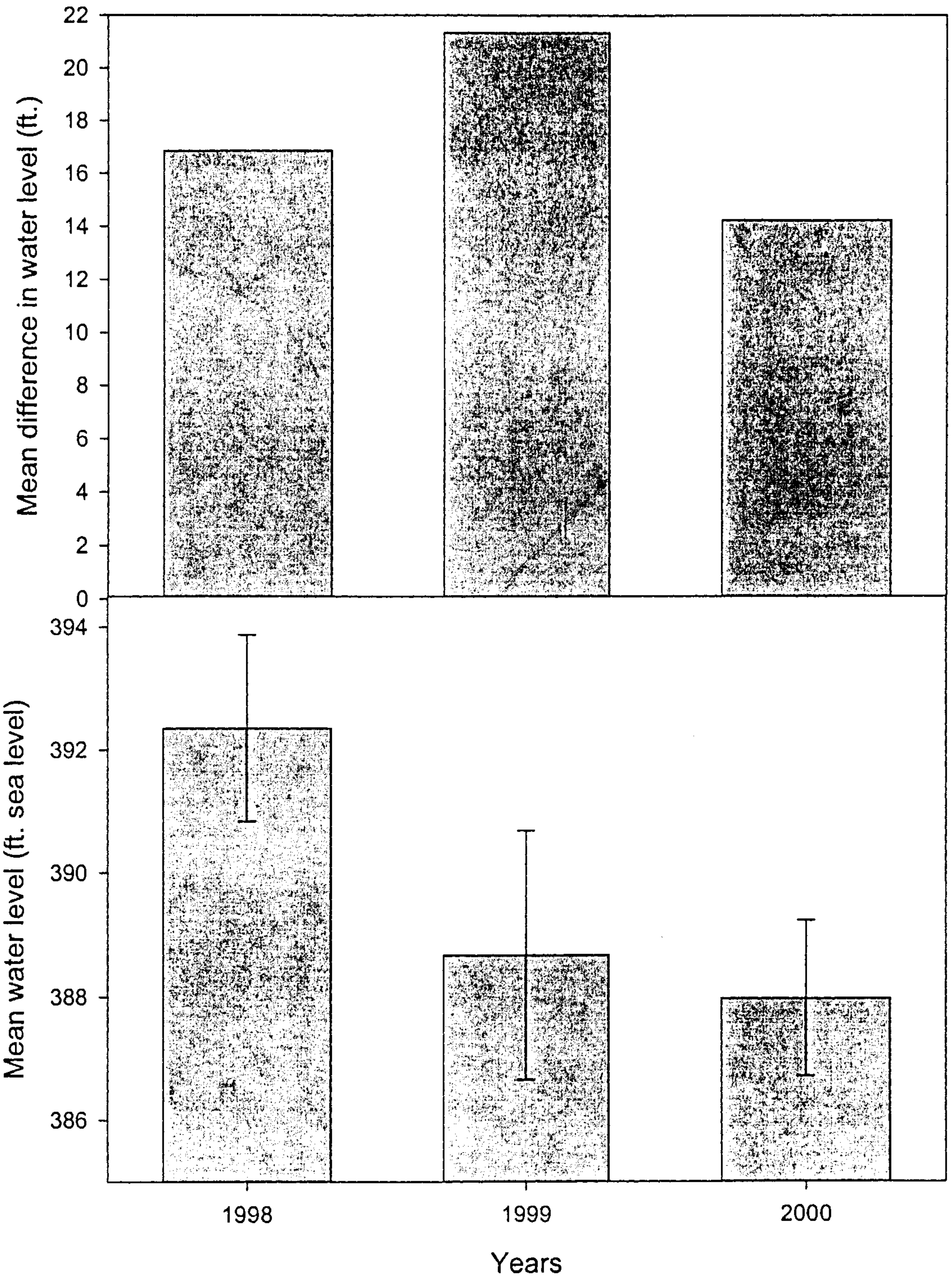

Figure 4. Water level fluctuation data for the Kaskaskia River from 1998 to 2000. Mean difference in water level (ft.) were taken from the difference in maximum and minimum mean monthly water levels for each year (top). Mean water level (ft.) were taken from monthly means for each year (bottom).

