MORPHOLOGICAL VARIATION BETWEEN JUVENILE WHITE BASS AND JUVENILE HYBRID STRIPED BASS

by

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While identifying recruitment bottlenecks for white bass *Morone chrysops*, we encountered difficulty distinguishing between age-0 white bass and age-0 hybrid striped bass *M. saxatilis x chrysops*. Accurate identification of juvenile white bass and hybrid striped bass will improve the quality of data gathered for research and monitoring efforts. The first objective of this study was to estimate biologists' accuracy identifying juvenile white bass and juvenile hybrid striped bass, and to determine which characteristics biologists were using during identification. Overall, identification accuracy was 71%. Biologists who placed less emphasis using the characteristic "broken horizontal lines" or who examined >99 age-0 *Morone* spp. during the past 12 months had greater identification accuracy. The second objective of this study was to develop a simple technique to distinguish juvenile white bass from juvenile hybrid striped bass. Fish pictures were digitized and body morphology was quantified by multivariate discriminant function analysis. Overall, species-classification rate was high (99.6%). Juvenile white bass were longer 1) between lateral line and origin of spiny dorsal fin, 2) between anal fin and lateral line, and 3) in caudal peduncle depth. Juvenile hybrid striped bass were longer 1) in midsection body length and 2) in head size. The ratio of caudal peduncle

depth to standard length (7.30) enabled us to distinguish between juvenile white bass and juvenile hybrid striped bass with an accuracy of 98.9%. Understanding which identification characteristics to use along with the application of quantifying fish body morphology will enable biologists to accurately distinguish between juvenile white bass and juvenile hybrid striped bass.

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Introduction

Hybridization of fish is a natural phenomenon that results from the interbreeding of two species (Schwenk et al. 2008). A hybrid generally retains traits from both parental species, including morphometric and meristic characteristics (Bishop 1968). Although hybridization occurs naturally, characteristics such as hybrid vigor and greater range of water quality tolerance make hybrids desirable for commercial production (Kerby 1980; Harrell and Dean 1988) and for stocking in recreational fisheries (Crawford et al. 1984).

A primary concern when stocking hybrids is the possible adverse effects on the gene pool of the parental species through introgression caused when hybrids reproduce with either parent species (Waldman 1986; Harrell and Dean 1988). Many studies have shown that hybrids are reproductively viable in the wild. In Precambrian Shield lakes, wild strain brook trout *Salvelinus fontinalis* and an interstrain (domestic x wild) hybrid were able to produce self-propagating populations, whereas the domestic strain was unable to reproduce (Fraser 1989). In a study evaluating F_1 hybrid crappies *Pomoxis annularis x nigromaculatus* and *P. nigromaculatus x annularis* for stocking in small impoundments, Hooe and Buck (1991) observed that both reciprocal F_1 hybrids were capable of backcrossing with their parent species, and both F_1 male hybrids had viabilities equal to that of their parents. After suspecting hybridization of sauger *Sander canadensis* and walleye *S. vitreus* in the headwaters of Cumberland Lake, Kentucky, Hearn (1986) removed viable milt and eggs from F_1 hybrids *S. canadensis x vitreus* and produced F_2 hybrids *S. canadensis x vitreus X S. canadensis x vitreus* in Kentucky's Minor E. Clark hatchery. The F_1 hybrids were also successfully backcrossed with male saugers to produce F_x hybrids.

Hybridization of the four North American *Morone* spp. (striped bass, white bass, white perch *M. americana*, and yellow bass *M. mississippiensis*) is widespread (Todd 1986; Crawford et al. 1984; Fries and Harvey 1989). The reproductive viability of *Morone* hybrids (Bishop 1968; Avise and Van Den Avyle 1984; Harrell 1984; Forshage et al. 1986; Fries and Harvey 1989) provides opportunities for these hybrids to reproduce naturally in wild environments. For example, 1.0, 29.0 and 1.8% of the *Morone* spp. captured by biologists using standardized gears in the Savannah River, Georgia (Avise and Van Den Avyle 1984), in Lake Palestine, Texas (Forshage et al. 1986), and in a conglomeration of 16 reservoirs throughout Texas (Storey et al. 2000), respectively, were F_x hybrids (i.e., later generation than F_1 hybrids).

The presence of *Morone* hybrids in recreational fisheries adds complexity for monitoring and understanding population dynamics, especially when species-specific assessments are desired. The presence of young (≤age 1) hybrid striped bass (wipers) *M. saxatilis x chrysops* decreases the likelihood of correctly identifying young pure-breed *Morone* spp. (Williams 1976; Harrell and Dean 1988; Muoneke et al. 1991), an important aspect of recruitment assessments that are often the basis of management decisions. Incorrect data on abundances of *Morone* spp. may be costly for management because white bass *M. chrysops*, striped bass *M. saxatilis* and hybrid striped bass, in particular, are frequently managed separately while in sympatry (Harrell and Dean 1988).

A common technique for distinguishing striped bass, white bass and their hybrids is the examination of basihyal tooth patches on the base of the tongue. White bass generally have one patch, whereas hybrid striped bass and striped bass have two patches (Bayless 1968; Bishop 1968; Williams 1976; Waldman 1986). This technique is best performed for juvenile fish by removing the tongue, dying it and examining it under a microscope; however, this is a lethal technique (Waldman 1986). Further, the use of this character as the only diagnostic tool in identifying *Morone* spp. is unreliable because variability exists in number and shape of basihyal tooth patches for white bass, hybrid striped bass and striped bass (Waldman 1986).

Morphometric analysis is another tool to distinguish among species and their hybrids (Williams 1976; Kerby 1980; Harrell and Dean 1988; Muoneke et al. 1991), as well as distinguish different feeding patterns within a species (Layzer and Clady 1987; Hjelm et al. 2001), and stunted from non-stunted individuals within a species (Chizinski et al. 2010). Layzer and Clady (1987) found that young-of-year bluegills *Lepomis macrochirus* collected from different microhabitats differed in body depth, caudal peduncle depth, and head length compared to standard length. Hjelm et al. (2001) demonstrated that overall body morphology in Eurasian yellow perch *Perca fluviatilis* was both a function of size and of diet. Yellow perch that fed in the pelagic zone, which consumed mainly zooplankton, developed a more fusiform body compared to yellow perch that fed in the littoral zone, which consumed zooplankton and macroinvertebrates.

Thus, morphometric analysis should be useful for distinguishing between white bass and hybrid striped bass, especially if these organisms occupy different habitats or feed on different prey types.

Indeed, morphometric differences (e.g., distance from anterior of anal fin to posterior of second dorsal fin [Muoneke et al. 1991] and head length divided by second anal fin spine length [Crawford et al. 1984]) exist between white bass, striped bass and their hybrids. However, precision of distinguishing white bass from hybrid striped bass is generally low (Muoneke et al. 1991). Unfortunately, none of these assessments focused on the early life stages of *Morone* spp. in natural environments. Thus, the objective for this study was to analyze morphometry of age-0 and age-1 *Morone* spp. captured from the wild to determine if a simple assessment can be used to distinguish juvenile white bass from juvenile hybrid striped bass.

Study Fishes

White Bass

White bass is the most popular and widespread species of the family Moronidae and is the only moronid species native to Nebraska. Although native, white bass were initially stocked in some Nebraska reservoirs to supplement wild populations. The first stocking of white bass in Nebraska occurred in 1889, though the first stocking by the Nebraska Game and Parks Commission occurred in 1944 when fish were transferred from Iowa to Lake McConaughy, Nebraska (Ellison 1987). White bass can be identified by its silver body with dark, unbroken stripes. Other characteristics of the white bass include a deep body, a high arched back, a single basihyal tooth patch on the upper surface of its tongue, and maximum size that generally does not exceed 2.7 kg (Pflieger 1997).

Hybrid Striped Bass

Hybrid striped bass, also known as wipers, were first produced in a hatchery setting during the early 1960's (Stevens 1967). The popularity of hybrid striped bass increased among fishery biologists due to their high survival rate, rapid growth rate, and adaptability to a wide range of environments (Bayless 1968; Bishop 1968; Ware 1975; Crawford et al. 1984; Muoneke et al. 1991). Hybrid striped bass resemble white bass more than striped bass; however, hybrid striped bass can grow to larger sizes than the white bass. The most common cross, known as the sunshine bass *M. saxatilis x chrysops*, is between a female striped bass and a male white bass. The reciprocal cross, known as the palmetto bass *M. chrysops x saxatilis*, is between a female white bass and a male striped bass. Both types of hybrid striped bass have been stocked in Nebraska reservoirs. Hybrid striped bass populations were established in select reservoirs throughout Nebraska in the early 1980's and are maintained through supplemental stockings. During 2007 and 2008, over 400,000 and 250,000 hybrid striped bass fingerlings were stocked in Nebraska waters, respectively.

Study Reservoirs

Initial efforts for the Southwest Reservoir Project were to examine recruitment bottlenecks for walleye and white bass populations in the five Nebraska reservoirs of the Republican River basin (Enders Reservoir, Harlan County Reservoir, Medicine Creek

Reservoir, Red Willow Reservoir, and Swanson Reservoir). Difficulties distinguishing juvenile *Morone* spp. led to the initiation of this study to examine morphometric differences between juvenile white bass and juvenile hybrid striped bass. Johnson Lake was added as a study site for the 2009 biologist identification test because hybrid striped bass were not stocked in any of the Republican River reservoirs during 2009.

Enders Reservoir

Enders Reservoir, located in southeastern Chase County, Nebraska, drains a watershed of 2,841 km^2 and covers 690 ha of surface area at conservation pool. Enders Dam was completed in 1951 impounding Frenchman Creek. Hybrid striped bass were first stocked in Enders Reservoir in 1993 and have been stocked on an annual or biannual schedule until 2005 (Tables 1-1 & 1-2). Hybrid striped bass were last stocked in 2005 because they exhibited poor condition and an extremely slow growth rate, causing a temporary suspension of future stockings.

Harlan County Reservoir

Harlan County Reservoir, located in Harlan County, Nebraska, drains a watershed of 18,554 km^2 and covers 5,362 ha of surface area at conservation pool. Harlan County Dam was completed in 1952 impounding the main stem of the Republican River. Hybrid striped bass were first stocked in Harlan County Reservoir in 1988 and have been stocked on a tri-annual schedule since 2005 (Tables 1-1 & 1-2).

Harry D. Strunk Lake (Medicine Creek Reservoir)

Medicine Creek Reservoir, located in southeastern Frontier County, Nebraska, drains a watershed of 2,279 km^2 and covers 748 ha of surface area at conservation pool. Medicine Creek Dam was completed in 1949 impounding Medicine Creek. Hybrid striped bass were first stocked in Medicine Creek Reservoir in 1986 and have since been stocked on an annual or biannual schedule (Tables 1-1 & 1-2).

Hugh Butler Lake (Red Willow Reservoir)

Red Willow Reservoir, located in southwestern Frontier County, Nebraska, drains a watershed of 1,890 km^2 and covers 659 ha of surface area at conservation pool. Red Willow Dam was completed in 1962 impounding Red Willow Creek. Hybrid striped bass were first stocked in Red Willow Reservoir in 1986 and have since been stocked on an annual or biannual schedule (Tables 1-1 & 1-2).

Johnson Lake

Johnson Lake, located in Gosper County, Nebraska, along the Central Supply Canal system, covers 1,133 ha of surface area at conservation pool. Johnson Lake provides water for two downstream hydroplants as part of the Nebraska Public Power District’s hydropower system. Hybrid striped bass were first stocked in Johnson Lake in 1992 and have since been stocked on an annual schedule (Tables 1-1 & 1-2).

Swanson Reservoir

Swanson Reservoir, located in Hitchcock County, Nebraska, drains a watershed of 22,403 km^2 and covers 2,012 ha of surface area at conservation pool. Trenton Dam was completed in 1953 impounding the main stem of the Republican River. Hybrid striped bass were first stocked in Swanson Reservoir in 1992 and have since been stocked on an annual or biannual schedule (Tables 1-1 & 1-2).

Goal

The goal of my study was to develop a technique to correctly distinguish age-0 and age-1 white bass and hybrid striped bass.

Objectives

- Determine how accurate biologists are at distinguishing age-0 and age-1 white bass and hybrid striped bass (Chapter 2).
- Develop an understanding of characteristics that biologists are using for field identification of age-0 and age-1 white bass and hybrid striped bass (Chapter 2).
- Describe the morphometric differences between juvenile white bass and juvenile hybrid striped bass (Chapter 3).

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Table 1-1. Number of hybrid striped bass and white bass stocked in study reservoirs during 1986-2009.

	Hybrid striped bass						White bass	
Year	Enders	Harlan	Johnson	Medicine Creek	Red Willow	Swanson	Harlan	Johnson
1986				29,152[a]	27,152[a]			
1987				0	150,000[b]			
1988		80,642[a]		400,000[b]	0			
1989		1,300[a]		0	0			52[c]
1990		3,004,000[b]		800,000[b]	500,000[b]			0
1991		0		0	1,200[a]			0
1992		1,500,000[b]	4,000,000[b]	618,616[d]	618,140[d]	34,975[a]		0
1993	14,000[a]	16,401[a]	0	0	0	300,000[b]	1,500,000[b]	0
1994	0	6,475,000[b]	0	18,500[a]	15,500[a]	26,420[a]	0	0
1995	2,040[a]	0	0	15,700[a]	0	0	0	0
1996	0	1,500,000[a]	29,500[a]	39,500[a]	15,500[a]	25,400[a]	0	0
1997	14,888[a]	67,510[a]	0	19,540[a]	0	0	0	0
1998	0	950,000[b]	16,766[a]	0	13,500[a]	25,750[a]	0	0
1999	30,820[a]	67,634[a]	14,000[a]	14[c]	18,434[a]	0	0	0
2000	0	24,175[a]	14,640[a]	25,690[a]	0	30,090[a]	0	0
2001	14,859[a]	0	24,228[a]	21,146[a]	21,483[a]	25,146[a]	0	0
2002	0	0	14,600[a]	34,100[a]	17,600[a]	30,800[a]	0	0
2003	8,716[a]	0	14,168[a]	0	0	0	0	0
2004	7,048[a]	0	14,000[a]	4,000[a]	5,500[a]	4,551[a]	0	0
2005	11,280[a]	16,000[a]	14,000[a]	6,625[a]	9,130[a]	17,820[a]	0	0
2006	0	0	28,000[a]	6,625[a]	0	14,080[a]	0	0
2007	0	0	40,475[a]	6,625[a]	16,300[a]	11,740[a]	0	0
2008	0	70,000[a]	43,780[a]	6,625[a]	5,750[a]	11,740[a]	0	0
2009	0	0	14,763[a]	0	0	0	0	0

[a] fingerling.
[b] fry.
[c] adult.
[d] 97% fry; 3% fingerling.

Table 1-2. Rate (number per ha [conservation pool]) of hybrid striped bass and white bass stocked in study reservoirs during 1986-2009.

	Hybrid striped bass						White bass	
Year	Enders	Harlan	Johnson	Medicine Creek	Red Willow	Swanson	Harlan	Johnson
1986				39[a]	41[a]			
1987				0	228[b]			
1988		15[a]		535[b]	0			
1989		0		0	0			0.05[c]
1990		560[b]		1,070[b]	759[b]			0
1991		0		0	2[a]			0
1992		280[b]	3,530[b]	802[d]	910[d]	17[a]		0
1993	20[a]	3	0	0	0	149[b]	280[b]	0
1994	0	1,208[b]	0	25[a]	24[a]	13[a]	0	0
1995	3[a]	0	0	21[a]	0	0	0	0
1996	0	280[a]	26[a]	53[a]	24[a]	13[a]	0	0
1997	22[a]	13[a]	0	26[a]	0	0	0	0
1998	0	177[b]	15[a]	0	20[a]	13[a]	0	0
1999	45[a]	13[a]	12[a]	0.02[c]	28[a]	0	0	0
2000	0	5[a]	13[a]	34[a]	0	15[a]	0	0
2001	22[a]	0	21[a]	28[a]	33[a]	12[a]	0	0
2002	0	0	13[a]	46[a]	27[a]	15[a]	0	0
2003	13[a]	0	13[a]	0	0	0	0	0
2004	10[a]	0	12[a]	5[a]	8[a]	2[a]	0	0
2005	16[a]	3[a]	12[a]	9[a]	14[a]	9[a]	0	0
2006	0	0	25[a]	9[a]	0	7[a]	0	0
2007	0	0	38[a]	9[a]	25[a]	6[a]	0	0
2008	0	13[a]	39[a]	9[a]	9[a]	6[a]	0	0
2009	0	0	13[a]	0	0	0	0	0

[a] fingerling.
[b] fry.
[c] adult.
[d] 97% fry; 3% fingerling.

Chapter 2. Identification accuracy of juvenile white bass and juvenile hybrid striped bass

Introduction

The presence of hybrids in recreational fisheries adds complexity for monitoring and understanding population dynamics, especially when species-specific assessments are desired. The importance of accurate fish identification by biologists has been documented (Storey et al. 2000); however, identification accuracy for species and assorted hybrids has been reported for few fishes. Baumsteiger et al. (2005) and Kennedy et al. (2009) reported identification accuracy by biologists for coastal cutthroat trout *Oncorhynchus clarkii clarkii*, anadromous rainbow trout *O. mykiss* and associated hybrid smolts from streams in California and Washington. Overall identification accuracy was >70%; however, identification accuracy of hybrid smolts was <55% (Baumsteiger et al. 2005; Kennedy et al. 2009). Baumsteiger et al. (2005) reported that fish size might influence identification accuracy because identification accuracy was lower for large (≥85 mm) juveniles compared to small (<85 mm) juveniles.

Accurate identification of *Morone* spp. is important for management decisions because white bass *M. chrysops*, striped bass *M. saxatilis* and hybrid striped bass *M. saxatilis x chrysops*, in particular, are frequently managed separately (Harrell and Dean 1988). Characteristics that are commonly used to identify white bass and hybrid striped bass include broken horizontal lines, body shape, and number of basihyal tooth patches on tongue. However, these characteristics can vary among fish and be unreliable, especially in juveniles (Waldman 1986). Only one study has reported identification accuracy of white bass and hybrid striped bass by fishery biologists. Biologists and technicians had an identification accuracy of 95% for white bass and hybrid striped bass collected from 16 Texas reservoirs; however, the majority of sampled fish were ≥254 mm and identification accuracy among reservoirs varied from 52% to 100% (Storey et al. 2000).

Accurate identification of ≥254 mm *Morone* spp. is important, especially for anglers; however, biologists routinely examine juvenile fish to estimate year-class strength (St. John and Black 2004; Smith et al. 2005). Inaccurate identification of juvenile fish can be costly to management agencies, especially when estimates of year-class strength influence stocking rates for the following year. This study was developed to determine how accurate biologists are at identifying juvenile *Morone* spp. from Nebraska reservoirs and to understand what characteristics biologists are using to distinguish juvenile white bass from juvenile hybrid striped bass.

Methods

Fish Collection

Morone spp. were collected from Johnson Lake, Gosper County, Nebraska (n = 72 age 0) and Harlan County Reservoir, Harlan County, Nebraska (n = 28; 1 age 0 and 27 age 1-2) on 23-24 September 2009 with standard electrofishing gear using pulsed DC (Reynolds 1996). Our goal was to collect 100 (70 age 0 and 30 age 1) *Morone* spp. from one reservoir (i.e., Johnson Lake) that had a high stocking rate of hybrid striped bass for year classes associated with targeted age groups. We targeted more age-0 than age-1 fish for this study because identification accuracy for age-0 fish was lower than age-1 fish during a 2008 pilot study, and we desired greater resolution for age-0 fish. We captured no age-1 *Morone* spp. from Johnson Lake; thus, we collected suspected age-1 fish from Harlan County Reservoir. The fish collected from Harlan County Reservoir exhibited unforeseen slow growth rates, and the majority of fish collected were age 2. For analysis, we grouped fish as younger (age 0) and older (age 1-2) juveniles.

Once collected, each fish was euthanized by cranial percussion and stored individually with an identification number in a plastic bag on ice until processed. A fin clip, approximately 300 mm^2, was taken from the caudal (preferred) or pectoral fin with dissecting scissors and placed in a prelabeled plastic vial filled with ~1.5 mL of absolute non-denatured ethanol for preservation. The dissecting scissors was rinsed with non-denatured ethanol between each specimen to prevent genetic contamination of samples. Genetic analysis (methods described below) of moronid samples was performed by the Molecular Conservation Genetics Laboratory (MCGL) of the U.S. Geological Survey-Wisconsin Cooperative Fishery Research Unit at the University of Wisconsin-Stevens Point. Reference samples (n = 53) for pure white bass (Guadalupe River above Canyon Reservoir, Cormal County, Texas) and striped bass (Trinity River below Lake Livingston, San Jacinto and Polk County, Texas) were included in the genetic analysis.

Genetic Analysis

Microsatellite DNA was chosen as the molecular marker for this study. Microsatellites are tandem arrays of short repeating motifs (2-8 base pairs) and are dispersed throughout the genome (Hallerman 2003). Variation in number of repeat motifs form different length variants or alleles at a specific locus that can be used to determine parental species and identify hybrids.

Analysis consisted of microsatellite genotyping all samples at five loci determined to be diagnostic between striped bass and white bass (Table 2-1; Couch et al. 2006). In our analysis, diagnostic allele distributions were observed for all five loci. Therefore, we determined a pure species to be an individual with alleles consistent with that species for all sampled loci. Alternatively, an F_1 individual was heterozygous for an allele from both species at all sample loci and an F_x individual had some combination of both locus-specific genotype categories. The DNA extractions were performed on fin clips using a 96-well modification of the Promega Wizard® Genomic DNA purification kit (Promega Corp., Madison, WI). Extracted DNA was quantified using a Nanodrop® ND-1000 spectrophotometer (Nanodrop Tech., Wilmington, DE) and normalized to 20 ng/μL in 50 μL TLE (Tris-low-EDTA buffer) prior to genotyping.

Five microsatellite loci (Table 2-1) were analyzed in two multiplex polymerase chain reactions (PCR) developed by the MCGL according to the recommended approach of Henegariu et al. (1997). The forward primer of each primer set was labeled with a 5' fluorescent label for subsequent size fractionation on an automated DNA sequencer. Multiplex PCR A consisted of 10 μL PCR reactions consisting of 1X PCR Buffer B (ThermoFisher Scientific, Inc., Waltham, MA), 0.60 mM dNTPs (0.15 mM each dNTP), 1.30 mM $MgCl_2$, 0.12 μM each MSM 1137 primer, 0.16 μM each MSM 1138 primer, 0.20 μM each MSM 1144 primer, 0.50 U *Taq* DNA polymerase (New England Biolabs, Inc., Ipswich, MA), and ddH_2O to volume. Multiplex PCR B consisted of 1X PCR

Buffer B, 0.6 mM dNTPs, 1.70 mM $MgCl_2$, 0.15 mM each MSM 1067 primer, 0.15 mM each MSM 1085 primer, 0.5 U *Taq* DNA polymerase and ddH_2O to volume. Temperature profiles consisted of an initial 2 min denaturation at 95^{o}C followed by 35 cycles of 95^{o}C/45 s, 54^{o}C/30 s (multiplex A) or 56^{o}C/30 s (multiplex B), 72^{o}C/30 s, a final 10 min extension at 72^{o}C and an indefinite hold at 10^{o}C. Amplified DNA was electrophoresed on an ABI 3730 DNA Analyzer (Applied Biosystems, Inc., Foster City, CA) with GeneFlo™ 625 (Chimerx, Inc., Milwaukee, WI) in-lane standard. Genotype data were collected using Genemapper® 4.0 (Applied Biosystems).