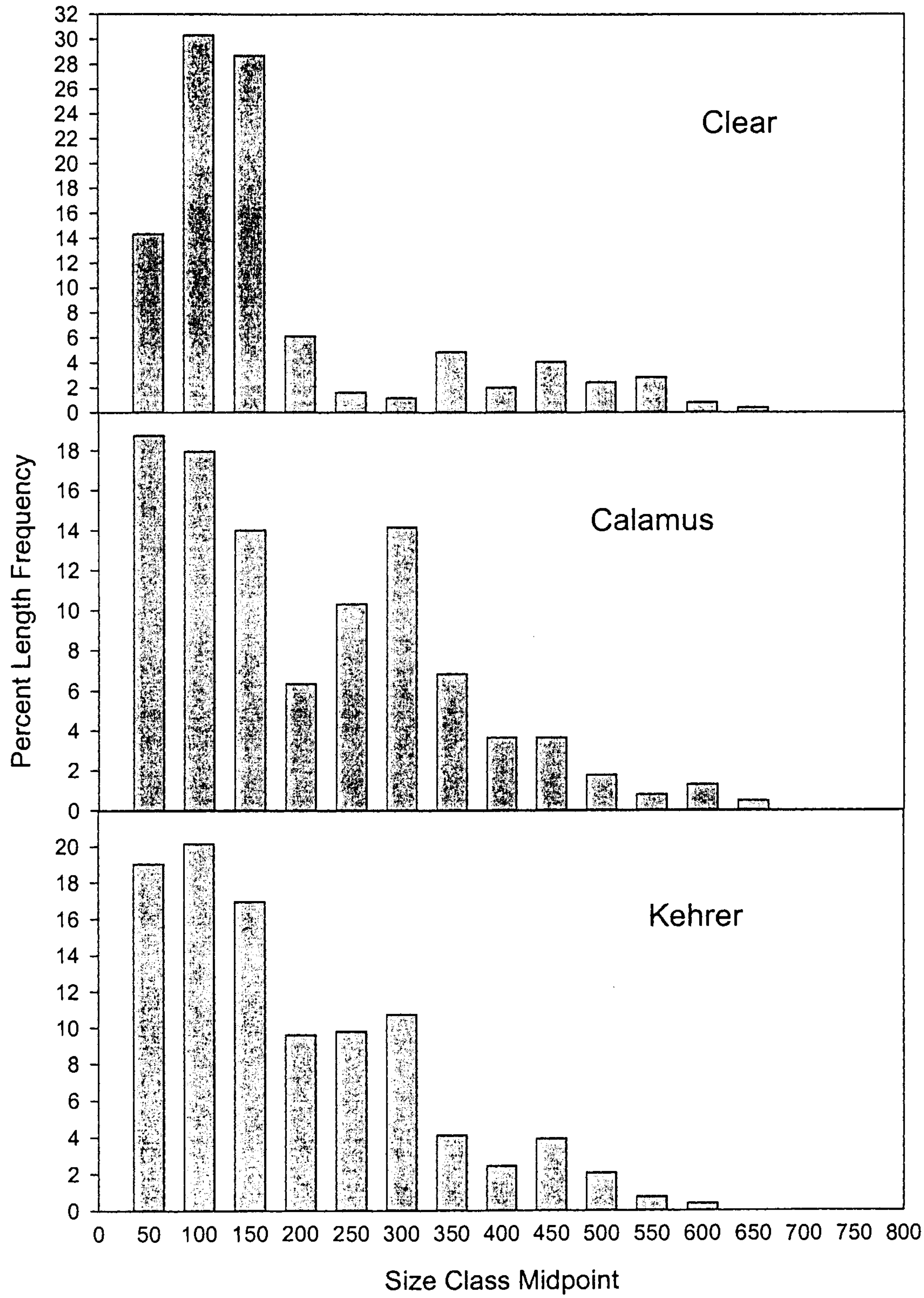

Figure 5a. Percent length frequency for all fish species collected from Clear, Calamus, and Halfmoon lakes. Percentages were based on combined CPUE (fish caught per half hour) for all fish collected in 1998, 1999, and 2000.

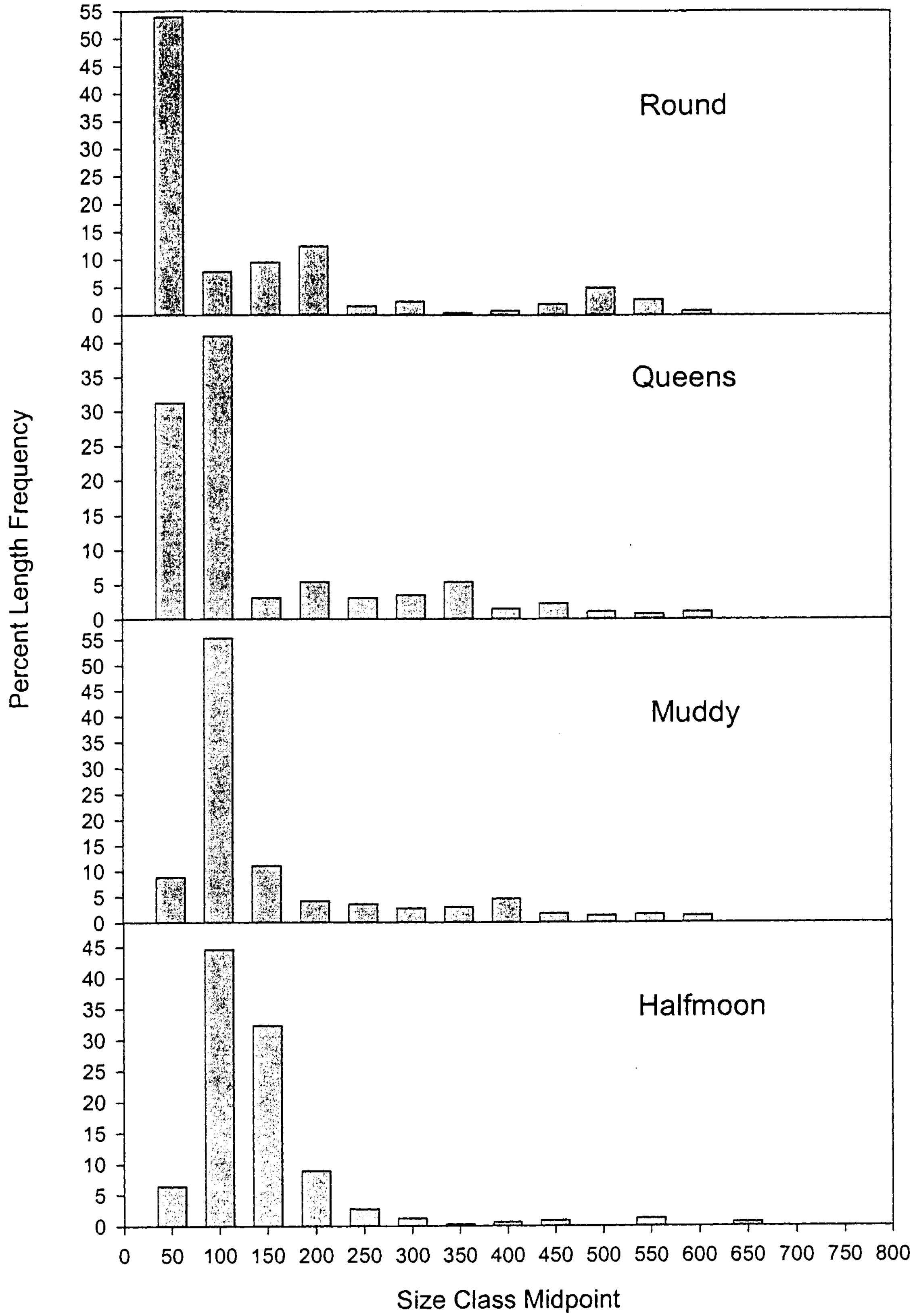

Figure 5b. Percent length frequency for all fish species collected from Round, Queens, Muddy, and Halfmoon lakes. Percentages were based on combined CPUE (fish caught per half hour) for all fish collected in 1998, 1999, and 2000.