Age Verification

Otoliths were removed from each fish (after the identification test described below) and stored in paper envelopes until processed. Otoliths were placed individually in a black dish filled with water and examined through a dissecting microscope by two independent readers who each assigned an age to each fish. If there was disagreement of assigned ages between readers, otoliths were reexamined by both readers together. If the readers could not agree on an age, the specimen was excluded from further morphometric, genetic, and identification analyses.

Identification Test

Fish were randomly assorted into groups of ten and placed in separate coolers that were assigned a number from 1 to 10. Collected fish were identified independently by biologists (n = 32; 10 employed by the Nebraska Game and Parks Commission and 22 employed by the University of Nebraska) on 24-28 September 2009. Biologists included in this identification test were comprised of graduate students, professors, and Nebraska

Game and Parks Commission fishery managers and administrators. Each biologist was provided a measuring board, clip board with 5 data sheets, and a pen. For each fish, biologists were instructed to identify, age, and indicate how confident (i.e., not, a little, somewhat, very, extremely) they were with their identification. Biologists were not allowed to re-evaluate an individual fish or change their responses once recorded.

To begin the process, biologists randomly chose a cooler, haphazardly selected a fish from within that cooler, identified it and placed it back into the cooler until every fish from that cooler had been identified. Biologists repeated this procedure until every fish from every cooler had been examined. After examination of every fish, biologists completed two questionnaires. The first questionnaire (Figure 2-1) was designed to learn what characteristics biologists used to identify specimens. The second questionnaire (Figure 2-2) was designed to determine if correlations existed between percent agreement of genetic and biologist identification with (1) how much importance a biologist placed for each characteristic during the identification process, (2) number of age-0 or age-1 *Morone* spp. that a biologist examined during the past 12 months, (3) number of years of experience a biologist had identifying fish, (4) number of years of experience a biologist had identifying *Morone* spp., and (5) highest educational degree earned by a biologist.

Statistical Analyses

A Kruskal-Wallis (KW) test was used to determine if differences ($\alpha = 0.05$) in length and weight existed between younger- and older-juvenile test specimens. A z-score (z) was calculated to determine if differences ($\alpha = 0.05$) existed between percent agreement of genetic and biologist identification for: (Test 1) younger- and older-juvenile

Morone spp., (Test 2) younger-juvenile white bass and younger-juvenile hybrid striped bass, and (Test 3) older-juvenile white bass and older-juvenile hybrid striped bass. Mean percent agreement between biologist identification and genetic identification was calculated for categorical post-test questionnaire answers and compared using a means Tukey test (GLM procedure) in SAS® (SAS Institute Inc. 2010) to determine if differences ($\alpha = 0.05$) existed.

Results

Genetic results were obtained for 98 of 100 sampled fish. The number of fish correctly identified by biologists out of 98 ranged from 49 to 96, with a mean ± SE of 69.9 ± 2.2 (Figure 2-3). Out of 98 fish, the number genetically identified as white bass and hybrid striped bass was 85 and 13, respectively. The number of white bass correctly identified by biologists ranged from 36 to 85 with a mean ± SE of 59.8 ± 2.1. The number of hybrid striped bass correctly identified by biologists ranged from 2 to 13, with a mean ± SE of 10.1 ± 0.5. Out of the 32 biologists that completed the identification test, 7 biologists had an identification accuracy >80% and 3 biologists had an identification accuracy >90%.

Test 1 – Differentiating younger-juvenile fish and older-juvenile fish

Out of 98 fish, 72 were verified as younger juveniles, ranging in total length from 112 to 168 mm with a mean ± SE of 129.8 ± 1.3 mm, and ranging in weight from 16.4 to 48.4 g with a mean ± SE of 26.09 ± 1.69 g. Out of 72 fish, the number of younger-juvenile fish correctly identified by biologists ranged from 37 to 70 with a mean ± SE of

52.9 ± 1.7. The remaining 26 fish were verified as older juveniles (6 age 1, 20 age 2), ranging in total length from 205 to 250 mm with a mean ± SE of 227.4 ± 2.2, and ranging in weight from 74.4 to 169.5 g with a mean ± SE of 116.06 ± 4.40. Out of 26 fish, the number of older-juvenile fish correctly identified by biologists ranged from 10 to 26 with a mean ± SE of 17.0 ± 0.8. Younger-juvenile *Morone* spp. differed from older-juvenile *Morone* spp. in total length (KW X^2 = 58.59, df = 1, P <0.0001) and weight (KW X^2 = 58.55, df = 1, P <0.0001). Identification accuracy did not differ between younger-juvenile *Morone* spp. and older-juvenile *Morone* spp. (mean ± SE difference in proportions = 0.081 ± 0.107; test to determine if different from zero: z = 0.76, P = 0.23).

Test 2 – Differentiating younger-juvenile white bass and younger-juvenile hybrid striped bass

Out of 72 younger-juvenile fish, the number genetically identified as white bass was 65, and these fish ranged in total length from 112 to 153 mm with a mean ± SE of 128.3 ± 1.1 mm, and weight from 16.4 to 41.7 g with a mean ± SE of 25.27 ± 0.63 g. Out of 65 fish, the number of younger-juvenile white bass correctly identified by biologists ranged from 31 to 65 with a mean ± SE of 47.5 ± 1.6. The number genetically identified as hybrid striped bass was 7, and these fish ranged in total length from 127 to 168 mm with a mean ± SE of 144.9 ± 5.0, and weight from 22.9 to 48.8 g with a mean ± SE of 33.49 ± 3.33. Out of 7 fish, the number of younger-juvenile hybrid striped bass correctly identified by biologists ranged from 2 to 7 with a mean ± SE of 5.4 ± 0.3. Younger-juvenile white bass differed from younger-juvenile hybrid striped bass in mean total length (KW X^2 = 10.58, df = 1, P = 0.001) and mean weight (KW X^2 = 7.23, df = 1, P =

0.01). Identification accuracy did not differ between younger-juvenile white bass and younger-juvenile hybrid striped bass (mean ± SE difference in proportions = -0.041 ± 0.168; test to determine if different from zero: z = -0.24, P = 0.59).

Test 3 – Differentiating older-juvenile white bass and older-juvenile hybrid striped bass

Out of 26 older-juvenile fish, the number genetically identified as white bass was 20, and these fish ranged in total length from 205 to 250 mm with a mean ± SE of 226.6 ± 2.6 mm, and weight from 74.4 to 169.5 g with a mean ± SE of 115.61 ± 5.25 g. Out of 20 fish, the number of older-juvenile white bass correctly identified by biologists ranged from 5 to 20 with a mean ± SE of 12.3 ± 0.7. The number genetically identified as hybrid striped bass was 6, and these fish ranged in total length from 220 to 245 mm with a mean ± SE of 230.3 ± 4.35, and weight from 101.1 to 151.1 g with a mean ± SE of 117.62 ± 8.08. Out of 6 fish, the number of older-juvenile hybrid striped bass correctly identified ranged from 0 to 6 with a mean ± SE of 4.7 ± 0.3. Older-juvenile white bass did not differ from older-juvenile hybrid striped bass in mean total length (KW X^2 = 0.31, df = 1, P = 0.56) or mean weight (KW X^2 = 0.05, df = 1, P = 0.81). Identification accuracy did not differ between older-juvenile white bass and older-juvenile hybrid striped bass (mean ± SE difference in proportions = -0.168 ± 0.201; test to determine if different from zero: z = -0.84, P = 0.20).

Post-test Questionnaires

Mean percent agreement between biologist identification and genetic identification was significantly different among categorical responses for two post-test questions. There was greater percent agreement for biologists that placed less importance using the characteristic presence/absence of broken horizontal lines than biologists who placed more importance on this characteristic (F = 6.80; df = 3, 28; *P* = 0.001; Figure 2-4). There was also greater percent agreement for biologists who examined >99 age-0 *Morone* spp. during the past 12 months than biologists that examined zero (F = 3.29; df = 2, 29; *P* = 0.05; Figure 2-5). No differences (*P* >0.10) existed for percent agreement of genetic and biologist identification as a function of the number of age-1 *Morone* spp. that a biologist examined during the past 12 months (Figure 2-6), emphasis placed on thickness or darkness of horizontal lines (Figure 2-7), emphasis placed on size of fish compared to other fish being sampled (Figure 2-8), years experience identifying fish (Figure 2-9), emphasis placed on overall body shape (Figure 2-10), emphasis placed on presence/absence of vertical bars (parr marks) (Figure 2-11), highest degree earned for each biologist (Figure 2-12), years experience identifying *Morone* (Figure 2-13), or emphasis placed on number or shape of tongue patches (Figure 2-14).

Discussion

For this study, biologists were on average less accurate (71%) than fishery biologists in Texas (95%) at identifying *Morone* spp. (Storey et al. 2000). However, biologists for this study examined juvenile fish, the majority of which was <200 mm. In contrast, the majority of *Morone* spp. identified by biologists in Texas was *Morone* spp. that were ≥254 mm. Thus, adult *Morone* spp. are likely easier to identify than juvenile *Morone* spp. Additionally, biologists for this study performed this test individually, identifying euthanized fish one at a time. Average test scores may have been greater if biologists worked in groups, examined live fish and were allowed to directly compare specimens.

Although field identification results from our pilot work during 2008 indicated that we were less accurate identifying younger-juvenile fish than older-juvenile fish, there was not a statistically significant difference in percent agreement between genetic and biologist identification for younger- (73%) and older-juvenile (65%) fish (Test 1). The identification accuracy for this test might be explained by the size differences (total length and weight) between younger-juvenile white bass and younger-juvenile hybrid striped bass and size similarities between older-juvenile white bass and older-juvenile hybrid striped bass. If biologists have a preconceived notion that hybrid striped bass are larger than white bass, biologist should have better identification accuracy among age groups that have substantial size differences (as was the case for younger-juvenile *Morone* spp. included in this assessment, but not for older-juvenile *Morone* spp. included in this assessment).

Percent agreement between genetic and biologist identification was similar for younger-juvenile white bass (73%) and younger-juvenile hybrid striped bass (77%); however, percent agreement between genetic and biologist identification for older-juvenile white bass (62%) was less than older-juvenile hybrid striped bass (78%). The pattern of scores from test 2 and test 3 are likely explained by the size differences between younger-juvenile white bass and hybrid striped bass and lack of size differences between older-juvenile white bass and hybrid striped bass. Small differences in size between older-juvenile white bass and hybrid striped bass along with a frequent occurrence of horizontal broken lines on white bass was the likely cause of biologists identifying more fish as hybrid striped bass than were in the sample. Size differences generally exist between older-juvenile white bass and older-juvenile hybrid striped bass in Nebraska waterbodies (Hurley 2001); however, growth rates for *Morone* spp. appear slower in Harlan County Reservoir than other Nebraska Republican River reservoirs (personal observation). Biologists may have had greater identification accuracy for older-juvenile *Morone* spp. if they examined fish from a different reservoir where size differences existed.

Two commonly used characteristics to distinguish white bass from hybrid striped bass are the presence/absence of broken horizontal lines and the number of basihyal tooth patches on the tongue. For this study, mean percent agreement between biologist identification and genetic identification was negatively related to the importance that biologist put on using the presence/absence of broken horizontal lines as an identifying characteristic (Figure 2-4). After initial propagation of hybrid striped bass in 1965, the presence of broken horizontal lines was thought to be a distinguishing characteristic for hybrid striped bass from both parental species. Williams (1976) noted that this "broken line syndrome" caused fishermen to quickly deem any fish with the faintest hint of broken horizontal lines a hybrid striped bass. The majority of white bass collected from Johnson Lake and Harlan County Reservoir for this study had some degree of broken lines (personal observation). This could cause biologists that put greater emphasis on the presence or absence of horizontal broken lines as an identifying characteristic to assign a greater percentage of fish as hybrid striped bass. There was no trend between test scores and use of the characteristic number of basihyal tooth patches, which reemphasizes the point that this characteristic is unreliable in small fish (Waldman 1986).

Overall, identification accuracy for this test by biologists was 71%; however, 7 of the 32 biologists had an accuracy >80%. Biologists that examined >99 age-0 *Morone* during the past 12 months scored significantly higher than biologists that examined none (Figure 2-5); thus, recent experience identifying many individuals of *Morone* spp. is important to accurate identification. This likely indicates that identifying juvenile white bass and juvenile hybrid striped bass is a specialized skill, which some biologists that participated in this test have obtained by examining lots of fish and using multiple characteristics. Educating inexperienced biologists on which characteristics they should use to distinguish juvenile white bass from juvenile hybrid striped bass is needed to improve overall identification accuracy. Further research is needed to determine how much overall identification accuracy would increase and which education methods are the most effective.

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Table 2-1. Microsatellite loci, primer sequence and fluorescent label, and diagnostic allele size ranges (in base pairs, bp) for white bass and striped bass used in this study. All loci were from Couch et al. (2006).

Locus	Primer Sequence (5' to 3')	Allele Size Range (bp) White Bass	Allele Size Range (bp) Striped Bass
MSM1067	F-NED™-GAATCAAATCCCTGCTGTTATAATCT R-CTATCTGGACTTTATCCCTACGAGTGA	157-157	191-207
MSM1085	F-HEX-TCTTTTATTTTTAGCCTCATTCAGACTGAT R-CAGCAACAGATGATGGTCAAGTATG	106-106	138-170
MSM1137	F-NED™-GCAGGCAGGTTTTATCTAGGTTAG R-ACACTCTCTGCCCTTTGAGTTC	123-127	149-247
MSM1138	F-6FAM™-GGCCACCTTCAACTAACATACTTC R-CGCTCCGTGTCTTGTCTAAAT	162-170	184-194[a]
MSM1144	F-HEX-CAGTGGGAGGGAGAGTAAATA R-GCAGGATAGGAATCAGTCG	172-178	120-144

[a] several reference fish had an allele size equal to 166 bp. None of the fish in our assessment had this allele size.

Insights on *Morone* Classification

Name: ____________________________ Date: ______________

1. Describe what technique(s) you used to distinguish between white bass and hybrid striped bass. Be as specific as you can. Use the fish diagram below to sketch any characteristics that you used. Also, note if techniques changed with fish size or age.

____
____
____
____
____
____
____
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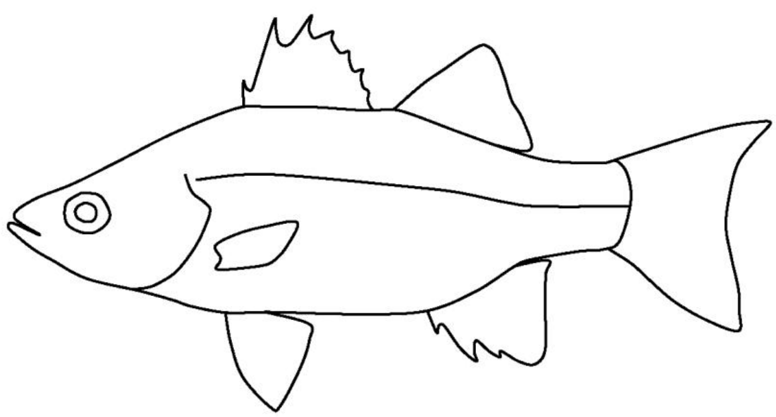
____



Continued on back

Figure 2-1. Questionnaire 1 given to biologists after completion of *Morone* spp. identification test to determine what characteristics biologists used to identify specimens.

2. What percentage of **age-0** *Morone* do you believe you **correctly** classified? ______%

3. Of the **age-0** *Morone* you **incorrectly** classified, which was more likely?

☐ a white bass incorrectly classified as a hybrid striped bass

☐ a hybrid striped bass incorrectly classified as a white bass

4. What percentage of **age-1** *Morone* do you believe you **correctly** classified? ______%

5. Of the **age-1** *Morone* you **incorrectly** classified, which was more likely?

☐ a white bass incorrectly classified as a hybrid striped bass

☐ a hybrid striped bass incorrectly classified as a white bass

6. How important do you believe is it for fishery biologists to correctly classify **age-0** *Morone*?

Not Important		Neutral		Very Important
①	②	③	④	⑤

7. How important do you believe is it for fishery biologists to correctly classify **age-1** *Morone*?

Not Important		Neutral		Very Important
①	②	③	④	⑤

8. What percentage of **age-0** *Morone* need to be correctly classified for the data to be useful to fishery biologist? ________%?

☐ Does not matter – data on age-0 *Morone* are never useful to fishery biologists.

9. What percentage of **age-1** *Morone* need to be correctly classified for the data to be useful to fishery biologist? ________%

☐ Does not matter – data on age-1 *Morone* are never useful to fishery biologists.

10. Please share any comments you wish:

____

____

____

Figure 2-1. continued.

Name: ___________________________ Date: ______________

1. Please indicate how important each of the following is to you when classifying **age-0** ***Morone***.

The presence/absence of broken horizontal lines:

Not Important		Somewhat Important		Very Important
①	②	③	④	⑤

The thickness or darkness of horizontal lines:

① ② ③ ④ ⑤

Overall body shape:

① ② ③ ④ ⑤

Number and shape of tongue patches:

① ② ③ ④ ⑤

The presence/absence of vertical bars (parr marks):

① ② ③ ④ ⑤

The size of the fish compared to other fish being sampled:

① ② ③ ④ ⑤

2. During the past 12 months (not including this survey), how many **age-0** ***Morone*** fish did you classify?

0 1-99 ≥ 100

3. During the past 12 months (not including this survey), how many **age-1** ***Morone*** fish did you classify?

0 1-99 ≥ 100

4. Are you currently pursuing a graduate degree? (Yes) (No)

If **yes**, which degree (e.g., B.S., M.S., Ph.D.)? ___________________

Continued on back

Figure 2-2. Questionnaire 2 developed based on results from questionnaire 1 (Figure 2-1) to determine if correlations existed between percent agreement of biologist and genetic identification with characteristics used by biologists during identification test and with biologists' experience and education.

If **no**, what is your highest degree? ___________________

How many years has it been since you acquired that degree? ___________

1. How many years of experience do you have classifying fish? _______________

2. How many years of experience do you have classifying fish from the family *Moronidae*? _______________

3. How did you learn to classify fish (e.g., classes, books, job experience)?
____
____

4. Are you an angler? (Yes) (No)

If **YES**, how often do you fish for ***Morone***?

Not Frequently		Somewhat Frequently		Very Frequently
①	②	③	④	⑤

5. What percentage of anglers do you think can classify age-1 or older ***Morone*** fish correctly? _____________

6. How important do you think is it for anglers to classify age-1 or older ***Morone*** fish correctly?

Not Important		Somewhat Important		Very Important
①	②	③	④	⑤

7. How frequent do you think hybrid striped bass are spawning in Nebraska reservoirs?

Not Frequently		Somewhat Frequently		Very Frequently
①	②	③	④	⑤

8. If hybrid striped bass are spawning in Nebraska reservoirs, how concerned should fishery biologists and NGPC be?

Not Concerned		Somewhat Concerned		Very concerned
①	②	③	④	⑤

Figure 2-2. continued.

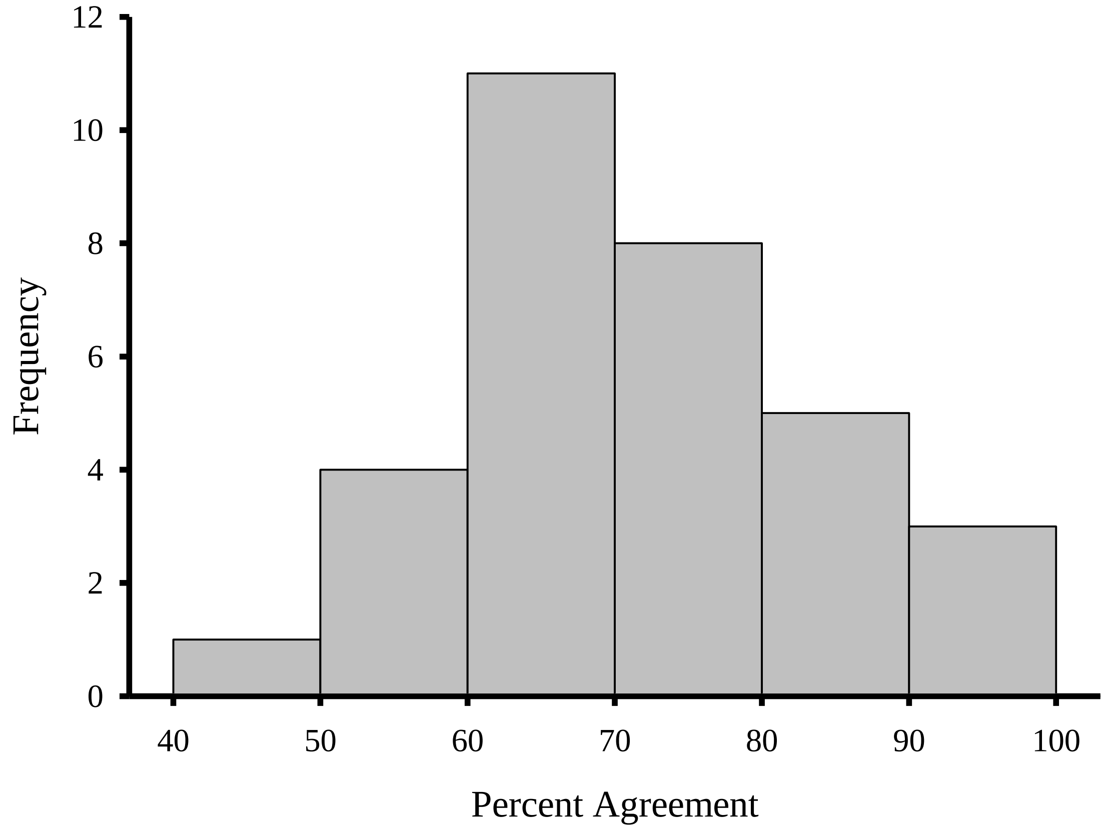


Figure 2-3. Distribution of fishery biologists scores on identification test. Score is percent agreement between biologist and genetic identification. Mean = 71%.