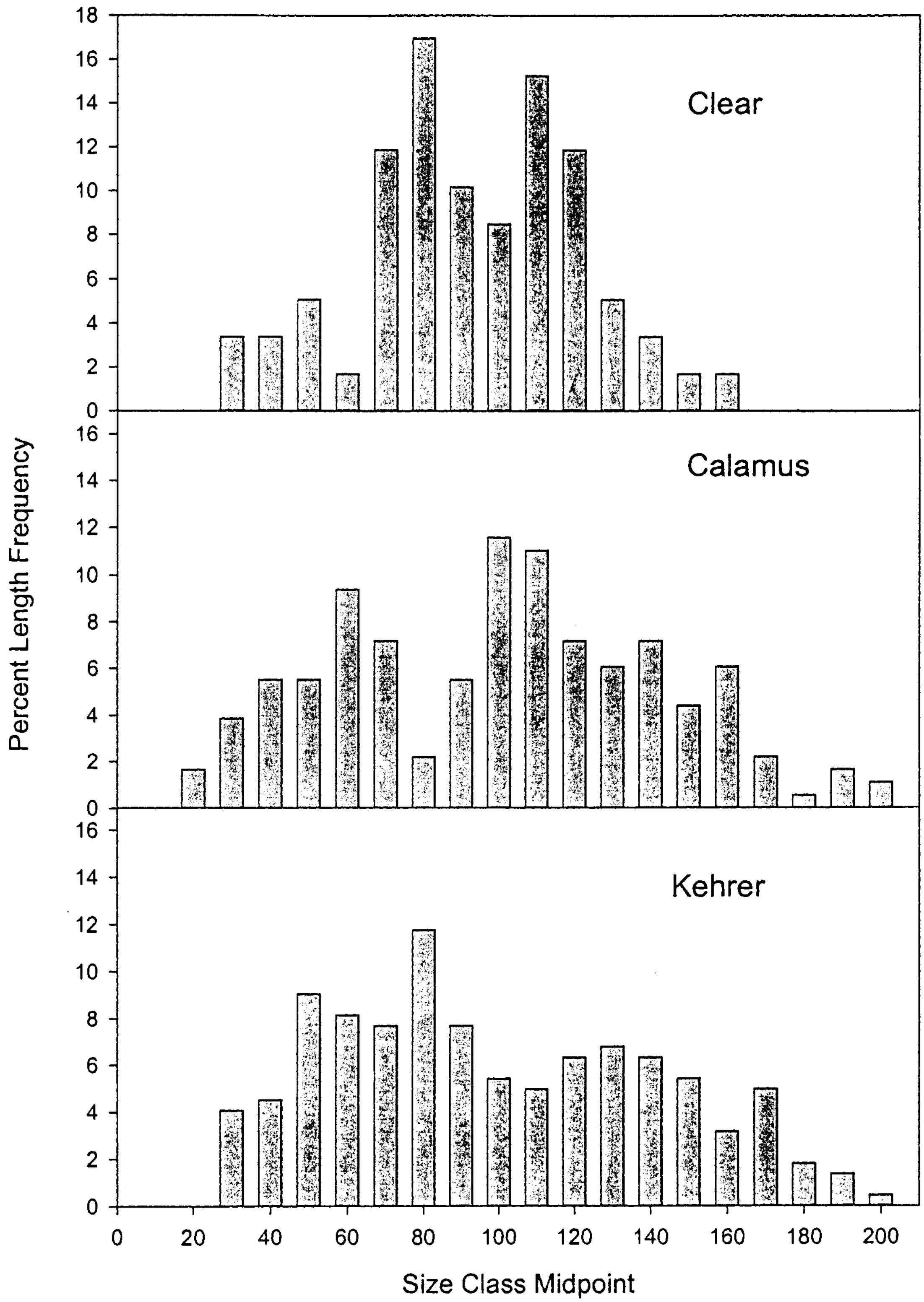

Figure 6a. Percent length frequency for all bluegill collected from Clear, Calamus, and Halfmoon lakes. Percentages were based on combined CPUE (fish caught per half hour) for all fish collected in 1998, 1999, and 2000.