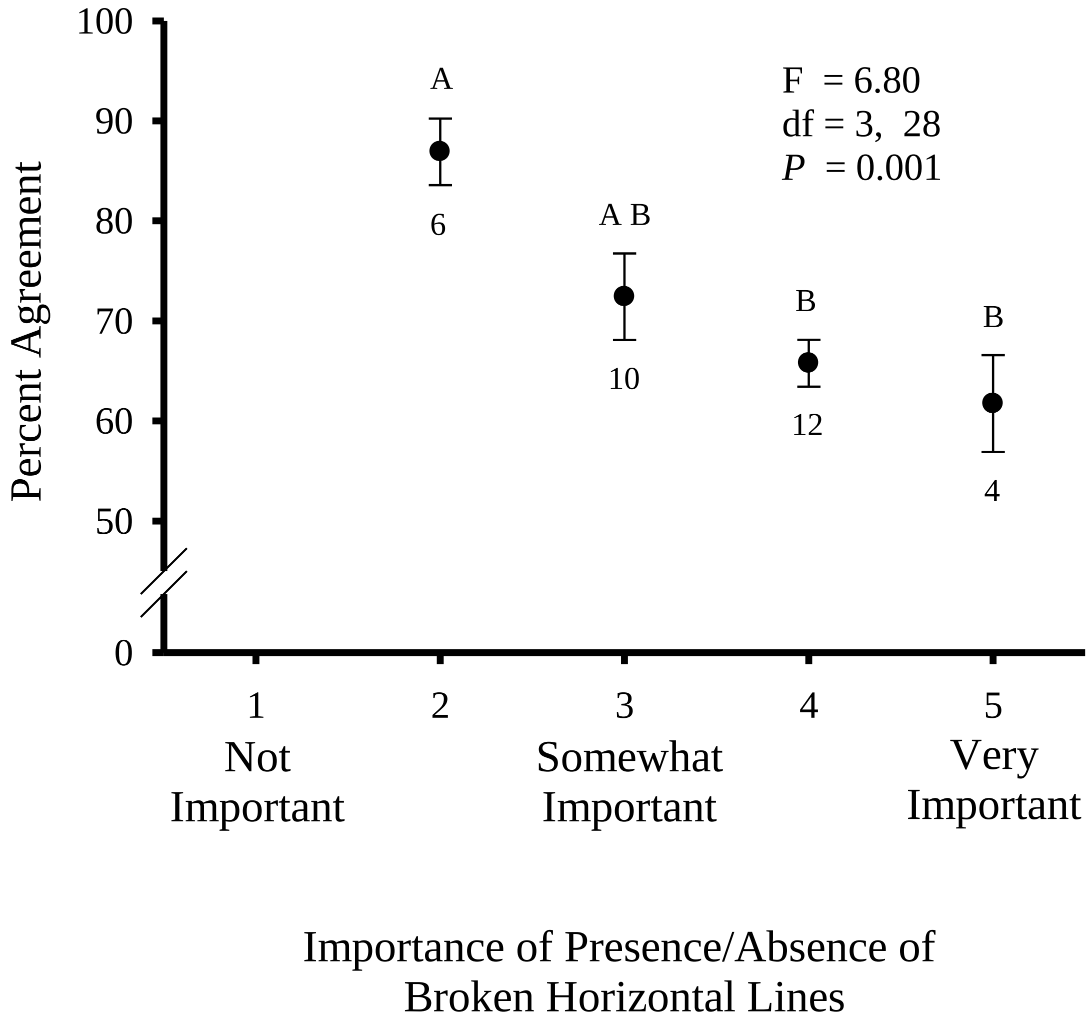


Figure 2-4. Mean ± SE percent agreement of biologist and genetic identification as a function of how important the use of presence/absence of broken horizontal lines was as a distinguishing characteristic for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Means with same capital letters above data points are not different (Tukey test, $\alpha = 0.05$). Numbers below data points represent sample size.

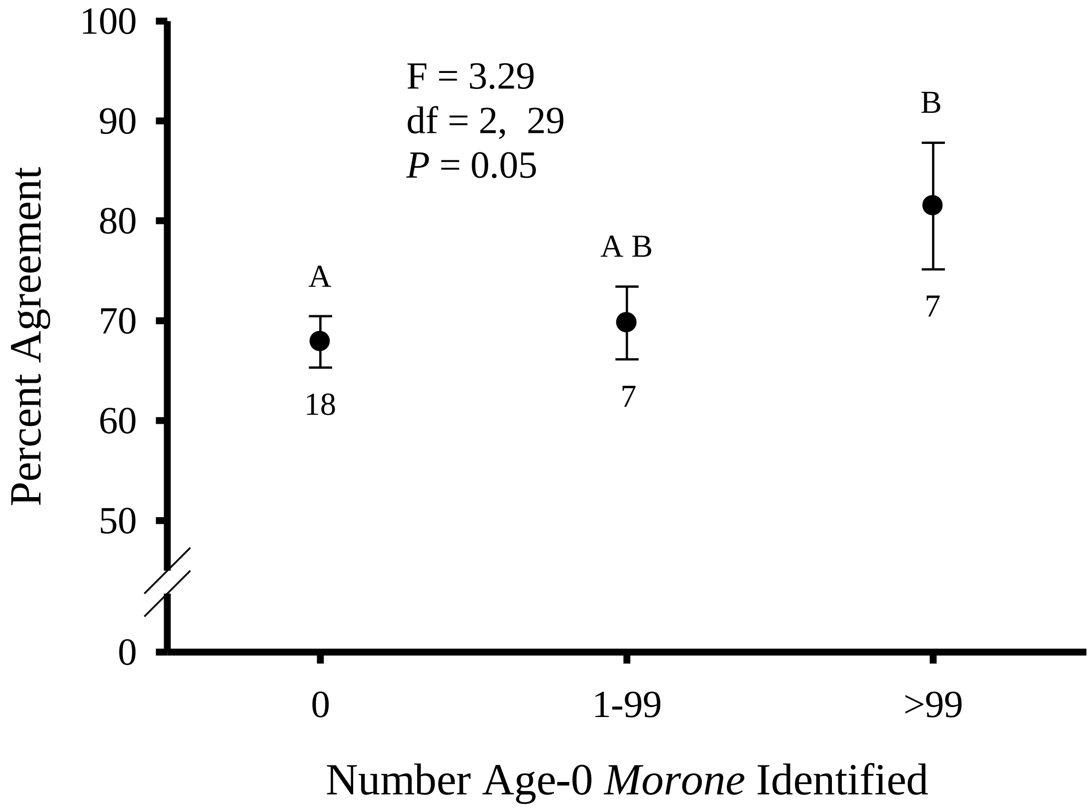


Figure 2-5. Mean ± SE percent agreement of biologist and genetic identification as a function of the number of age-0 *Morone* identified by each biologist during the past 12 months. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Means with same capital letters above data points are not different (Tukey test, $\alpha = 0.05$). Numbers below data points represent sample size.

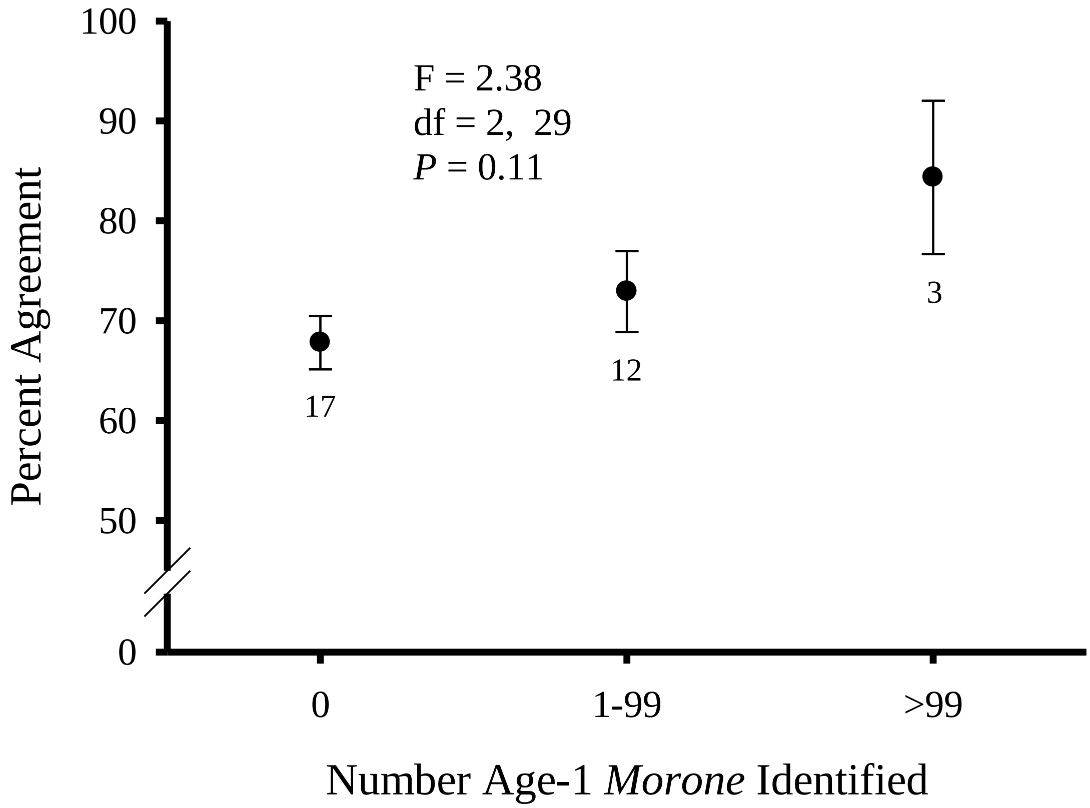


Figure 2-6. Mean ± SE percent agreement of biologist and genetic identification as a function of the number of age-1 *Morone* identified by each biologist during the past 12 months. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

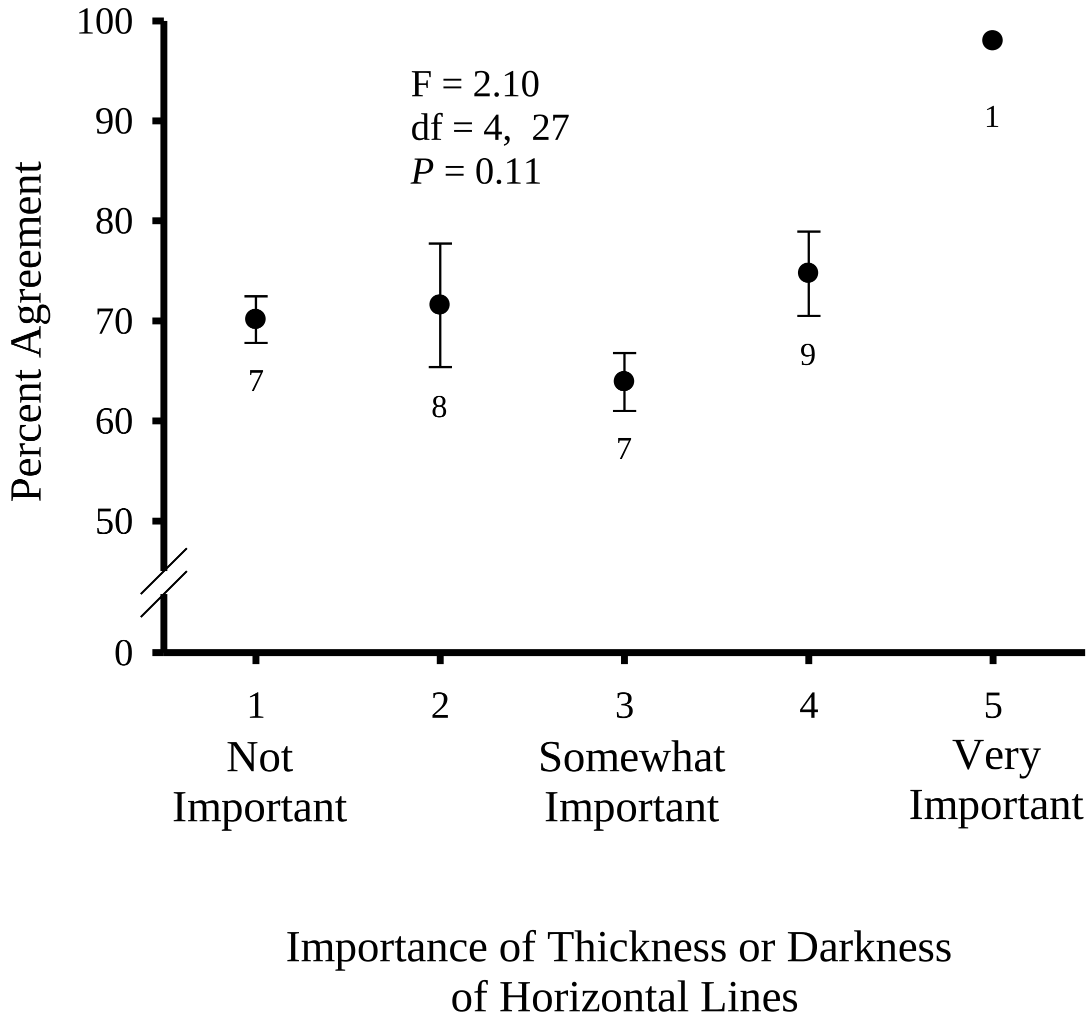


Figure 2-7. Mean ± SE percent agreement of biologist and genetic identification as a function of how important the use of thickness or darkness of horizontal lines was as a distinguishing characteristic for each biologist. No error bars shown ($n = 1$) for extremely important. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

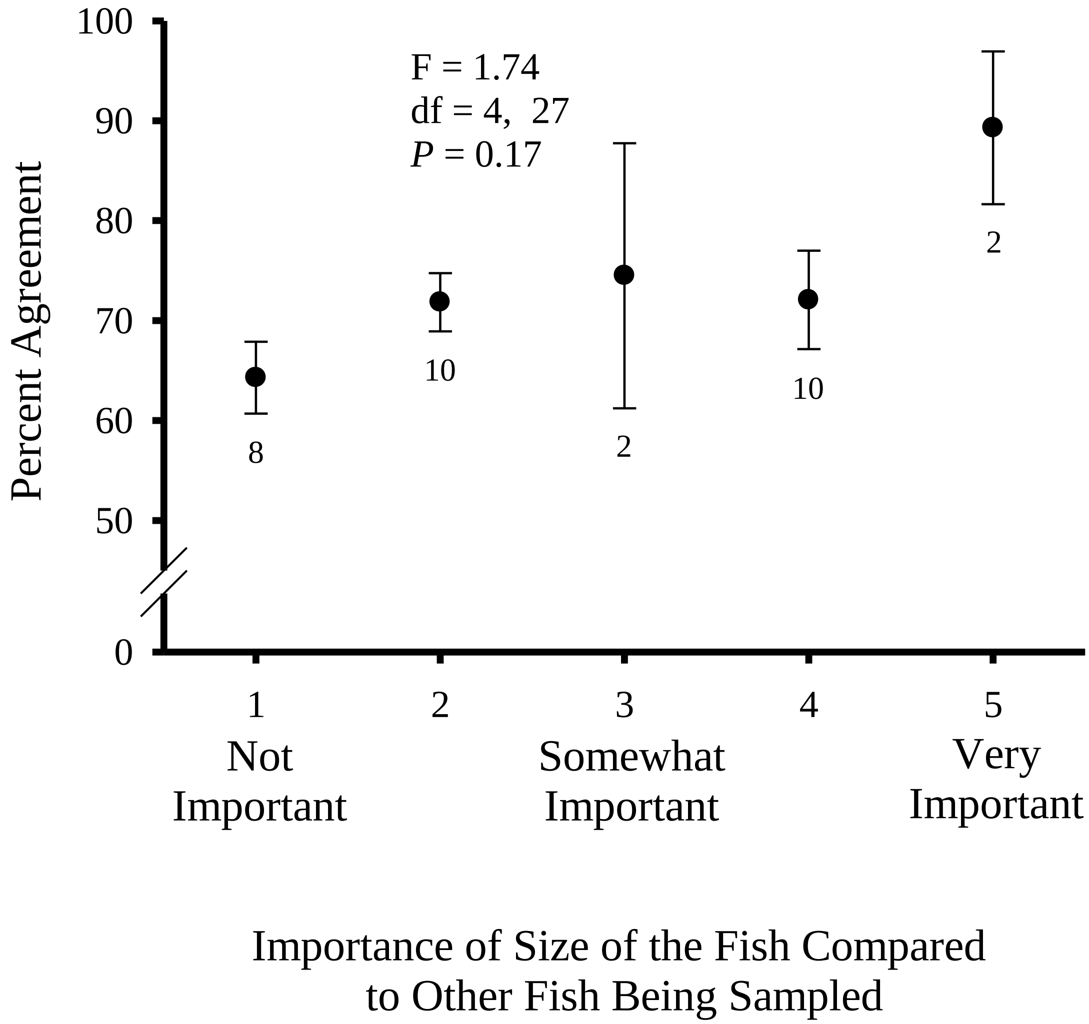


Figure 2-8. Mean ± SE percent agreement of biologist and genetic identification as a function of how important the use of size of fish compared to other fish being sampled was as a distinguishing characteristic for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

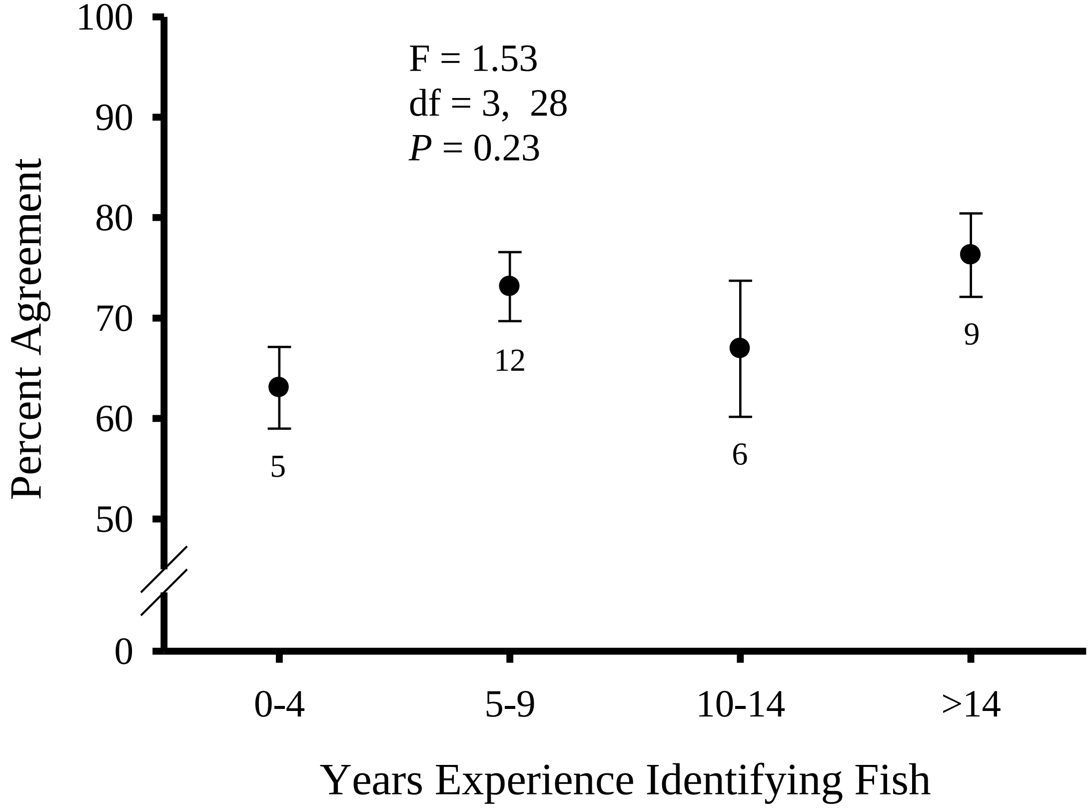


Figure 2-9. Mean ± SE percent agreement of biologist and genetic identification as a function of years experience identifying fish for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

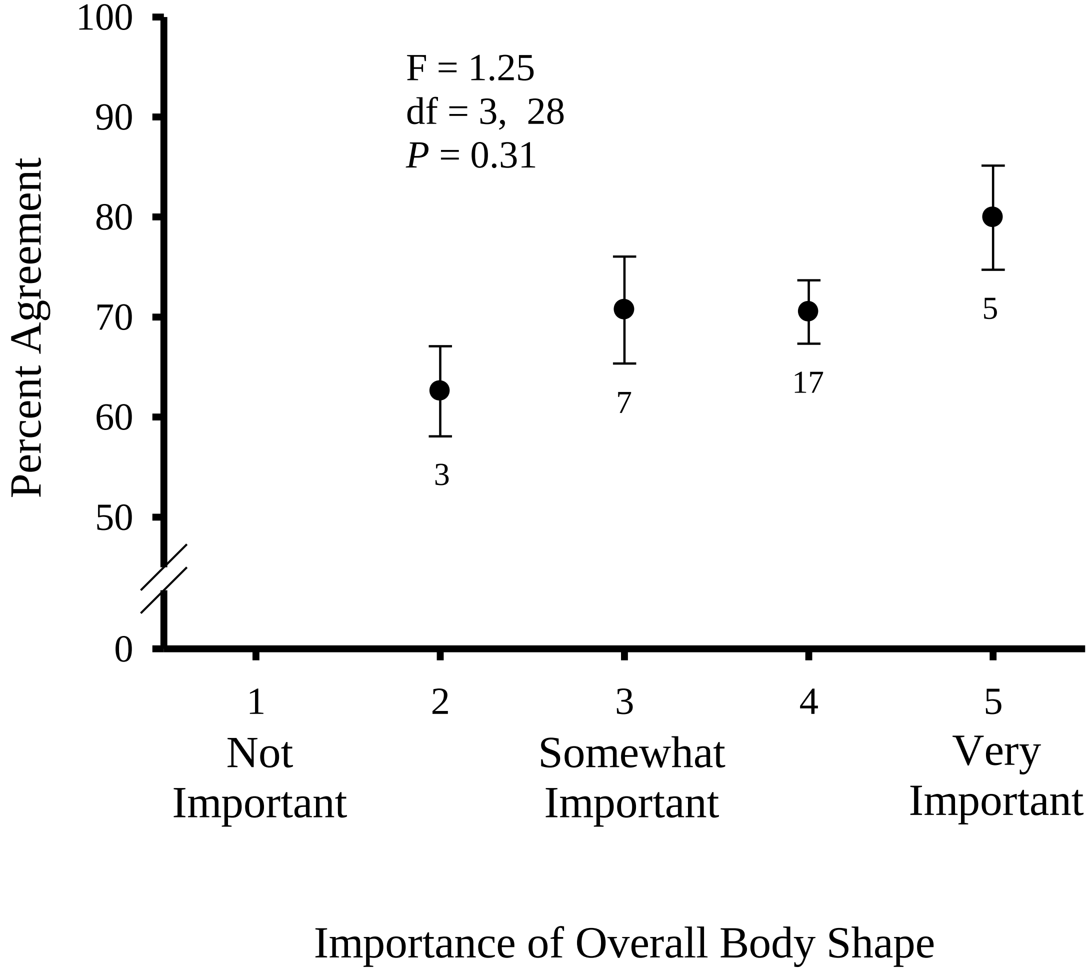


Figure 2-10. Mean ± SE percent agreement of biologist and genetic identification as a function of how important the use of overall body shape was as a distinguishing characteristic for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

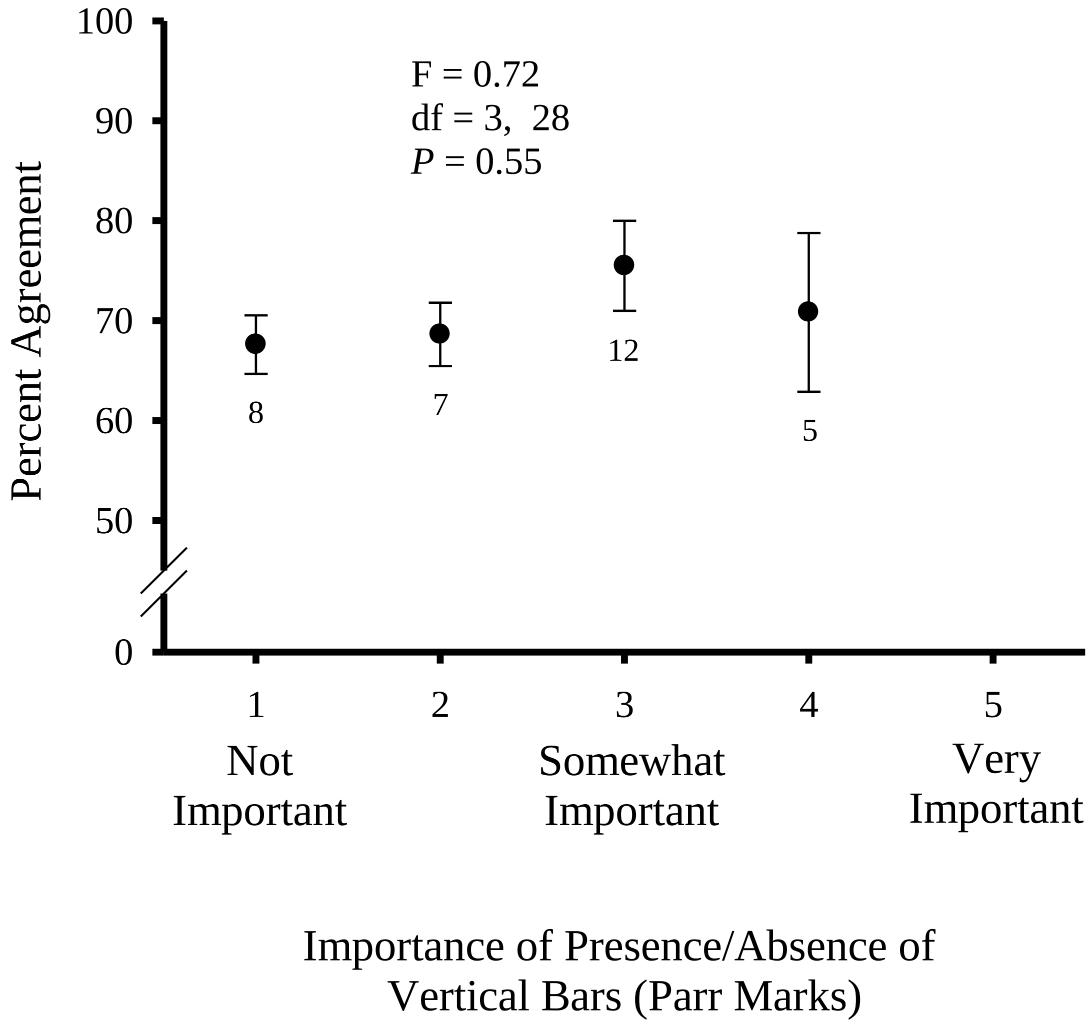


Figure 2-11. Mean ± SE percent agreement of biologist and genetic identification as a function of how important the use of presence/absence of vertical bars (parr marks) was as a distinguishing characteristic for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

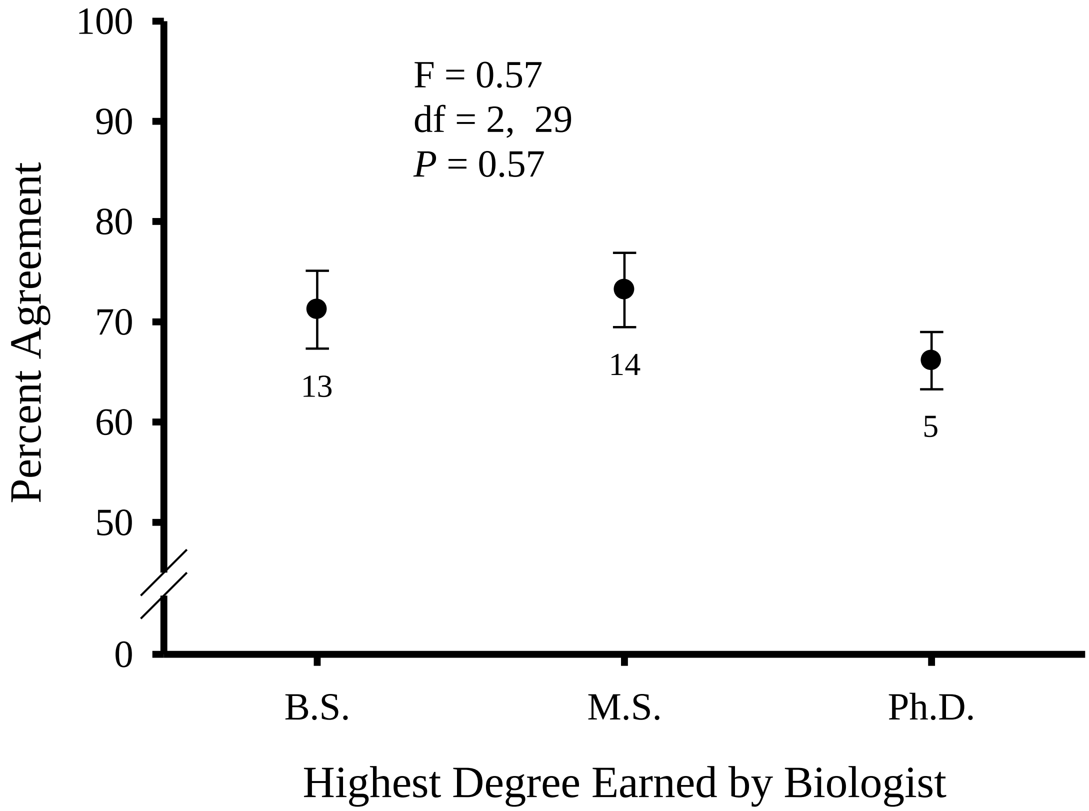


Figure 2-12. Mean ± SE percent agreement of biologist and genetic identification as a function of the highest degree earned for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

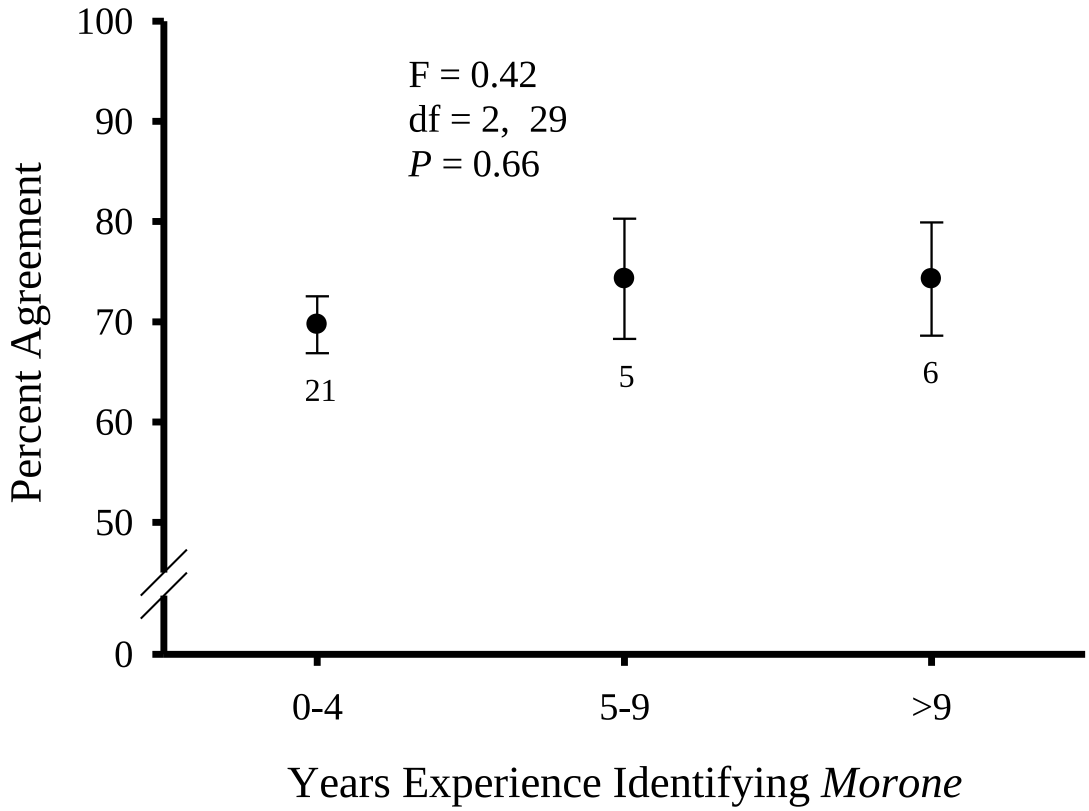


Figure 2-13. Mean ± SE percent agreement of biologist and genetic identification as a function of years experience identifying *Morone* for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

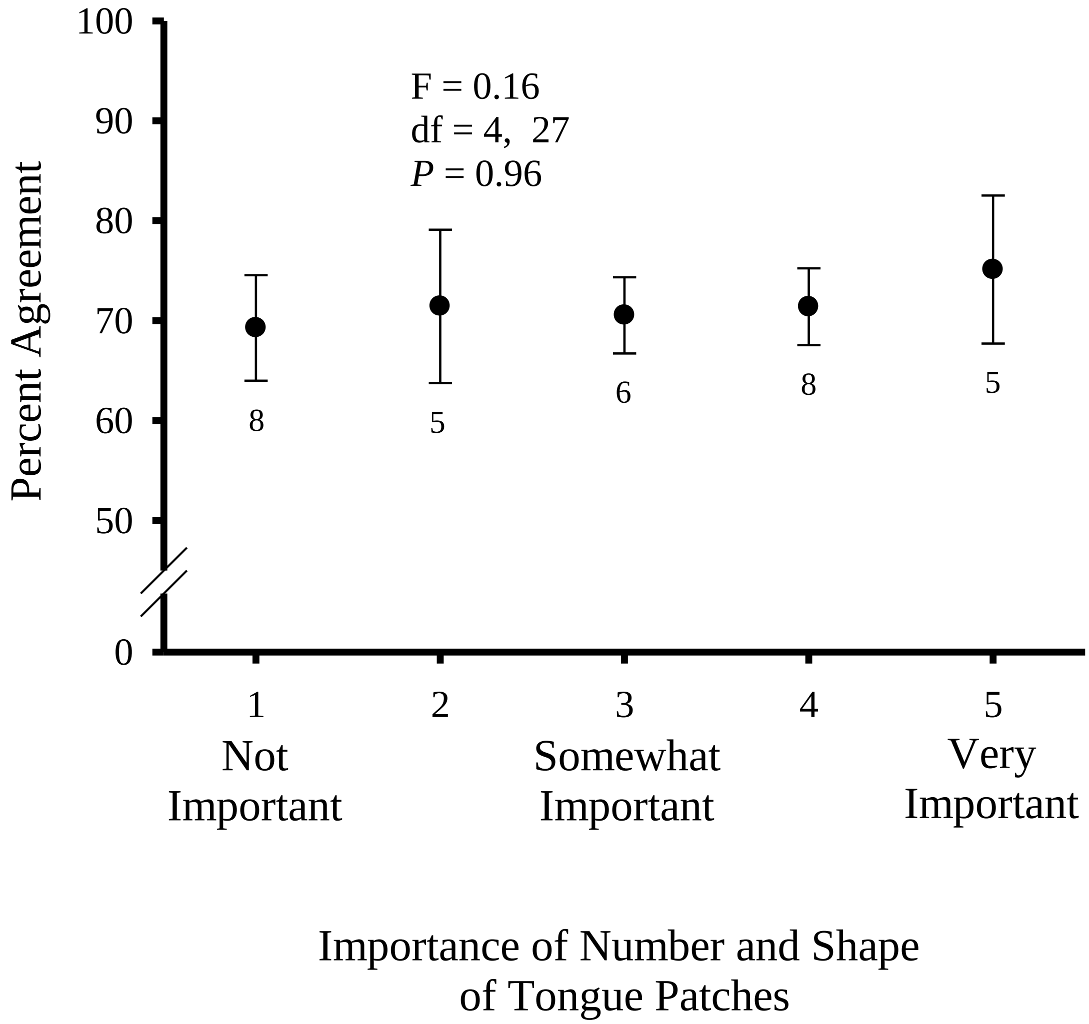


Figure 2-14. Mean ± SE percent agreement of biologist and genetic identification as a function of how important the use of number and shape of tongue patches was as a distinguishing characteristic for each biologist. Statistics are reported for general linear model (PROC GLM in SAS®) that was used to test for an overall effect. Numbers below data points represent sample size.

Chapter 3. Morphological differences between juvenile white bass and juvenile hybrid striped bass

Introduction

Hybrid striped bass *Morone saxatilis x chrysops*, also known as wipers, have been widely stocked throughout the range of both white bass *M. chrysops* and striped bass *M. saxatilis* since they were first produced in a hatchery by Robert E. Stevens in 1965 (Bishop 1968). The goals of initial stockings of hybrid striped bass were to establish populations of large, pelagic predators to take advantage of abundant forage species (e.g., gizzard shad *Dorosoma cepedianum*) (Ware 1975). Hybrid striped bass quickly became popular among management agencies for stocking because of the hybrid's tolerance to a wide range of water-quality conditions and fast early growth (Forshage et al. 1986). Hybrid striped bass are commonly targeted by recreational anglers because of their large size, aggressive fighting behavior, and palatable filets (Crawford et al. 1984).

Although hybrid striped bass stockings can benefit recreational fishing, these management actions can have adverse affects on fish populations. Prey similarities between stocked hybrid striped bass and other sport fish (e.g., walleye *Sander vitreus*, striped bass, white bass) can lead to interspecific competition for available resources (Bishop 1968; Ware 1975). Natural reproduction of hybrid striped bass (i.e., backcrosses) can lead to introgression of undesirable genes and production of deformed and undesirable progeny (Ware 1975). Identification difficulties of white bass and their hybrids can lead to confusion among biologists, law enforcement personnel and anglers when these fish species coexist within a given waterbody (Williams 1976).

Accurate identification of white bass, striped bass and their hybrids is essential when determining population abundances, especially when these fish are managed separately (Storey et al. 2000). The harvest of adult fish under different regulations makes it necessary for accurate identification by anglers, creel clerks, and conservation officers. Accurate identification of juvenile fish is important for biologists when determining year-class strength, a necessary component when examining recruitment variation (Harrell and Dean 1988).

Differences in morphology and meristics can be useful for field identification needs, including distinguishing species and their hybrids (Kennedy et al. 2009), distinguishing stunted and non-stunted fish (Chizinski et al. 2010), and distinguishing fish using different habitats (Svanbäck and Eklöv 2003). When examining fish morphology, it is important to account for allometric growth by distinguishing differences in shape from differences in size. Generally, examining juvenile fish or fish of similar sizes reduces the effect that allometric growth has on morphology.

Differences in morphology and meristics among white bass, striped bass and their hybrids have been well studied since the initial propagation of hybrid striped bass for stocking in recreational fisheries. Although hybrid striped bass retain characteristics of both parental species, they more closely resemble white bass (Kerby et al. 1971). Characteristics (e.g., basihyal tooth patches on the base of the tongue) that enable biologists to distinguish between white bass and striped bass may not be reliable for identifying their hybrids, especially in juvenile fish (Waldman 1986). Differences among *Morone* spp. in dentition (Bishop 1968; Williams 1976; Waldman 1986), meristic (Bishop 1968; Bayless 1968; Kerby 1979; Crawford et al. 1984; Harrell and Dean 1988; Storey et al. 2000) and morphometric (Williams 1976; Kerby 1980; Crawford et al. 1984; Harrell and Dean 1988; Muoneke et al. 1991; Storey et al. 2000) characteristics have been examined in prior studies. The majority of these studies reported differences between white bass and striped bass, and striped bass and hybrid striped bass; however, precision for distinguishing white bass from hybrid striped bass is generally low (Muoneke et al. 1991).

Although some differences have been identified as distinguishing characteristics between pure *Morone* spp. and their hybrids, there is a need for a simple technique to distinguish between juvenile white bass and juvenile hybrid striped bass. During a study to determine recruitment bottlenecks for white bass populations in Nebraska irrigation reservoirs, difficulties accurately identifying juvenile *Morone* spp. (Figure 3-1) confounded efforts to estimate year-class strength. The present study was designed to develop a technique to distinguish juvenile (age 0 and age 1) white bass from juvenile F_1 hybrid striped bass using morphological differences.

Study Area

Enders Reservoir

Enders Reservoir, located in southeastern Chase County, Nebraska, drains a watershed of 2,841 km^2 and covers 690 ha of surface area at conservation pool. Enders Dam was completed in 1951 impounding Frenchman Creek. Hybrid striped bass were first stocked in Enders Reservoir in 1993 and have since been stocked on an annual or biannual schedule (Tables 3-1 & 3-2); however, hybrid striped bass were last stocked in 2005 because they had poor condition and an extremely slow growth rate, causing a temporary suspension of future stockings.

Harlan County Reservoir

Harlan County Reservoir, located in Harlan County, Nebraska, drains a watershed of 18,554 km^2 and covers 5,362 ha of surface area at conservation pool. Harlan County Dam was completed in 1952 impounding the Republican River. Hybrid striped bass were first stocked in Harlan County Reservoir in 1988 and have been stocked on a tri-annual schedule since 2005 (Tables 3-1 & 3-2).

Harry D. Strunk Lake (Medicine Creek Reservoir)

Medicine Creek Reservoir, located in southeastern Frontier County, Nebraska, drains a watershed of 2,279 km^2 and covers 748 ha of surface area at conservation pool. Medicine Creek Dam was completed in 1949 impounding Medicine Creek. Hybrid striped bass were first stocked in Medicine Creek Reservoir in 1986 and have since been stocked on an annual or biannual schedule (Tables 3-1 & 3-2).

Hugh Butler Lake (Red Willow Reservoir)

Red Willow Reservoir, located in southwestern Frontier County, Nebraska, drains a watershed of 1,890 km^2 and covers 659 ha of surface area at conservation pool. Red Willow Dam was completed in 1962 impounding Red Willow Creek. Hybrid striped bass were first stocked in Red Willow Reservoir in 1986 and have since been stocked on an annual or biannual schedule (Tables 3-1 & 3-2).

Swanson Reservoir

Swanson Reservoir, located in Hitchcock County, Nebraska, drains a watershed of 22,403 km^2 and covers 2,012 ha of surface area at conservation pool. Trenton Dam was completed in 1953 impounding the Republican River. Hybrid striped bass were first stocked in Swanson Reservoir in 1992 and have since been stocked on an annual or biannual schedule (Tables 3-1 & 3-2).

Methods

Fish Collection

Morone spp. were collected during autumn 2008 and 2009 from Enders Reservoir, Harlan County Reservoir, Medicine Creek Reservoir, Red Willow Reservoir, and Swanson Reservoir with standard electrofishing gear using pulsed DC (Reynolds 1996). The goal was to collect 100 (50 age 0 and 50 age 1) fish from each reservoir each year; thus, three year classes of *Morone* spp. were sampled. Random sites were generated for each reservoir using ArcMap™ v. 9.3 (ESRI®, Inc. 2008) from shoreline layers created from Nebraska Game and Parks Commission Lake mapping program.

Each random site was sampled for a 100 m transect near shore at the vegetation line in water <3 m deep. Each transect was broken into 25 m sections and the first age-0 and first age-1 *Morone* spp. that was seen while sampling within each section was collected with no more than four age-0 and four age-1 *Morone* spp. collected from each transect. This protocol was enacted to help reduce bias by limiting the collection of multiple individuals from the same school of fish.

If we could not capture 50 age-1 *Morone* spp. from random sites in 50 attempts, each reservoir was broken into five sections of roughly equal shoreline length starting at the center of the dam. Taking into account age-1 *Morone* spp. already collected, we sampled each shoreline section until we had approximately ten fish from each section. While sampling, we collected fish at least 25-m apart and allowed at least 25 minutes to pass before collecting fish from the same area to reduce the chance of collecting fish from the same school.

In addition to *Morone* spp. collected from reservoirs, age-0 hybrid striped bass (2008 n = 43; 2009 n = 112) were collected from Calamus State Fish Hatchery, Nebraska to verify that pure F_1 hybrid striped bass were being stocked into Nebraska waterbodies. Calamus State Fish Hatchery received hybrid striped bass as fry from Byron State Fish Hatchery, Oklahoma. Fry were reared in earthen ponds at Calamus until collection.

Fish Processing

Once collected, fish were euthanized by cranial percussion and stored individually with an identification number in a plastic bag that was placed on ice. All fish were processed within 24 h of collection. Fish were weighed (g) and measured for total length (mm). Fish were laid on a black corkboard, with the spiny and soft dorsal fin, pectoral fin, and anal fin stretched out and pinned allowing for easier morphometric assessment (Figure 3-1). Digital photographs were taken of the left side of each unpreserved fish with an 8.0 megapixels camera with the flash from a distance of ~0.75 m. The fish identification number and a metric ruler were included in each picture, allowing us to match the photograph with genetic identification and to have a reference length in each photograph for digitizing.

After fish had been photographed, a fin clip, approximately 300 mm^2, was removed from the caudal (preferred) or pectoral fin with dissecting scissors and placed in a prelabeled plastic vial filled with ~1.5 mL of absolute non-denatured ethanol for preservation. The dissecting scissors was rinsed with non-denatured ethanol between each specimen to prevent genetic contamination of samples. Genetic analysis (methods described below) of moronid samples was performed by the Molecular Conservation Genetics Laboratory (MCGL) of the U.S. Geological Survey-Wisconsin Cooperative Fishery Research Unit at the University of Wisconsin-Stevens Point. Reference samples (n = 53) for pure white bass (Guadalupe River above Canyon Reservoir, Cormal County, Texas) and striped bass (Trinity River below Lake Livingston, San Jacinto and Polk County, Texas) were included in the genetic analysis.

Genetic Analysis

Microsatellite DNA was chosen as the molecular marker for this study. Microsatellites are tandem arrays of short repeating motifs (2-8 base pairs) and are dispersed throughout the genome (Hallerman 2003). Variation in number of repeat motifs form different length variants or alleles at a specific locus that can be used to determine parental species and identify hybrids.

Analysis consisted of microsatellite genotyping all samples at five loci determined to be diagnostic between striped bass and white bass (Table 3-3; Couch et al. 2006). In our analysis, diagnostic allele distributions were observed for all five loci. Therefore, we determined a pure species to be an individual with alleles consistent with that species for all sampled loci. Alternatively, an F_1 individual was heterozygous for an allele from both species at all sample loci and an F_x individual had some combination of both locus-specific genotype categories. The DNA extractions were performed on fin clips using a 96-well modification of the Promega Wizard® Genomic DNA purification kit (Promega Corp., Madison, WI). Extracted DNA was quantified using a Nanodrop® ND-1000 spectrophotometer (Nanodrop Tech., Wilmington, DE) and normalized to 20 ng/μL in 50 μL TLE (Tris-low-EDTA buffer) prior to genotyping.

Five microsatellite loci (Table 3-3) were analyzed in two multiplex polymerase chain reactions (PCR) developed by the MCGL according to the recommended approach of Henegariu et al. (1997). The forward primer of each primer set was labeled with a 5' fluorescent label for subsequent size fractionation on an automated DNA sequencer. Multiplex PCR A consisted of 10 μL PCR reactions consisting of 1X PCR Buffer B (ThermoFisher Scientific, Inc., Waltham, MA), 0.60 mM dNTPs (0.15 mM each dNTP), 1.30 mM $MgCl_2$, 0.12 μM each MSM 1137 primer, 0.16 μM each MSM 1138 primer, 0.20 μM each MSM 1144 primer, 0.50 U *Taq* DNA polymerase (New England Biolabs, Inc., Ipswich, MA), and ddH_2O to volume. Multiplex PCR B consisted of 1X PCR Buffer B, 0.6 mM dNTPs, 1.70 mM $MgCl_2$, 0.15 mM each MSM 1067 primer, 0.15 mM each MSM 1085 primer, 0.5 U *Taq* DNA polymerase and ddH_2O to volume. Temperature profiles consisted of an initial 2 min denaturation at 95^{o}C followed by 35 cycles of 95^{o}C/45s, 54^{o}C/30s (multiplex A) or 56^{o}C/30s (multiplex B), 72^{o}C/30s, a final

10 min extension at 72°C and an indefinite hold at 10°C. Amplified DNA was electrophoresed on an ABI 3730 DNA Analyzer (Applied Biosystems, Inc., Foster City, CA) with GeneFlo™ 625 (Chimerx, Inc., Milwaukee, WI) in-lane standard. Genotype data was collected using Genemapper® 4.0 (Applied Biosystems).