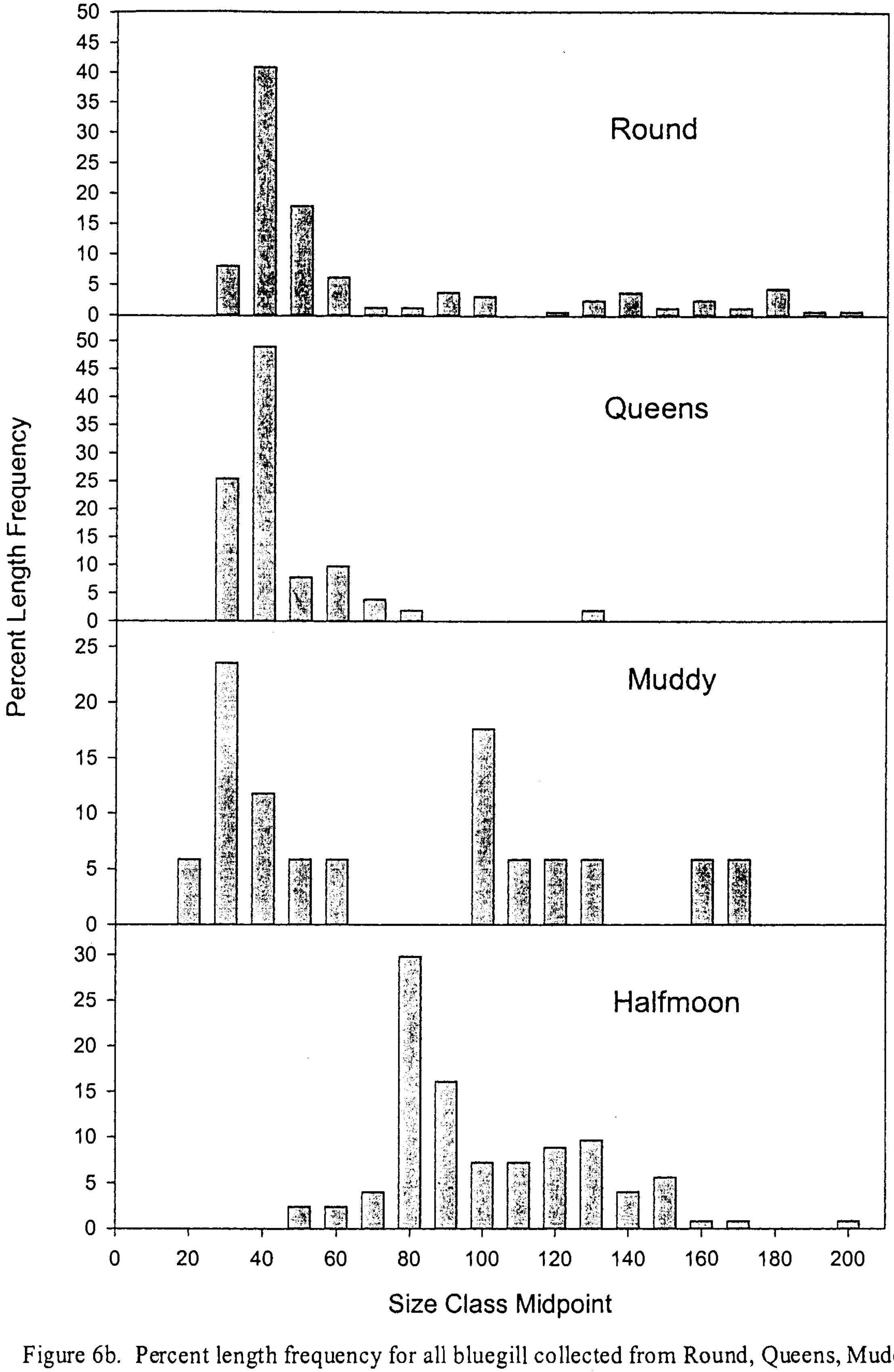

Figure 6b. Percent length frequency for all bluegill collected from Round, Queens, Muddy, and Halfmoon lakes. Percentages were based on combined CPUE (fish caught per half hour) for all fish collected in 1998, 1999, and 2000.