Age Verification

Otoliths were removed and stored in envelopes after fish had been photographed. Once in the laboratory, otoliths were placed individually in a black dish filled with water and examined using a dissecting microscope by two independent readers for age assignment. If there was disagreement of assigned ages between readers, otoliths were reexamined simultaneously by both readers. If the readers could not agree on an age, the specimen was excluded from further morphometric and genetic analysis.

Digitizing Photographs

Digital photographs were uploaded to a computer and digitized using tpsDig2© v. 2.15 (Rohlf 2010). A reference length was defined for each picture by measuring a length of 10 mm on the metric ruler at a magnification of 2.358. On each fish, landmark (n = 19) and semi-landmark (n = 15) points were indentified, which coincided with major points on the outline of the fish body, the midpoint of the eye, the base of the pectoral fin and the lateral line (Table 3-4, Figure 3-2). Semi-landmark points are defined as landmarks that depend on other points (Russo et al. 2008).

When this study was initiated, the focus was to use body morphology to distinguish juvenile white bass and juvenile hybrid striped bass. It was decided *a posteriori* to examine fin spine lengths; thus, fin spines were measured from photographs.

Landmark points (*n* = 10) were identified on the base and tip of the second, third, and fourth spines of the spiny dorsal fin, and the second and third spines of the anal fin. Some photographs were excluded from spine length analysis due to inability to place landmark points accurately.

Morphometric Analyses

Morphometric analysis followed the methods describe in Chizinski et al. (2010). Multivariate discriminant function analysis (DFA) on log-transformed interlandmarked distances between coordinates was used to assess differences between white bass and hybrid striped bass, and age-0 and age-1 fish. A set of 73 pair-wise distances among landmarks created a truss (Strauss and Bookstein 1982) that was used for morphological analyses. Size-free canonical variables were calculated by 1) finding the pooled within-group principal component; 2) regressing characters independently on the first within-group principal component, which characterized size variation from each truss character independently; 3) restoring the group centroids; and 4) using the regression residuals in the DFA (Strauss 1995). Additionally, a set of five pair-wise distances among landmarked spines (second spiny dorsal fin spine, third spiny dorsal fin spine, fourth spiny dorsal fin spine, second anal fin spine, and third anal fin spine) were used to assess differences between white bass and hybrid striped bass.

After determining if differences existed between *a priori* groupings, loadings (correlations between the size-free distances and the discriminant function scores) identified characteristics that contributed to morphological differences between groups. Variables with an absolute loading $\geq$0.30, which is commonly accepted in other studies using similar analysis, were assumed to significantly contribute to shape variation. Multivariate analysis of variance (MANOVA) was used to assess the morphological divergence ($\alpha = 0.05$) between groups in SAS® (SAS Institute Inc. 2010). Misclassification error rates were estimated using jackknifed size-free, log-transformed morphological characteristics. Discriminant function analysis and misclassification rate analysis utilized a Matlab® toolbox (Mathworks© 2010) in Matlab® (v. 7.7).

Body-Length Measurement Analyses

After conducting the truss analysis, we investigated whether individual body measurements between easily identifiable landmark points (e.g., origin of soft dorsal fin base, end of anal fin base) that substantially (|loading value| >0.30) contributed to the separation along DFA axis 1 could be used as a simpler approach to distinguish between taxonomic groups (i.e., white bass and hybrid striped bass). We screened individual body measurements using an analysis of covariance (ANCOVA) to determine if the interaction (i.e., taxonomic group and standard length) was significantly different (R© v. 2.12; R© Development Core Team 2008). Individual body measurements that were significantly different between taxonomic groups were then used in a logistic regression to determine the reclassification accuracy (R© v. 2.12; R© Development Core Team 2008). Ratios (standard length/body measurement length) were calculated using each measurement for both taxonomic groups.

Results

Fish Sampling

A total of 875 (*n* = 518 age 0, *n* = 336 age 1, *n* = 21 age 2) *Morone* spp. was collected from study reservoirs and a total of 166 age-0 *Morone* spp. was collected from Calamus State Fish Hatchery for morphological analysis. The target goal of 100 fish from each reservoir was not met due to adverse weather conditions and weak *Morone* spp. year classes. Among the fish collected from reservoirs, at least one locus was amplified for 863 fish. Out of 863, 859 fish were genetically identified as being either white bass (*n* = 806) or F_1 hybrid striped bass (*n* = 53), and 4 fish were genetically identified as F_x hybrid striped bass. Of the 4 fish genetically identified as F_x hybrid striped bass, 2 fish from Harlan County Reservoir and 1 fish from Swanson Reservoir exhibited alleles representative of white bass and F_1 hybrid striped bass, and 1 fish from Red Willow Reservoir exhibited alleles representative of white bass, striped bass and F_1 hybrid striped bass. These four fish were excluded from morphometric analysis. Among the fish collected from Calamus State Fish Hatchery, at least one locus was amplified for 164 fish. Out of 164, 159 fish were genetically identified as F_1 hybrid striped bass and 5 fish were genetically identified as F_x hybrid striped bass. Of the 5 fish genetically identified as F_x hybrid striped bass, 4 fish exhibited alleles representative of white bass and F_1 hybrid striped bass, and 1 fish exhibited alleles representative of striped bass and F_1 hybrid striped bass. These 5 fish were excluded from morphometric analysis.

Morphometric Analyses

Fish were excluded from morphometric analysis if poor picture quality prevented precise placement of landmark points (*n* = 117; 12 white bass, 105 hybrid striped bass), if photographs were accidently deleted (*n* = 27; 26 white bass, 1 hybrid striped bass), if fish age was >1 (*n* = 21; 21 white bass), or if fish were highly influential (>7 standard deviation from the mean) data points (*n* = 4; 2 white bass, 2 hybrid striped bass). In total, photographs were digitized for 741 white bass and 100 hybrid striped bass (Table 3-5). Among the white bass, there were 468 age-0 and 273 age-1 fish. Among the hybrid striped bass, there were 71 age-0 and 29 age-1 fish.

Bivariate plots of canonical loadings of morphometric distances from the discriminant function analysis revealed distinct differences in morphology between juvenile white bass and hybrid striped bass (Figure 3-3). The separation between white bass and hybrid striped bass morphotypes occurred along the first discriminant axis (axis 1; Figure 3-3), which explained 73.9% of the variation in morphological distances. Distances that significantly contributed to shape variation that tended to be longer in white bass were associated with body depth between the spiny dorsal fin and lateral line, the anal fin and lateral line, and in the caudal peduncle region, whereas distances that tended to be longer in hybrid striped bass were associated with the features in the head region and lengths in the midsection of the fish (Figure 3-4). Loading values were greatest for distance from origin of anal fin base (landmark 25) to lateral line (landmark 41), and for distance from base of fourth anal fin ray (landmark 20) to lateral line (landmark 41) (Table 3-6).

The separation between age-0 and age-1 fish occurred along the second discriminant axis (axis 2; Figure 3-3), which explained 21.3% of the variation in morphological distances. Distances that significantly contributed to shape variation that tended to be longer in age-0 fish were associated with the caudal peduncle and head regions, whereas distances that tended to be longer in age-1 fish were associated with body length around the anterior region of the dorsal fin, and body depth between the dorsal fin and lateral line (Figure 3-5). Loading values were greatest for distance from origin of spiny dorsal fin base (landmark 5) to base of sixth spiny dorsal fin spine (landmark 10), and for distance from tip of snout (landmark 1) to center of eye (landmark 30) (Table 3-6).

There were morphological differences for the interaction taxonomic group x age (MANOVA, F = 23.18; df = 2, 836; P = <0.001; Table 3-7). Taxonomic group demonstrated the greatest morphological separation; no white bass were incorrectly reclassified as hybrid striped bass, few (n = 3 of 71) age-0 hybrid striped bass were incorrectly reclassified as white bass, and no age-1 hybrid striped bass were incorrectly reclassified as white bass (Table 3-8). The successful reclassification excluding age (100% and 97% for white bass and hybrid striped bass, respectively; Table 3-8) emphasized the clear morphological discrimination between juvenile white bass and juvenile hybrid striped bass.

Body-Length Measurement Analyses

Of the 841 fish used for morphometric analysis, 233 fish were excluded from body length measurement analysis due to low precision placing landmark points to measure spine length. In total, photographs were digitized for body-length measurements for 537 white bass and 71 hybrid striped bass. Among the white bass, there were 362 age-0 and 175 age-1 fish. Among the hybrid striped bass, there were 43 age-0 and 28 age-1 fish.

There were length differences (P = <0.001) between taxonomic groups for distance from fourth anal fin ray base to origin of anal fin base (Table 3-9; Figure 3-6), distance from origin of soft dorsal fin base to origin of anal fin base (Table 3-9; Figure 3-7), depth of caudal peduncle (Table 3-9; Figure 3-8), distance from end of soft dorsal fin base to end of anal fin base (Table 3-9; Figure 3-9), third anal fin spine (Table 3-9; Figure 3-10), and second anal fin spine (Table 3-9; Figure 3-11). Lengths for these distances tended to be longer in white bass. There were no length differences (P > 0.70) between taxonomic groups for second dorsal fin spine (Table 3-9; Figure 3-12), third dorsal fin spine (Table 3-9; Figure 3-13), and fourth dorsal fin spine (Table 3-9; Figure 3-14). The reclassification accuracy (98.9%) was greatest when using the measurement depth of caudal peduncle as a function of standard length (Table 3-10). The ratio that best reclassified collected fish to taxonomic group for standard length to caudal peduncle depth was 7.30 (Table 3-11).

Discussion

During this study, nine fish were excluded from morphometric analysis due to suspicion that they were later generation (i.e., F_x or F_2) hybrid striped bass. Of the nine suspect backcrosses, four were collected from the study reservoirs. These fish were collected from year classes that had received hybrid striped bass stockings; therefore, it is unknown whether these fish were naturally produced in the reservoir. One age-1 fish collected from Red Willow Reservoir in 2008 exhibited a combination of locus-specific genotypes consistent with white bass, striped bass, and hybrid striped bass; results typical of F_2 or backcross (F_x) hybrids. If these F_x hybrid striped bass were naturally produced in the study reservoirs, it would indicate that spawning by F_1 hybrid striped bass is occurring; however, the low incidence (0.41%) of later generation *Morone* hybrids in our sample indicates that recruitment of these fish into the population is very low. The percentage of backcrosses from our study were less than findings by Avise and Van Den Avyle (1984) and Storey et al. (2000) who determined 1.0% and 1.8% of sampled fish were F_x hybrid striped bass.

Juvenile white bass and hybrid striped bass collected during this study differed noticeably in morphology. Hybrids generally display intermediate characteristics of their parental species and results from this study confirm this. Striped bass have a larger head (Williams 1976) and a slender body shape (Pflieger 1997) compared to white bass. Therefore, it was not surprising the head region and length in midsection were larger in hybrid striped bass than white bass.

Morphometric analysis for this study revealed longer distances between the lateral line and origin of spiny dorsal fin in white bass, consistent with a higher-arching back or “hump” that is commonly mentioned as a characteristic of the white bass (Pflieger 1997). Muoneke et al. (1991) reported that the distance between the anterior of the anal fin and the posterior of the second dorsal fin was greater in white bass than hybrid striped bass. Results from the current study were similar, with distance from the lateral line to the base of anal fin greater for white bass than hybrid striped bass. Our analysis also indicated greater caudal peduncle depth for white bass than hybrid striped bass. This differs from Muoneke et al. (1991), who did not indicate caudal peduncle depth as an important morphometric character for their study.

When examining fish morphology, deciphering between fish shape and size can be difficult, especially when fish exhibit allometric growth. If resources are available, fish exhibiting allometric growth have greater growth in fleshly structures than bony structures as size increases (Ricker 1975). Previous studies that examined morphology of *Morone* spp. documented the importance of removing allometric variation within populations. The juvenile fish examined in this study ranged in total length from 66-347 mm and these fish likely exhibited allometric growth. Genetically identified white bass and hybrid striped bass were grouped by age before morphometric analysis, thereby enabling the separation of taxonomic-group variation from age-group variation (axis 1 compared to axis 2).

Small fish need to develop in a way to maximize their ability to catch and eat prey and their ability to avoid predators. The variation in axis 2 between age-0 and age-1 *Morone* spp. from this study indicated differences in head and caudal peduncle size (larger for age 0), and differences in size between the lateral line and origin of the spiny dorsal fin (larger for age 1). The early development of the head region likely enables juvenile *Morone* spp. a quicker transition to piscivory and increases the range of prey size that they can consume. Sutton and Ney (2001) reported that differences in growth for age-0 striped bass were attributed to size-dependent differences in prey consumption and diet quality in Smith Mountain Lake, Virginia; larger age-0 striped bass were strict piscivores and consumed alewives *Alosa pseudoharengus*, whereas smaller age-0 fish consumed zooplankton, aquatic insects, and small cyprinids. The early development of the tail region likely improves swimming capability, which assists in the capture of prey and in avoidance of predation (Fisher and Hogan 2007). The greater size in fleshy structure below the dorsal fin for age-1 fish likely indicates the body area that exhibits the fastest growth as fish develop from age 0 to age 1.

Classification error for *Morone* groups (i.e., age-0 white bass, age-1 white bass, age-0 hybrid striped bass, age-1 hybrid striped bass) was low (<6%). The goal of this study was to use morphology to distinguish between white bass and hybrid striped bass, not between age-0 and age-1 fish. When classification error by age is removed by summing cross-validation percentages for the correct species identified, the error was low (<0.01%). The error associated with morphological difference by age emphasizes the importance of age validation (Beamish and McFarlane 1983) and an independent technique (e.g., otoliths, scales) to assign fish age. Harrell and Dean (1988) reported 83% accuracy in distinguishing pure *Morone* spp. and their hybrids, and Muoneke et al. (1991) reported 80% accuracy distinguishing white bass from hybrid striped bass. Morphological classification of juvenile white bass and juvenile hybrid striped bass completed in this study increased resolution to 99.6%.

Quantifying body morphology to distinguish juvenile white bass and juvenile hybrid striped bass using the truss analysis described above can be time consuming. Assessing body and fin-spine length differences uses a much simpler technique to distinguish between juvenile white bass and juvenile hybrid striped bass. All body length measurements separated juvenile white bass from juvenile hybrid striped bass, with depth of caudal peduncle as a function of standard length having the greatest reclassification accuracy (98.9%). Second anal spine length was longer for juvenile white bass than juvenile hybrid striped bass, which supports previous findings by Kerby (1980) and Muoneke et al. (1991). In addition, the third anal spine length was longer for juvenile white bass than juvenile hybrid striped bass for fish collected in this study.

The accurate reclassification using the depth of caudal peduncle provides biologists a simple technique to distinguish between juvenile white bass and juvenile hybrid striped bass. Standard length (mm) and depth of caudal peduncle (mm) can easily be measured with calipers by biologists in the field. Biologists would determine classification for collected specimens by visually plotting measurements (Figure 3-8) to match collected specimens to taxonomic group or by comparing collected specimens to the ratio of depth of caudal peduncle to standard length. If the standard length divided by the caudal peduncle depth is $\leq$7.30, the fish should be classified as a white bass; otherwise, the fish should be classified as a hybrid striped bass. The addition of recording these two measurements during sampling efforts would minimally increase sampling time; however, the increased identification accuracy for juvenile white bass and juvenile hybrid striped bass would improve the quality of data.

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Table 3-1. Number of hybrid striped bass and white bass stocked in study reservoirs during 1986-2009.

	Hybrid striped bass					White bass
Year	Enders	Harlan	Medicine Creek	Red Willow	Swanson	Harlan
1986			29,152[a]	27,152[a]		
1987			0	150,000[b]		
1988		80,642[a]	400,000[b]	0		
1989		1,300[a]	0	0		
1990		3,004,000[b]	800,000[b]	500,000[b]		
1991		0	0	1,200[a]		
1992		1,500,000[b]	618,616[d]	618,140[d]	34,975[a]	
1993	14,000[a]	16,401[a]	0	0	300,000[b]	1,500,000[b]
1994	0	6,475,000[b]	18,500[a]	15,500[a]	26,420[a]	0
1995	2,040[a]	0	15,700[a]	0	0	0
1996	0	1,500,000[a]	39,500[a]	15,500[a]	25,400[a]	0
1997	14,888[a]	67,510[a]	19,540[a]	0	0	0
1998	0	950,000[b]	0	13,500[a]	25,750[a]	0
1999	30,820[a]	67,634[a]	14[c]	18,434[a]	0	0
2000	0	24,175[a]	25,690[a]	0	30,090[a]	0
2001	14,859[a]	0	21,146[a]	21,483[a]	25,146[a]	0
2002	0	0	34,100[a]	17,600[a]	30,800[a]	0
2003	8,716[a]	0	0	0	0	0
2004	7,048[a]	0	4,000[a]	5,500[a]	4,551[a]	0
2005	11,280[a]	16,000[a]	6,625[a]	9,130[a]	17,820[a]	0
2006	0	0	6,625[a]	0	14,080[a]	0
2007	0	0	6,625[a]	16,300[a]	11,740[a]	0
2008	0	70,000[a]	6,625[a]	5,750[a]	11,740[a]	0
2009	0	0	0	0	0	0

[a] fingerling.
[b] fry.
[c] adult.
[d] 97% fry; 3% fingerling.

Table 3-2. Rate (number per ha [conservation pool]) of hybrid striped bass and white bass stocked in study reservoirs during 1986-2009.

	Hybrid striped bass					White bass
Year	Enders	Harlan	Medicine Creek	Red Willow	Swanson	Harlan
1986			39[a]	41[a]		
1987			0	228[b]		
1988		15[a]	535[b]	0		
1989		0	0	0		
1990		560[b]	1,070[b]	759[b]		
1991		0	0	2[a]		
1992		280[b]	802[d]	910[d]	17[a]	
1993	20[a]	3	0	0	149[b]	280[b]
1994	0	1,208[b]	25[a]	24[a]	13[a]	0
1995	3[a]	0	21[a]	0	0	0
1996	0	280[a]	53[a]	24[a]	13[a]	0
1997	22[a]	13[a]	26[a]	0	0	0
1998	0	177[b]	0	20[a]	13[a]	0
1999	45[a]	13[a]	0.02[c]	28[a]	0	0
2000	0	5[a]	34[a]	0	15[a]	0
2001	22[a]	0	28[a]	33[a]	12[a]	0
2002	0	0	46[a]	27[a]	15[a]	0
2003	13[a]	0	0	0	0	0
2004	10[a]	0	5[a]	8[a]	2[a]	0
2005	16[a]	3[a]	9[a]	14[a]	9[a]	0
2006	0	0	9[a]	0	7[a]	0
2007	0	0	9[a]	25[a]	6[a]	0
2008	0	13[a]	9[a]	9[a]	6[a]	0
2009	0	0	0	0	0	0

[a] fingerling.
[b] fry.
[c] adult.
[d] 97% fry; 3% fingerling.

Table 3-3. Microsatellite loci, primer sequence and fluorescent label, and diagnostic allele size ranges (in base pairs, bp) for white bass and striped bass used in this study. All loci were from Couch et al. (2006).

Locus	Primer Sequence (5' to 3')	Allele Size Range (bp) White Bass	Allele Size Range (bp) Striped Bass
MSM1067	F-NED™-GAATCAAATCCCTGCTGTTATAATCT R-CTATCTGGACTTTATCCCTACGAGTGA	157-157	191-207
MSM1085	F-HEX-TCTTTTATTTTTAGCCTCATTCAGACTGAT R-CAGCAACAGATGATGGTCAAGTATG	106-106	138-170
MSM1137	F-NED™-GCAGGCAGGTTTTATCTAGGTTAG R-ACACTCTCTGCCCTTTGAGTTC	123-127	149-247
MSM1138	F-6FAM™-GGCCACCTTCAACTAACATACTTC R-CGCTCCGTGTCTTGTCTAAAT	162-170	184-194[a]
MSM1144	F-HEX-CAGTGGGAGGGAGAGTAAATA R-GCAGGATAGGAATCAGTCG	172-178	120-144

[a] several reference fish had an allele size equal to 166 bp. None of the fish in our assessment had this allele size.

Table 3-4. Number and location of landmark points (Figure 3-2).

Number	Location
1	Tip of snout
2	Midpoint between 1 and 3
3	Inflection point on head
4	Midpoint between 3 and 5
5	Origin of spiny dorsal fin base
6	Base of 2^{nd} spiny dorsal fin spine
7	Tip of 2^{nd} spiny dorsal fin spine
8	Base of 3^{rd} spiny dorsal fin spine
9	Tip of 3^{rd} spiny dorsal fin spine
10	Base of 6^{th} spiny dorsal fin spine
11	Origin of soft dorsal fin base
12	Base of 6^{th} soft dorsal fin ray
13	End of soft dorsal fin base
14	Midpoint between 14 and 16
15	Dorsal origin of caudal fin base
16	Convergence of caudal fin base and lateral line
17	Ventral origin of caudal fin base
18	Midpoint between 18 and 20
19	End of anal fin base
20	Base of 4^{th} anal fin ray
21	Base of 3^{rd} anal fin spine
22	Tip of 3^{rd} anal fin spine
23	Base of 2^{nd} anal fin spine
24	Tip of 2^{nd} anal fin spine
25	Origin of anal fin base
26	Midpoint between 26 and 28
27	Origin of pelvic fin base
28	Convergence of operculum and underside of fish
29	Most distant point of operculum from tip of snout
30	Center of eye
31	End of pectoral fin base
32	Origin of pectoral fin base
33	Point on lateral line between 5 and 28
34	Point on lateral line between 12 and 26
35	Point on lateral line between 14 and 20
36	Midpoint between 3 and 4
37	Midpoint between 4 and 5
38	Midpoint between 28 and 29
39	Midpoint between 1 and 29
40	Midpoint between 34 and 35 on lateral line
41	Midpoint between 35 and 36 on lateral line
42	Midpoint on lateral line between 17 and 36
43	Base of 4^{th} spiny dorsal fin spine
44	Tip of 4^{th} spiny dorsal fin spine

Table 3-5. Descriptive statistics of white bass (WHB) and hybrid striped bass (HSB) included in morphometric analysis. Fish were collected during 2008-2009 from either the five Nebraska reservoirs within the Republican River basin or provided by the Calamus State Fish Hatchery.