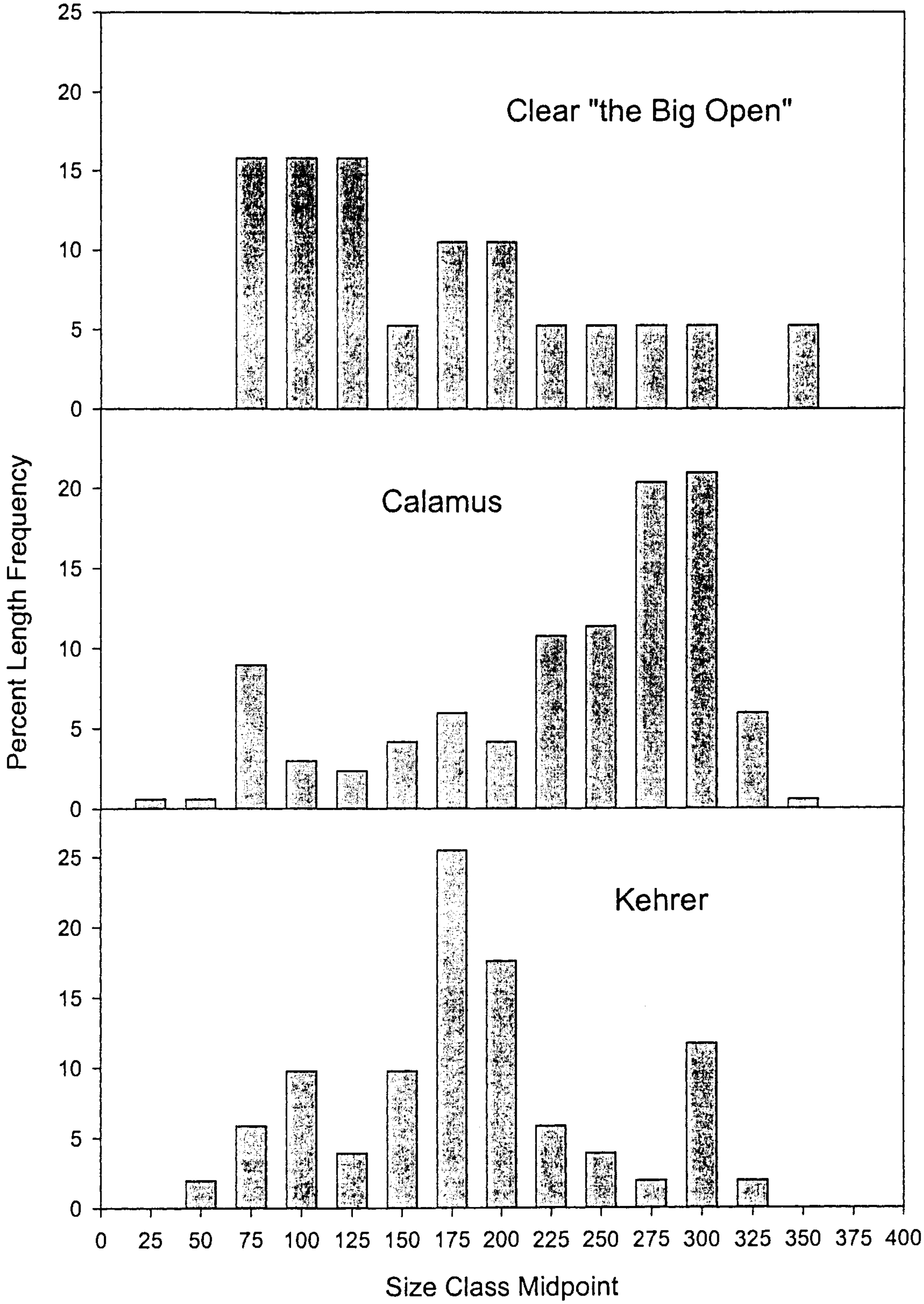

Figure 7a. Percent length frequency for all crappie collected from Clear, Calamus, and Halfmoon lakes. Percentages were based on combined CPUE (fish caught per half hour) for all fish collected in 1998, 1999, and 2000.

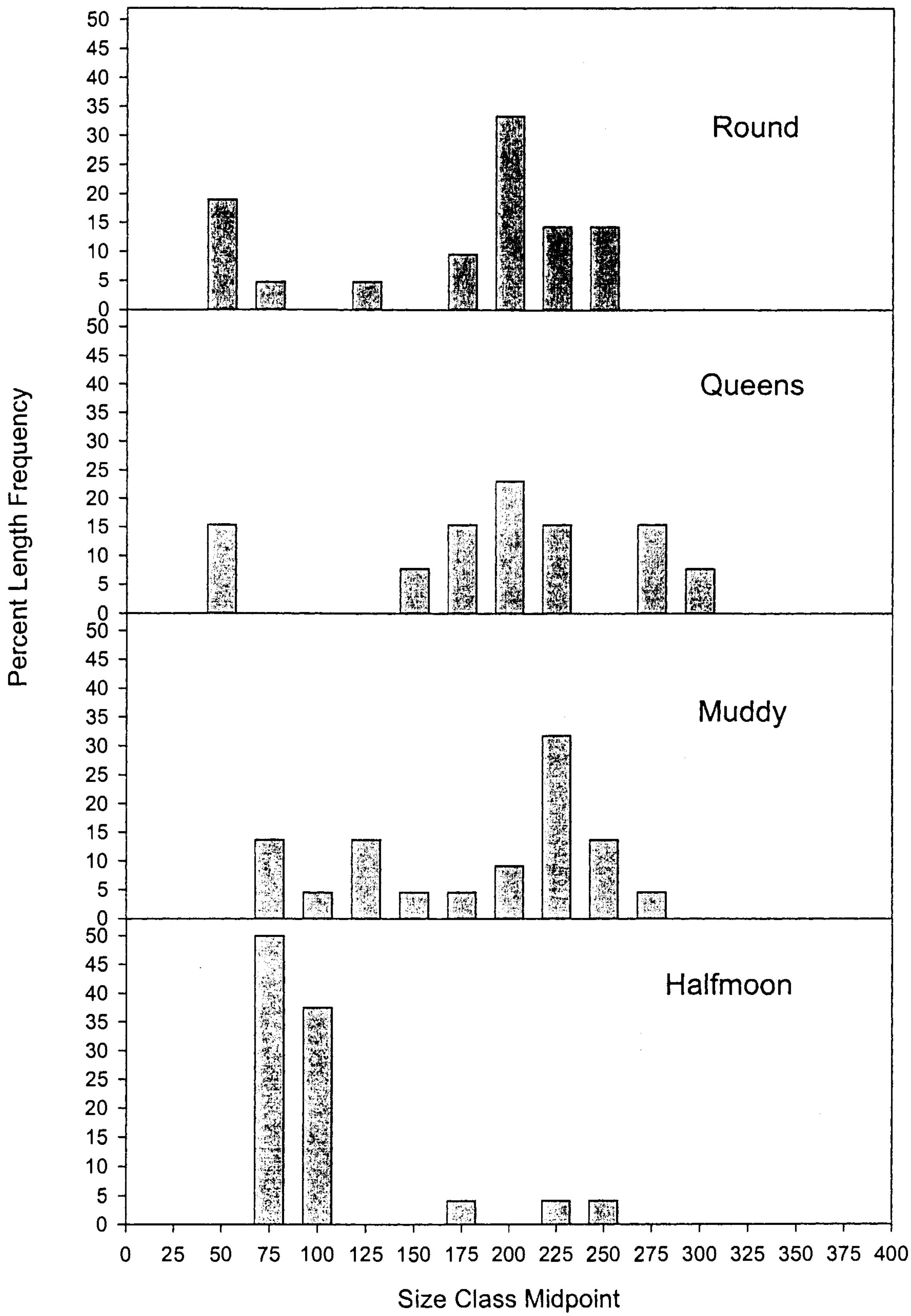

Figure 7b. Percent length frequency for all crappie collected from Round, Queens, Muddy, and Halfmoon lakes. Percentages were based on combined CPUE (fish caught per half hour) for all fish collected in 1998, 1999, and 2000.