Location	Genetically Identified Taxonomic Group	Age	*n*	Minimum Total Length (mm)	Maximum Total Length (mm)	Mean ± SE Total Length (mm)	Minimum Weight (g)	Maximum Weight (g)	Mean ± SE Weight (g)
Enders	WHB	0	105	86	200	134.2 ± 2.4	6.5	113.6	33.90 ± 2.08
		1	57	205	275	227.4 ± 1.8	89.4	268.2	140.77 ± 4.52
	HSB	0	0						
		1	0						
Harlan County	WHB	0	72	121	170	145.6 ± 1.4	22.5	58.1	38.94 ± 1.02
		1	55	179	210	192.4 ± 0.8	55.3	93.0	75.60 ± 0.92
	HSB	0	12	142	175	160.9 ± 2.8	34.8	59.5	47.90 ± 2.03
		1	12	217	245	228.0 ± 3.0	90.0	151.1	112.43 ± 5.60
Medicine Creek	WHB	0	94	82	150	119.9 ± 1.4	6.2	44.2	22.03 ± 0.81
		1	105	189	285	221.6 ± 1.4	77.0	241.1	136.35 ± 3.14
	HSB	0	3	162	202	178.0 ± 12.2	50.5	113.2	76.80 ± 18.80
		1	1	286	286	286.0	261.1	261.1	261.10
Red Willow	WHB	0	102	105	171	144.0 ± 1.3	12.6	55.3	36.14 ± 0.92
		1	41	210	272	250.3 ± 1.8	125.3	264.5	187.97 ± 4.44
	HSB	0	2	161	172	166.5 ± 5.5	47.7	48.4	48.05 ± 0.35
		1	8	290	325	306.5 ± 4.4	247.4	362.5	310.84 ± 12.90
Swanson	WHB	0	94	95	185	134.9 ± 2.4	10.0	85.3	35.47 ± 1.97
		1	27	246	286	268.4 ± 1.6	196.3	314.1	260.38 ± 5.79
	HSB	0	5	113	201	169.2 ± 16.2	14.3	111.5	69.26 ± 16.17
		1	8	316	347	328.8 ± 4.2	385.5	541.6	454.30 ± 19.02
Hatchery	HSB	0	51	66	158	104.7 ± 3.4	2.9	47.9	16.16 ± 1.67

Table 3-6. Discriminant function loading values (Chapter 3) for distances between landmarks (see Figure 3-2 for landmark locations) digitized on fish pictures. Axis 1 represents separation between taxonomic groups (positive value indicates distance relatively greater for hybrid striped bass, negative value indicates distance relatively greater for white bass). Axis 2 represents separation between age groups (positive value indicates distance relatively greater for age-0 fish, negative value indicates distance relatively greater for age-1 fish). Loading values >|0.30| are indicated with asterisks.

Landmark A	Landmark B	Axis 1 Loading	Axis 2 Loading
1	2	0.21931	0.44345*
1	30	0.16849	0.56597*
1	39	0.42180*	0.19110
2	3	0.10689	0.41069*
2	30	0.08677	0.36800*
3	29	0.09386	0.10664
3	30	0.17638	0.09737
3	36	0.12148	-0.05935
4	29	0.07727	0.09944
4	33	0.07687	-0.38664*
4	36	0.10164	-0.31083*
4	37	0.14305	-0.20146
5	10	-0.26093	-0.64275*
5	33	-0.51807	-0.26268
5	37	0.07968	-0.32357*
10	11	0.63637*	-0.04077
10	33	-0.46112*	-0.46234*
10	40	0.01243	-0.14846
11	12	0.59210*	-0.12288
11	34	-0.20357	-0.09758
11	40	-0.09525	-0.19701
12	13	0.29324	-0.03592
12	34	-0.24103	0.10449
12	41	-0.01345	-0.00206
13	14	0.22707	0.08628
13	35	-0.11505	0.10134
13	41	0.18996	0.21410
14	15	0.15393	0.05741
14	35	0.03596	0.30654*
14	42	-0.45565*	0.18670
15	16	-0.49505*	0.11273
15	42	0.00907	0.20004

Table 3-6. Continued.

Landmark A	Landmark B	Axis 1 Loading	Axis 2 Loading
16	17	-0.50284*	-0.16182
16	18	-0.22488	0.39958*
16	42	0.19725	0.18825
17	18	0.06055	0.31128*
18	19	0.13996	0.17656
18	42	-0.63052*	0.30892*
19	20	0.07938	-0.19520
19	35	-0.59078*	0.35669*
19	41	-0.28826	0.14165
19	42	-0.34857*	0.44922*
20	25	-0.63012*	-0.07046
20	41	-0.64988*	0.19530
25	26	0.59644*	-0.23055
25	34	-0.60732*	0.07186
25	41	-0.80453*	0.10193
26	27	0.55509*	-0.22669
26	31	0.61312*	-0.24978
26	34	-0.08167	0.07215
26	40	-0.20007	0.14414
27	31	-0.02565	-0.14337
27	38	-0.20091	-0.20241
28	29	-0.34916*	-0.02227
28	30	0.46164*	0.16109
28	32	-0.36790*	0.10931
28	38	0.01492	-0.19372
28	39	0.33800*	0.37360*
29	30	-0.09477	-0.02035
29	32	0.00617	-0.04930
29	33	0.39232*	0.05982
29	36	0.18924	0.15198
30	39	0.10153	0.28869
31	32	0.27076	-0.13598
31	33	0.21839	0.07940
31	38	-0.53846*	0.04478
31	40	0.51238*	-0.25278
32	33	0.31275*	-0.05194
32	38	-0.30522*	0.10722

Table 3-6. Continued.

Landmark A	Landmark B	Axis 1 Loading	Axis 2 Loading
33	37	-0.36975*	-0.38073*
33	40	0.55936*	-0.38680*
34	40	0.57870*	-0.29469
34	41	0.37196*	-0.13839
35	41	0.33732*	-0.09546
35	42	0.17731	0.17970

Table 3-7. Multivariate analysis of variance (MANOVA) of log-transformed distances for *Morone* spp. Taxonomic group is white bass or hybrid striped bass and age is 0 or 1; df (N) = numerator df and df (D) = denominator df.

Factor	df (N)	df (D)	Wilks	F-value	*P*-value
Taxonomic group	2	836	0.105	3,544.32	<0.001
Age	2	836	0.568	318.26	<0.001
Taxonomic group x age	2	836	0.947	23.18	<0.001

Table 3-8. Cross-validation of morphological characteristics for age-0 white bass (WHB), age-1 white bass (WHB), age-0 hybrid striped bass (HSB) and age-1 hybrid striped bass (HSB). Classification error was determined using jackknifed, size-free log-transformed morphological characteristics.

Group	*n*	Age-0 WHB	Age-1 WHB	Age-0 HSB	Age-1 HSB
Age-0 WHB	468	448	20	0	0
Age-1 WHB	273	13	260	0	0
Age-0 HSB	71	1	2	58	10
Age-1 HSB	29	0	0	4	25

Table 3-9. Analysis of covariance (ANCOVA) of body measurements for *Morone* spp. Covariates were standard length and taxonomic group (i.e., white bass or hybrid striped bass). Statistics are reported for interaction between covariates; df (N) = numerator df and df (D) = denominator df.

Variable	df (N)	df (D)	F-value	*P*-value
Base of Fourth Anal Fin Ray to Origin of Anal Fin Base	1	604	163.25	<0.001
Origin of Soft Dorsal Fin Base to Origin of Anal Fin Base	1	604	99.18	<0.001
Depth of Caudal Peduncle	1	604	81.80	<0.001
End of Soft Dorsal Fin Base to End of Anal Fin Base	1	604	71.24	<0.001
Third Anal Fin Spine	1	604	65.22	<0.001
Second Anal Fin Spine	1	604	42.22	<0.001
Second Dorsal Fin Spine	1	604	0.10	0.75
Third Dorsal Fin Spine	1	604	0.04	0.85
Fourth Dorsal Fin Spine	1	604	0.03	0.86

Table 3-10. Classification accuracy to taxonomic group of body measurements as a function of standard length for white bass and hybrid striped bass. Classification accuracy was determined using logistic regression analysis.

Variable	Percent Correct
Depth of Caudal Peduncle	98.9
Base of Fourth Anal Fin Ray to Origin of Anal Fin Base	98.3
Origin of Soft Dorsal Fin Base to Origin of Anal Fin Base	98.0
End of Soft Dorsal Fin Base to End of Anal Fin Base	97.3
Second Anal Fin Spine	94.7
Third Anal Fin Spine	92.9

Table 3-11. Mean ± SE of the body measurement (mm) to standard length (mm) ratio for genetically identified taxonomic group (WHB = white bass; HSB = hybrid striped bass). Best separating ratio is the ratio for that body measurement that classifies collected specimens to genetically identified taxonomic group with greatest overall reclassification accuracy.

Variable	Taxonomic Group	Ratio ± SE	Best Separating Ratio	Reclassification Accuracy
Depth of Caudal Peduncle	WHB	6.77 ± 0.01	7.30	98.7%
	HSB	7.81 ± 0.04		
Base of Fourth Anal Fin Ray to Origin of Anal Fin Base	WHB	11.54 ± 0.02	12.80	97.7%
	HSB	13.60 ± 0.07		
Origin of Soft Dorsal Fin Base to Origin of Anal Fin Base	WHB	2.93 ± 0.01	3.20	95.7%
	HSB	3.34 ± 0.02		
End of Soft Dorsal Fin Base to End of Anal Fin Base	WHB	5.24 ± 0.01	5.75	97.6%
	HSB	5.94 ± 0.03		
Second Anal Fin Spine	WHB	9.92 ± 0.04	11.90	89.8%
	HSB	11.59 ± 0.14		
Third Anal Fin Spine	WHB	8.60 ± 0.02	9.90	90.9%
	HSB	9.54 ± 0.10		

Figure 3-1. Photograph of *Morone* spp. (fins stretched and pinned for placement of landmark points) collected during 2008 and 2009 while electrofishing. Similarities in characteristics (e.g., body shape, basihyal tooth patches, broken horizontal lines) confounded identification attempts. Genetic identification was hybrid striped bass (top photograph), white bass (middle photograph), and white bass (bottom photograph).

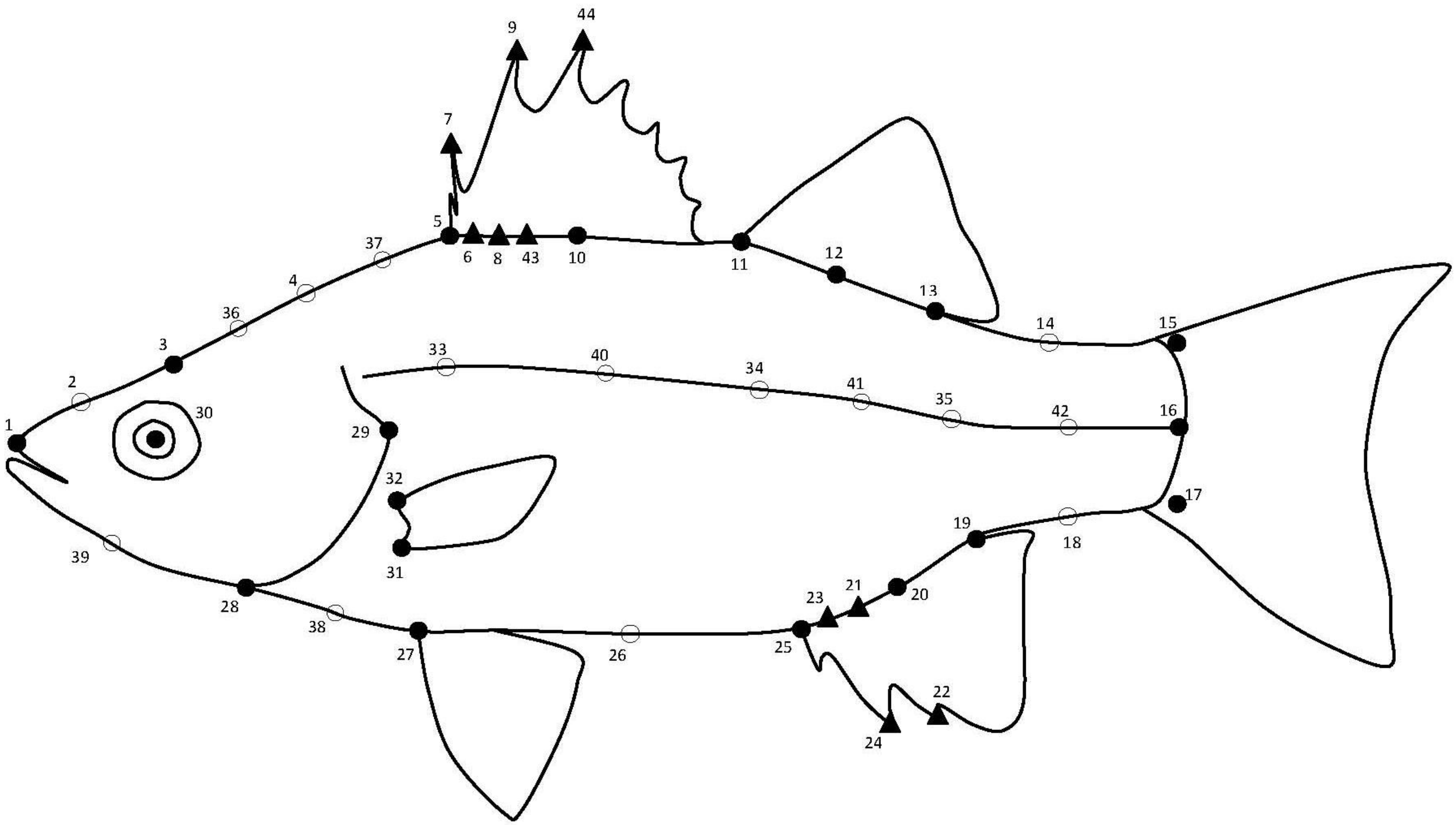

Figure 3-2. Landmark (●) and semi-landmark (○) points for truss network and landmark points (▲) for spine measurements (Table 3-5).

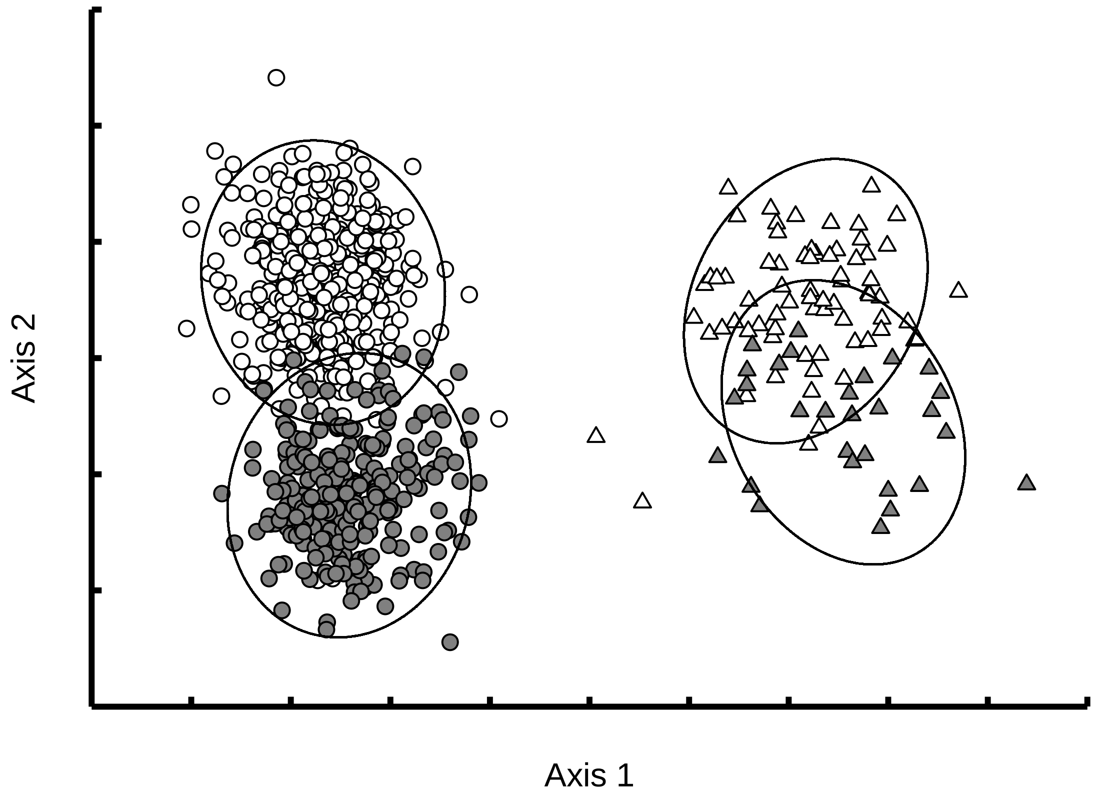

Figure 3-3. Discriminant function analysis (DFA) of white bass and hybrid striped bass by age: age-0 white bass (○), age-1 white bass (●), age-0 hybrid striped bass (△), and age-1 hybrid striped bass (▲). Ellipses represent the 95% confidence interval around the centroid for each group.

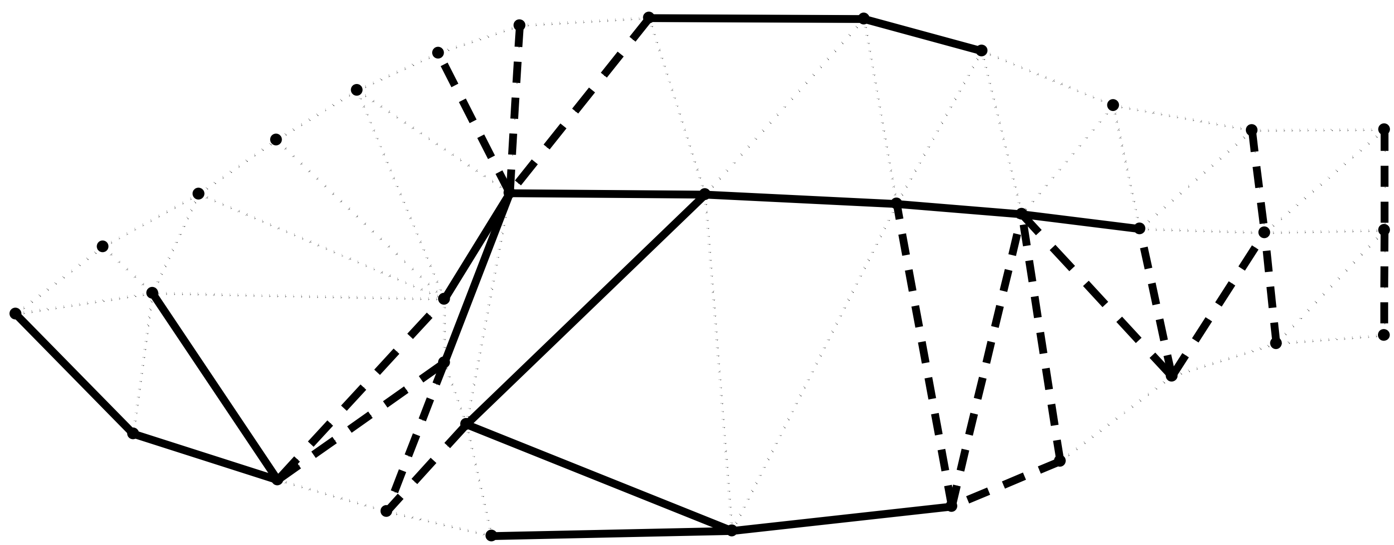

Figure 3-4. Significant loadings and landmark points between white bass and hybrid striped bass (first discriminant axis). Thick dash lines indicate morphological distances relatively greater in white bass; thick solid lines indicate morphological distances relatively greater in hybrid striped bass; dotted lines indicate no significant difference.

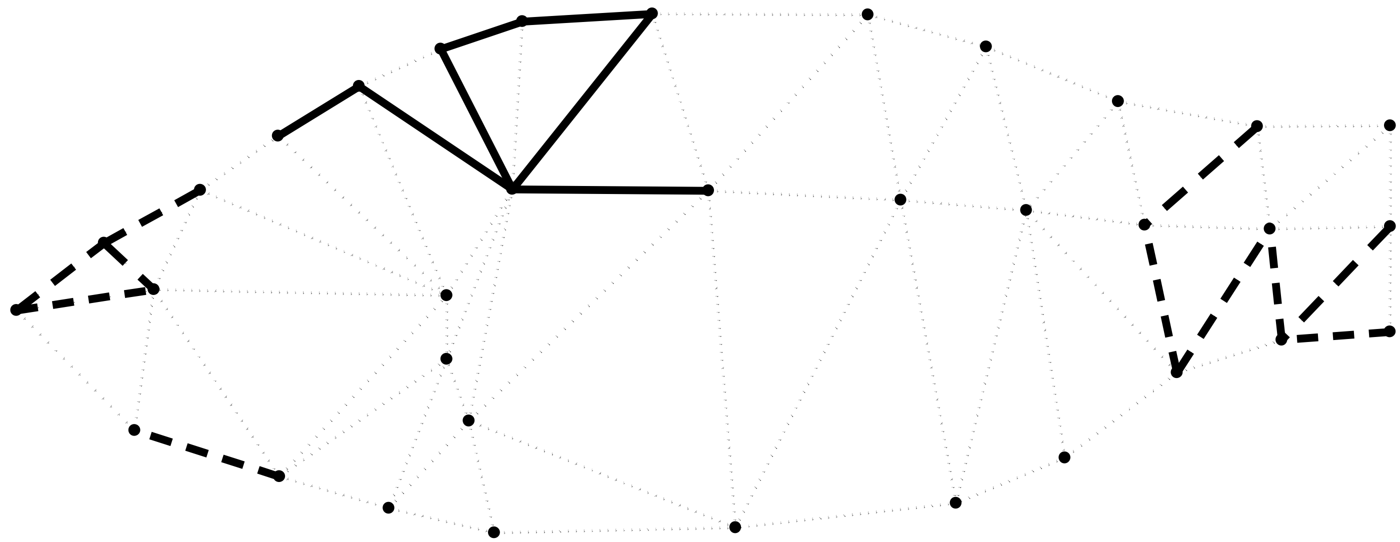

Figure 3-5. Significant loadings and landmark points between age-0 and age-1 fish (second discriminant axis). Thick dash lines indicate morphological distances greater in age-0 fish; thick solid lines indicate morphological distances greater in age-1 fish; dotted lines indicate no significant difference.

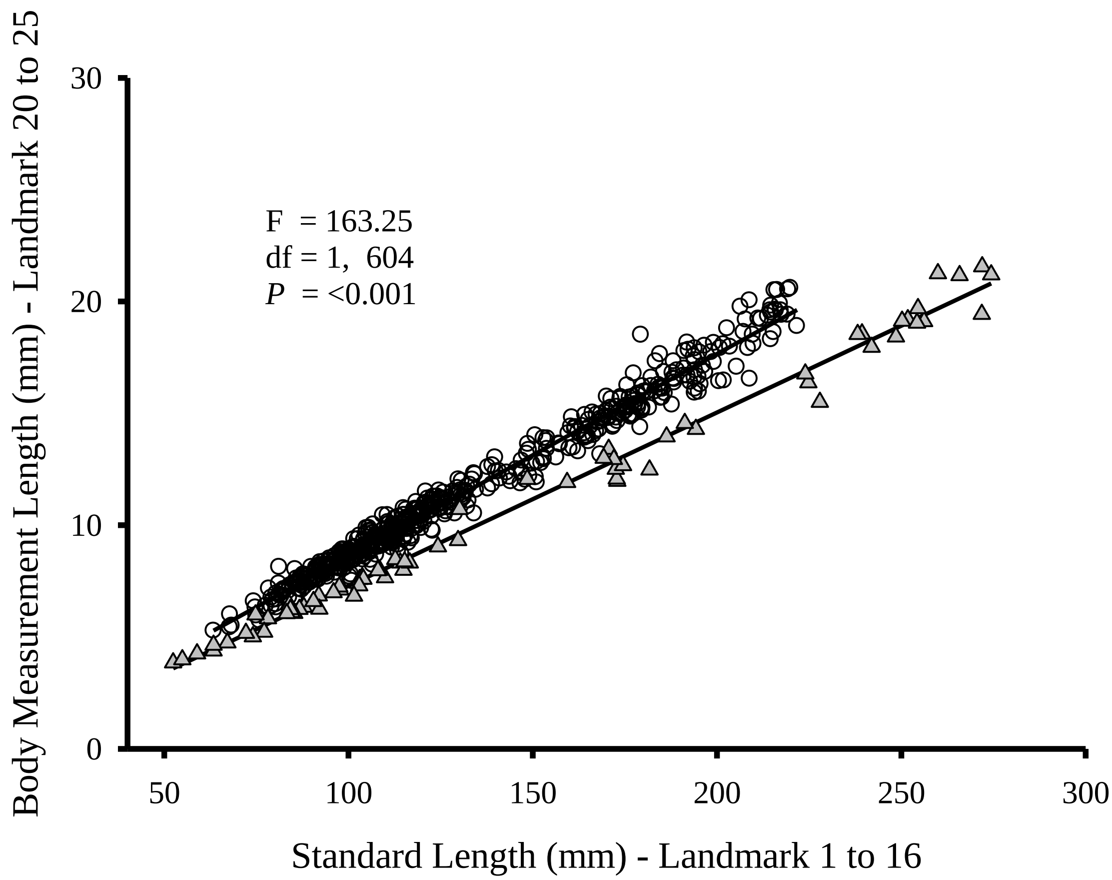

Figure 3-6. Length from base of fourth anal fin ray to origin of anal fin base (landmark 20 to 25) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

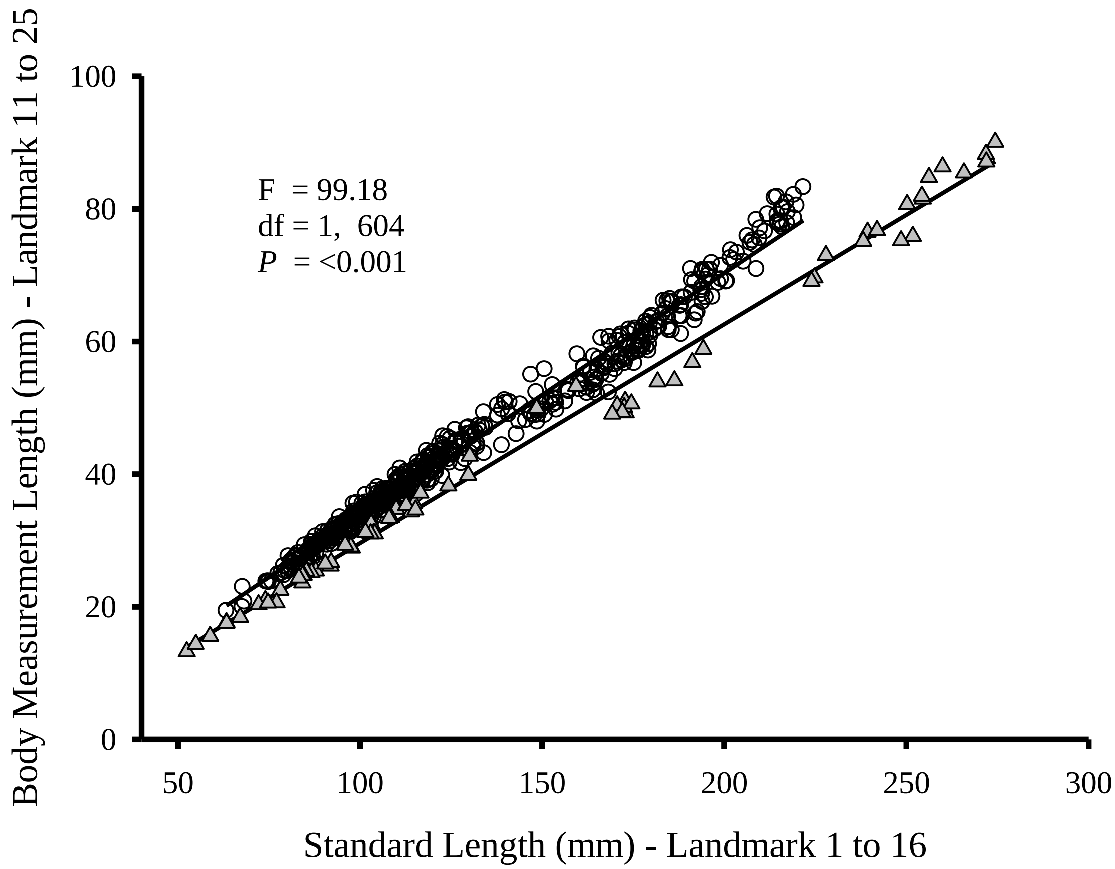

Figure 3-7. Length from origin of soft dorsal fin base to origin of anal fin base (landmark 11 to 25) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

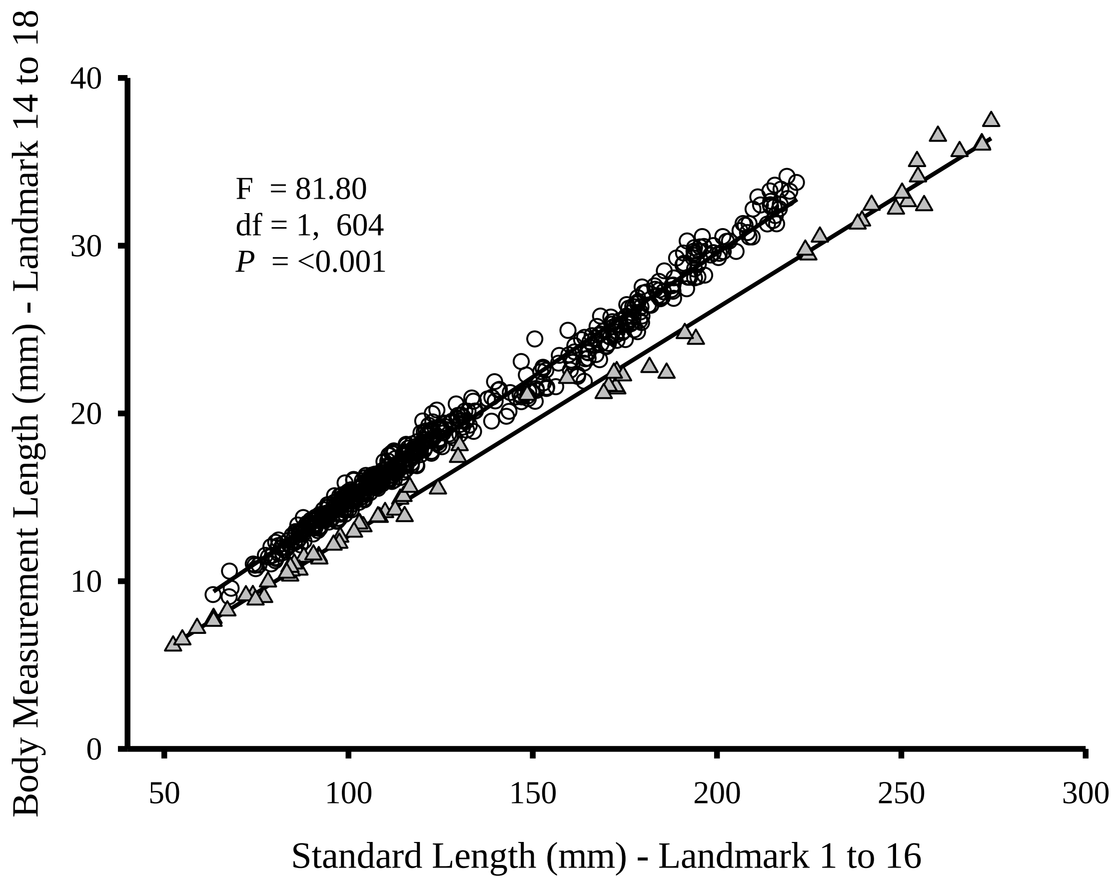

Figure 3-8. Depth of caudal peduncle (landmark 14 to 18) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

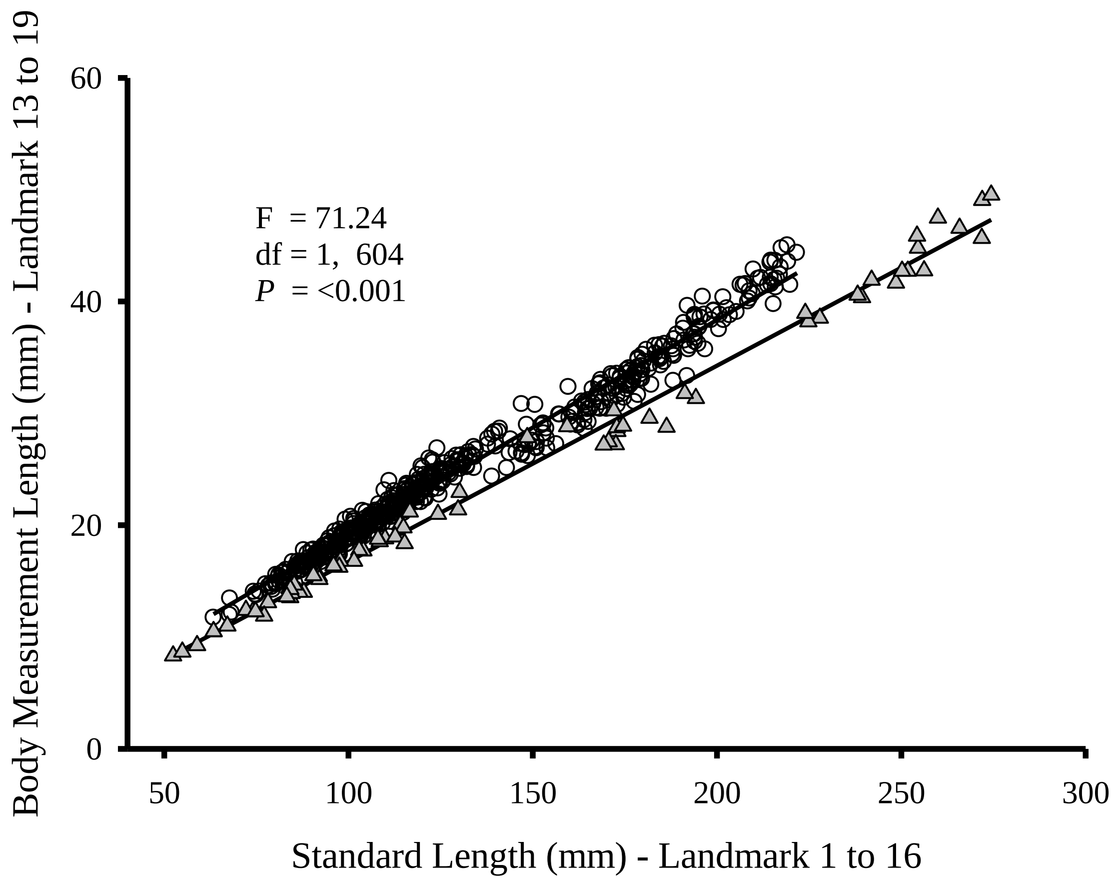

Figure 3-9. Length from end of soft dorsal fin base to end of anal fin base (landmark 13 to 19) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

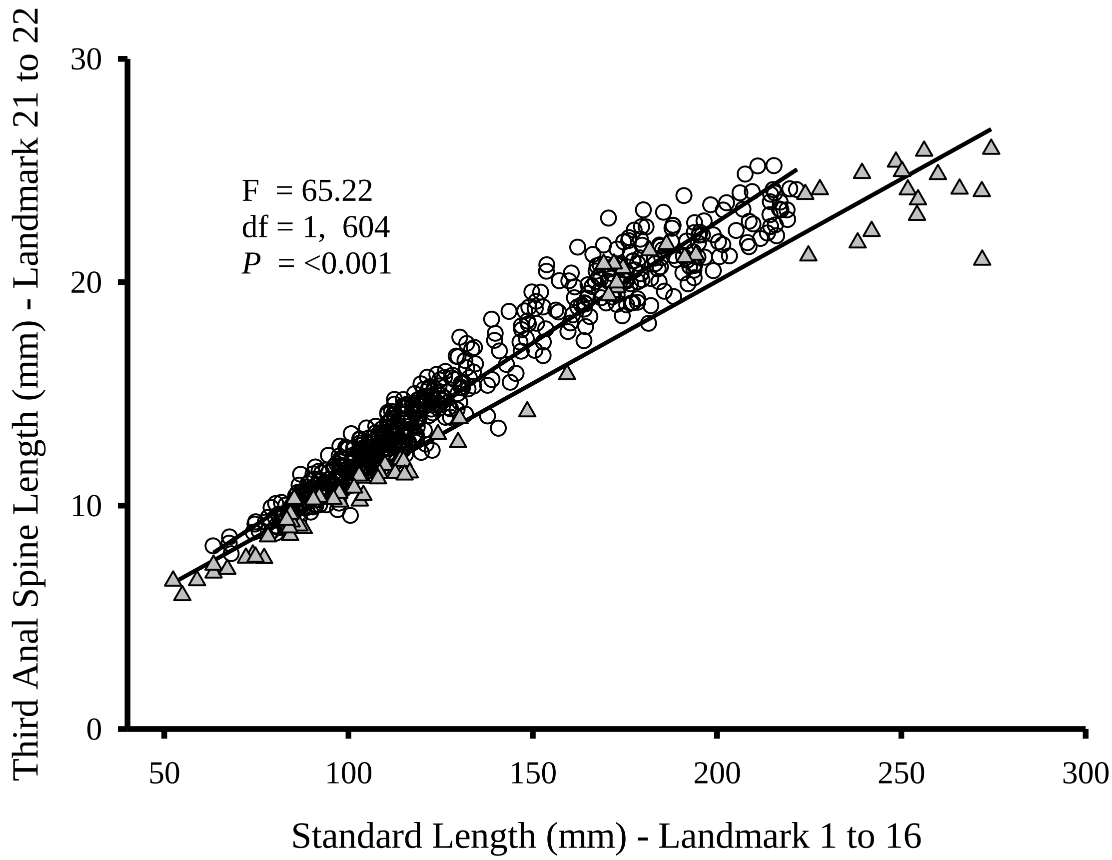

Figure 3-10. Third anal fin spine length (landmark 21 to 22) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

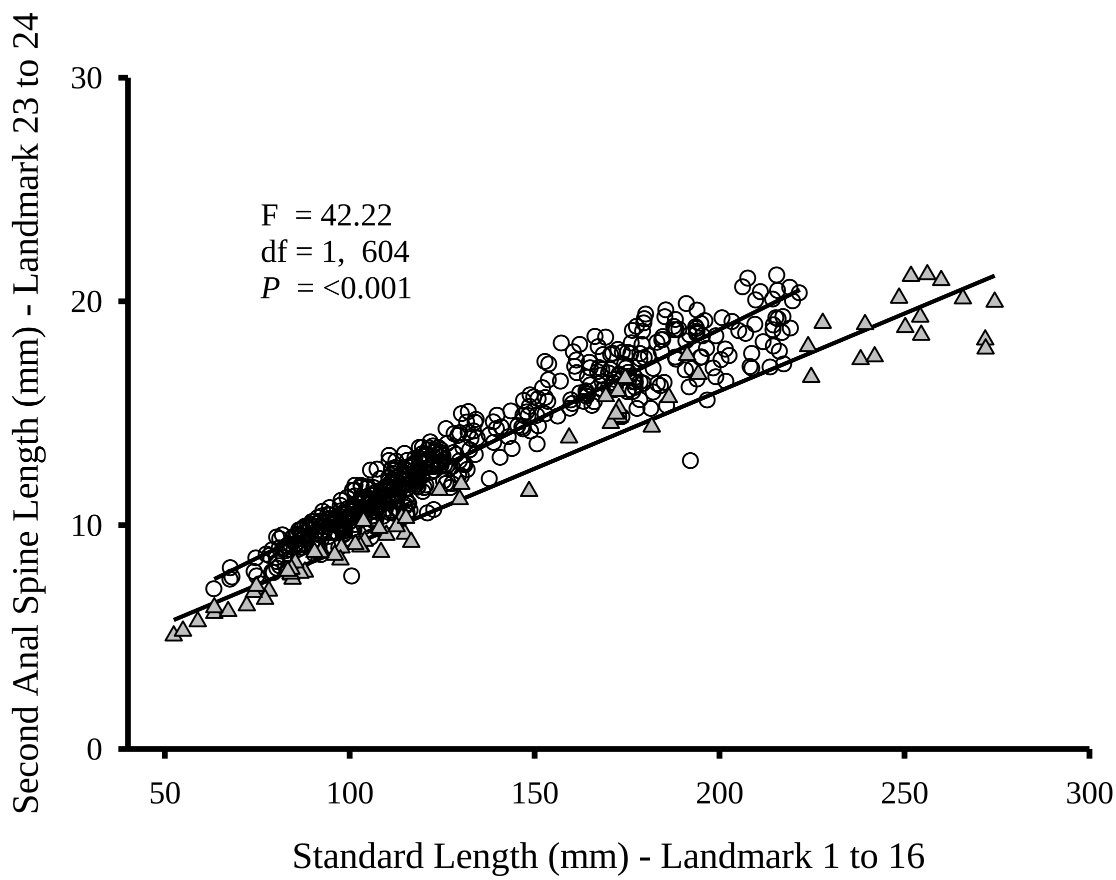

Figure 3-11. Second anal fin spine length (landmark 23 to 24) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

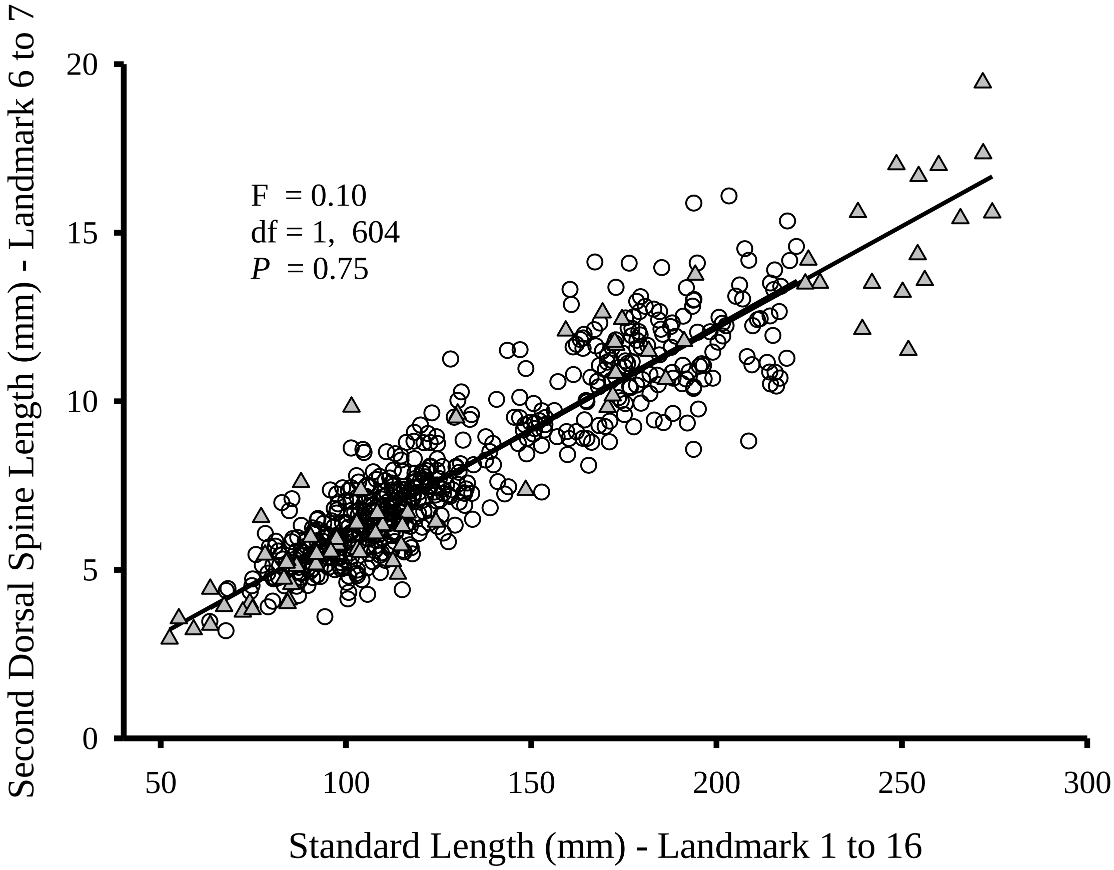

Figure 3-12. Second dorsal fin spine length (landmark 6 to 7) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

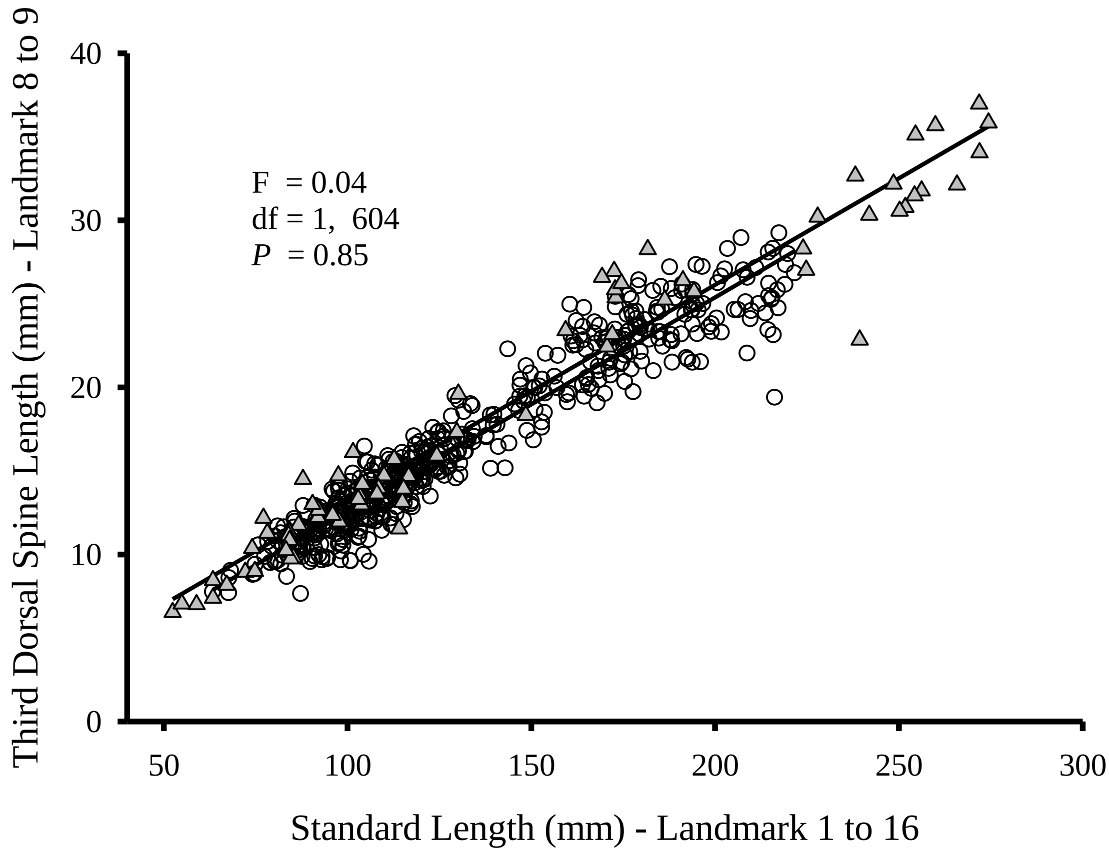

Figure 3-13. Third dorsal fin spine length (landmark 8 to 9) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

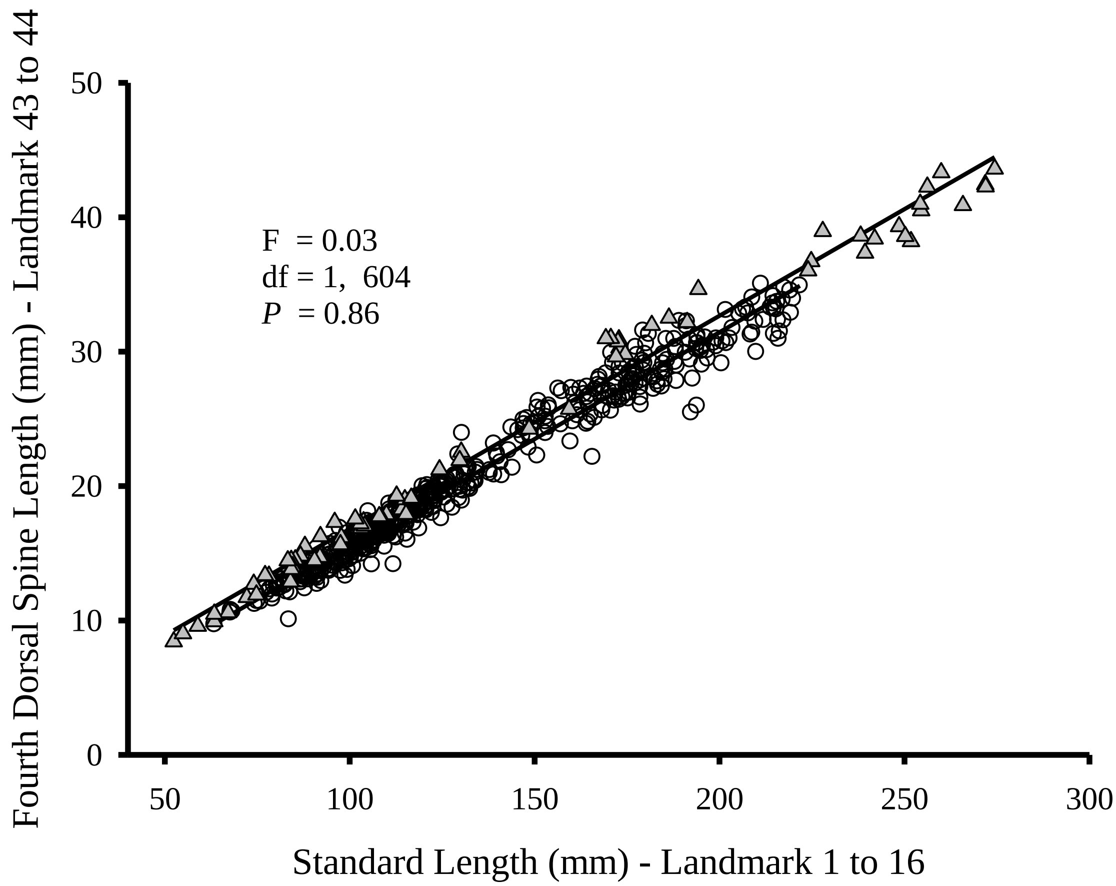

Figure 3-14. Fourth dorsal fin spine length (landmark 43 to 44) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Statistics are reported for ANCOVA.

Chapter 4. Management Implications and Future Research

White bass *Morone chrysops* and hybrid striped bass *M. saxatilis x chrysops* are important sportfish to recreational angling, especially in irrigation reservoirs of the Republican River basin in southwestern Nebraska. In these reservoirs, white bass are maintained by natural production, although recruitment is variable from year to year. Hybrid striped bass are managed as "put, grow and take" fisheries in these reservoirs and populations are maintained by fingerling stockings.

Stocking frequency and rate for hybrid striped bass is calculated for each reservoir each year by indexing abundance of adult fish collected using gill nets during autumn. Estimating adult abundance to determine stocking frequency and rate has a time lag that can be eliminated by estimating year-class strength for age-1 white bass and juvenile hybrid striped bass. However, the accuracy of estimating year-class strength for age-1 white bass and juvenile hybrid striped bass is limited by the lack of diagnostic characteristics to distinguish between these two groups of fish.

Identification Test

An identification test (Chapter 2) was used to determine the accuracy of biologists working independently to distinguish between juvenile white bass and juvenile hybrid striped bass. This test was also used to provide insight about characteristics that should and should not be used when distinguishing between juvenile white bass and juvenile hybrid striped bass. Mean accuracy for the identification test by biologists was 71%; however, 7 of the 32 biologists had an accuracy >80%. Biologists that examined >99 age-0 *Morone* during the past 12 months scored significantly higher than biologists that examined none (Figure 2-4); thus, recent experience handling many individuals of *Morone* spp. is important to accurate identification. I recommend emphasizing the use of horizontal line thickness (especially below the lateral line), fish size, and body shape (Chapter 3) to distinguish between juvenile white bass and juvenile hybrid striped bass. The presence/absence of broken horizontal lines or the number of basihyal tooth patches, traditionally used to distinguish between adult white bass and adult hybrid striped bass, should not be used to distinguish between juvenile white bass from juvenile hybrid striped bass. Clearly, identifying juvenile white bass and juvenile hybrid striped bass is a specialized skill, which some biologists that participated in this test have obtained. Biologists with minimal experience identifying juvenile *Morone* spp. should be trained by experienced biologists who examine many juvenile *Morone* spp. each year. Training of inexperienced biologists should include in-field comparisons of juvenile white bass and juvenile hybrid striped bass.

Periodic tests, like the one I conducted in Chapter 2, may be necessary to ensure that biologists are accurately identifying juvenile *Morone* spp. Future *Morone* spp. identification tests for biologists could use morphological analysis (Chapter 3) to assign identification to test specimens rather than genetic analysis because morphological resolution is high (this study). That is, morphological-based identification can be compared to biologist identification to determine accuracy by biologists identifying juvenile white bass and juvenile hybrid striped bass. Much of the associated cost and time for genetic analysis can be eliminated by using morphological identification instead of genetic identification, thereby making future identification tests more feasible.

The identification test was designed to evaluate ability of biologists to distinguish between juvenile white bass and juvenile hybrid striped bass when working independently. Further research is needed to determine if identification accuracy would improve by having biologists work together and allowing biologists to directly compare specimens, both of which are methods currently used by Nebraska Game and Parks Commission biologists when conducting annual fall gill-net sampling. Additional identification tests should include older-juvenile (age 1 and age 2) white bass and hybrid striped bass from waterbodies other than Harlan County Reservoir to determine if identification accuracy is similar among Nebraska waterbodies.

Morphological Differences

I was able to correctly classify juvenile white bass and juvenile hybrid striped bass to taxonomic group 99% of the time using digitized fish photographs to quantify body morphology (see Chapter 3), which is a substantial improvement to the biologist identification. Although this technique may not be useful when fish are collected with a sampling gear that deforms body shape (e.g., gill nets), this technique can be used to accurately identify fish collected using sampling gears that do not deform body shape (e.g., electrofisher, trap nets). It may not be feasible to use this technique for all specimens collected during sampling efforts as a result of the many juvenile *Morone* spp. that are often collected. In such instances, biologists could employ two tactics: 1) photograph a random sample of juvenile *Morone* spp. to compare field identification with group classification by body morphology or 2) photograph fish that exhibit characteristics of both white bass and striped bass and are thus difficult to accurately identify.

I was able to correctly classify juvenile white bass and juvenile hybrid striped bass to taxonomic group 98.9% of the time using two body measurements (standard length and depth of caudal peduncle). This is a simple procedure that biologists can use during sampling efforts to increase accuracy of distinguishing between juvenile white bass and juvenile hybrid striped bass. Standard length (mm) and depth of caudal peduncle (mm) can easily be measured with calipers. If the standard length divided by the caudal peduncle depth is ≤ 7.30, the fish should be classified as a white bass; otherwise, the fish should be classified as a hybrid striped bass (Figure 4-1). The addition of recording these two measurements during sampling efforts would minimally increase sampling time; however, the increased identification accuracy for juvenile white bass and juvenile hybrid striped bass would improve the quality of data. If identification accuracy of 99.9% is desired, I recommend removing a fin clip (as described in Chapter 3) for genetic analysis.

Stocking Implications

For this study, we used genetic analysis (microsatellite nDNA) to assign sampled fish to taxonomic group for morphological analysis. The genetic analysis results also provided us information regarding the possible stocking of or natural recruitment of F_x hybrid striped bass in Nebraska waterbodies. Overall, 9 fish out of 1,133 (0.79%) genetically identified fish collected for this study were identified as F_x hybrid striped bass. Of the 1,133 fish genetically identified for this study, 166 were collected from Calamus State Fish Hatchery, Nebraska. Out of 166 fish, 5 fish (3%), which were collected during 2008, were genetically identified as F_x hybrid striped bass (Appendix 1).

The other 4 F_x hybrid striped bass, which were collected during 2008, were collected from the study reservoirs (see paragraph below). It is likely that the F_x hybrid striped bass collected from Calamus were produced when an F_x hybrid striped bass was accidently used as brood stock at the Byron State Fish Hatchery, Oklahoma. This was likely an honest mistake made by the personnel responsible for collecting and breeding of pure white bass and pure striped bass. The stocking of F_x hybrid striped bass into Nebraska waterbodies has two major concerns. The first is that F_x hybrid striped bass are unlikely to have the faster growth rate (i.e., hybrid vigor) of F_1 hybrid striped bass. The second is an increased rate in deformities in F_x hybrid striped bass (Bishop 1968), which could lead to an increase in mortality rate if these deformities decrease the individual's ability to capture prey or escape predators.

Of the 1,133 fish genetically identified for this study, 967 fish were collected from the study reservoirs. Out of 967 fish, 4 fish (0.41%), which were collected during 2008, were genetically identified as F_x hybrid striped bass (Appendix 1). These 4 fish were collected from Harlan County Reservoir (n = 2), Red Willow Reservoir (n =1), and Swanson Reservoir (n = 1) (Appendix 1). It is unknown if these fish were naturally produced in the reservoirs or were stocked as part of the Nebraska Game and Parks Commission supplemental stocking program because these 4 fish were collected from year classes that received hybrid striped bass stockings (see Chapter 1, Table 1-1). Of these 4 fish, 3 individuals (Harlan County Reservoir and Swanson Reservoir) were collected from the same year class (2008) as the F_x hybrid striped bass that were collected from Calamus State Fish Hatchery. Thus, it is possible that these individuals were produced at the Byron State Fish Hatchery and stocked as part of the F_1 hybrid striped bass stockings. We did sample one age-1 fish from Red Willow Reservoir during 2008 that was genetically identified as an F_x hybrid striped bass. This fish was the only individual sampled that exhibited a combination of locus-specific genotypes consistent with white bass, striped bass, and hybrid striped bass (Appendix 1; Fish number T08-05993).

We did sample some year classes of fish that did not receive Nebraska Game and Parks Commission supplemental stockings of F_1 hybrid striped bass. Of the 414 fish sampled from these year classes, we did not genetically identify any fish as F_x or F_1 hybrid striped bass. This result along with the low occurrence (<0.01%) of genetically identified F_x hybrid striped bass from the year classes that did receive stockings provide evidence that even if hybrid striped bass are reproducing in Nebraska waterbodies, recruitment of these individuals is very low.

Although recruitment of F_x hybrid striped bass in Nebraska waterbodies is low, Nebraska Game and Parks Commission should take precautions to ensure that future stockings of F_1 hybrid striped bass do not include F_x hybrid striped bass. I recommend contacting the personnel at Byron State Fish Hatchery to inquire what steps they are taking to prevent the use of F_x hybrid striped bass as brood stock. I further recommend Byron State Fish Hatchery use a protocol, including genetic analysis, to verify fish collected for brood stock are pure white bass and pure striped bass. Finally, I see no disadvantages for the Nebraska Game and Parks Commission to continue managing hybrid striped bass populations in Nebraska reservoirs as “put, grow and take” fisheries.

References

Bishop, R. D. 1968. Evaluation of the striped bass (*Roccus saxatilis*) and white bass (*R. chrysops*) hybrids after two years. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 21:245-254.

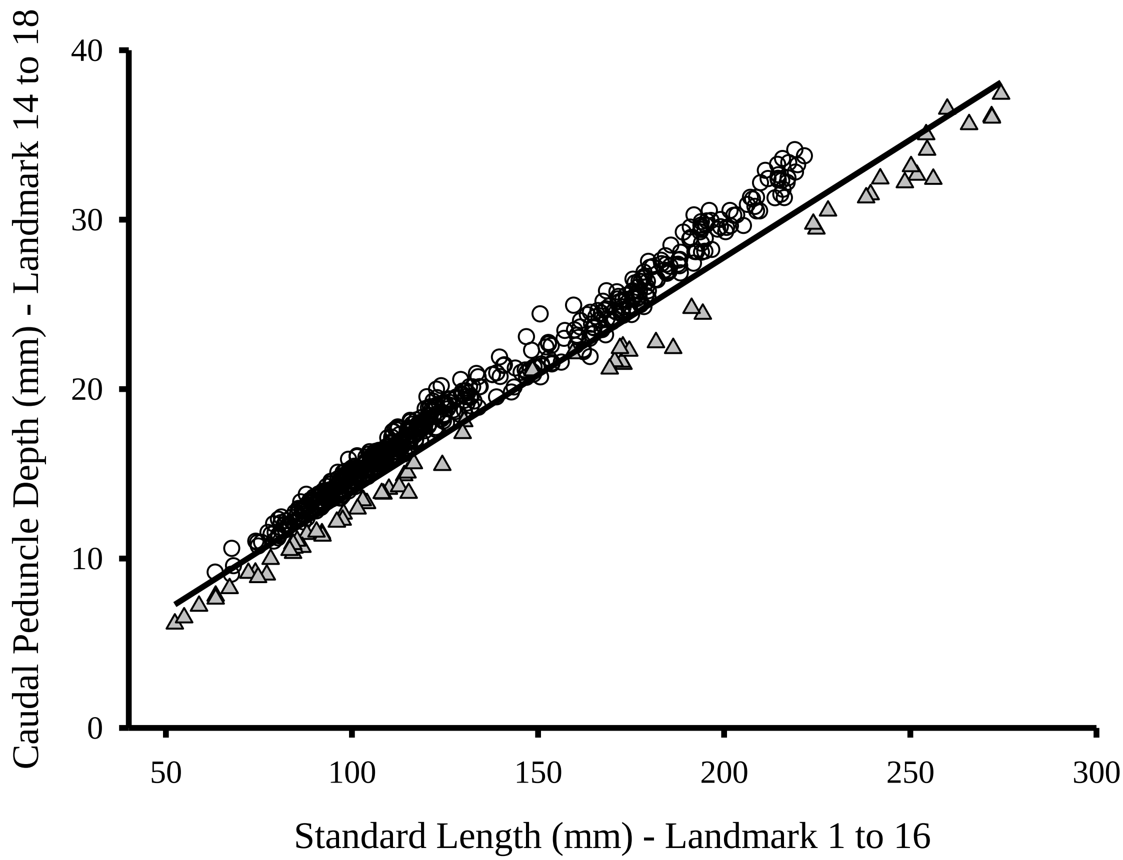

Figure 4-1. Depth of caudal peduncle (landmark 14 to 18) as a function of standard length (landmark 1 to 16) for white bass (○) and hybrid striped bass (▲). Reference line is provided for a ratio of standard length to caudal peduncle depth equal to 7.3; points below this line have a ratio >7.3 and points above this line have a ratio <7.3.

Appendix 1. Age, standard length (SL; mm), weight (Wt; g), fish identification assigned during processing in field (ID_f; HSB = F_1 hybrid striped bass; WHB = white bass; F_x = backcross hybrid striped bass), fish identification assigned from genetic analysis (ID_g), and base-pair lengths (gray cell indicates base-pair length from striped bass and white cell indicates base-pair length from white bass) from diagnostic loci (1137, 1138, 1144, 1067 and 1085) used for genetic analysis for *Morone* spp. collected from Nebraska reservoirs and Calamus State Fish Hatchery during 2008 and 2009. Fish number is the number assigned by the Wisconsin Cooperative Fishery Research Unit (the second and third characters represent year of collection). Also identified are the analyses (A) for which each fish was included (beginning of alphabet) or reason fish was excluded from assessment (end of alphabet): a = included in identification test (Chapter 2); b = included in truss analysis (Chapter 3); c = included in body measurement analysis (Chapter 3); t = excluded because fish was collected by different sampling methods than those described in Chapter 3; u = excluded because of poor picture quality; v = excluded because picture was accidently deleted; w = excluded because fish ID_g was not white bass or F_1 hybrid striped bass; x = excluded because fish age was >1; y = excluded because zero loci were amplified during genetic analysis; z = excluded because fish was a highly influential data point for truss analysis.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T08-06408	0	45	1.8	HSB	HSB	125	185	166	186	142	174	157	199	106	156	u
Calamus	T08-06409	0	39	1.2	HSB	HSB	125	179	166	194	142	174	157	191	106	150	u
Calamus	T08-06410	0	41	1.6	HSB	HSB	125	179	170	194	142	174	157	191	106	150	u
Calamus	T08-06411	0	47	2.0	HSB	HSB	125	179	166	194	142	174	157	191	106	150	u
Calamus	T08-06412	0	41	1.5	HSB	HSB	125	185	166	192	138	174	157	199	106	158	u
Calamus	T08-06413	0	47	2.1	HSB	HSB	125	185	166	194	138	174	157	199	106	150	u
Calamus	T08-06414	0	46	2.1	HSB	HSB	125	179	168	192	142	174	157	191	106	138	u
Calamus	T08-06415	0	44	1.8	HSB	F_x	125	125	166	194			157	191	106	150	w
Calamus	T08-06416	0	48	2.2	HSB	HSB	125	185	166	186	138	174	157	205	106	138	u
Calamus	T08-06417	0	49	2.2	HSB												y
Calamus	T08-06418	0	45	2.0	HSB	HSB	125	179	170	194	142	174	157	191	106	150	u
Calamus	T08-06419	0	47	2.1	HSB												y
Calamus	T08-06420	0	42	1.6	HSB	HSB	125	247	168	192	142	174			106	138	u
Calamus	T08-06421	0	44	1.8	HSB	HSB	125	247	166	192	142	174	157	199	106	138	u
Calamus	T08-06422	0	48	2.3	HSB	HSB	125	225	166	194	142	174	157	199	106	150	u

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T08-06423	0	50	2.4	HSB	HSB	125	185	166	186	130	172			106	138	u
Calamus	T08-06424	0	38	1.1	HSB	F_x	125	125	170	194	142	174	157	191	106	150	w
Calamus	T08-06425	0	46	2.0	HSB	HSB	125	185	166	186	142	174			106	156	u
Calamus	T08-06426	0	44	1.8	HSB	HSB	125	225	166	186	138	174	157	199	106	156	u
Calamus	T08-06427	0	44	1.6	HSB	HSB	125	185	166	186	138	174	157	205	106	138	u
Calamus	T08-06428	0	47	2.3	HSB	HSB	125	185	166	186	142	174	157	199	106	156	u
Calamus	T08-06429	0	46	2.2	HSB	HSB	125	185	166	186	130	174			106	138	u
Calamus	T08-06430	0	52	2.9	HSB	HSB	125	179	166	192	142	174	157	191	106	138	u
Calamus	T08-06431	0	50	2.5	HSB	HSB	125	185	166	186	138	174			106	138	u
Calamus	T08-06432	0	44	1.5	HSB	HSB	125	185	166	186	138	172	157	199	106	138	u
Calamus	T08-06433	0	56	3.6	HSB	HSB	125	185	166	186	138	174	157	199	106	138	u
Calamus	T08-06434	0	45	2.1	HSB	HSB	125	185	166	186	138	174			106	156	u
Calamus	T08-06435	0	42	1.6	HSB	HSB	125	225	166	186	138	174			106	156	u
Calamus	T08-06436	0	48	2.4	HSB	F_x	125	225	170	186	142	142			106	156	w
Calamus	T08-06437	0	34	0.9	HSB	HSB	125	179	170	194	142	174			106	150	u
Calamus	T08-06438	0	48	2.2	HSB	HSB	125	179	166	192	142	174			106	138	u
Calamus	T08-06439	0	50	2.4	HSB	HSB	125	247	166	192	142	174			106	138	u
Calamus	T08-06440	0	39	1.0	HSB	HSB	125	247	166	192	142	174	157	191	106	138	u
Calamus	T08-06441	0	48	2.1	HSB	HSB	125	179	170	192	142	174			106	138	u
Calamus	T08-06442	0	47	2.0	HSB	HSB	125	247	170	192	142	174	157	191	106	138	u
Calamus	T08-06443	0	48	2.2	HSB	HSB	125	247	170	192	142	174	157	199	106	138	u
Calamus	T08-06444	0	46	2.0	HSB	HSB	125	179	170	192	142	174					u
Calamus	T08-06445	0	42	1.6	HSB	HSB	125	185	166	186	130	174			106	138	u
Calamus	T08-06446	0	47	2.1	HSB	HSB	125	179	166	192	142	174			106	138	u
Calamus	T08-06447	0	46	1.9	HSB	HSB	125	185	166	186	130	172			106	138	u

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T08-06448	0	40	1.5	HSB	HSB	125	247	170	194	142	174	157	191	106	150	u
Calamus	T08-06449	0	48	2.2	HSB	HSB	125	185	166	186	138	174	157	199	106	138	u
Calamus	T08-06450	0	44	1.6	HSB	HSB	125	185	166	186	142	174	157	199	106	156	u
Calamus	T08-06451	0	42	1.5	HSB	HSB	125	247	166	192	142	174			106	138	u
Calamus	T08-06452	0	46	2.1	HSB	HSB	125	179	168	192	142	174			106	138	u
Calamus	T08-06453	0	44	1.8	HSB	HSB	125	185	170	186	122	174	157	199	106	144	u
Calamus	T08-06454	0	43	1.7	HSB	HSB	125	247	168	194	142	174	157	191	106	150	u
Calamus	T08-06455	0	44	1.7	HSB	HSB	125	179	170	194	142	174			106	150	u
Calamus	T08-06456	0	46	1.9	HSB	F_x	125	185	166	194	142	174	157	157	106	150	w
Calamus	T08-06457	0	40	1.4	HSB	F_x	125	155	166	186	142	174	157	157	106	144	w
Calamus	T09-07803	0	130	47.9	HSB	HSB	125	225	166	186	130	174	157	199	106	150	bc
Calamus	T09-07804	0	118	36.3	HSB	HSB	125	165	166	192	138	174	157	205	106	150	bc
Calamus	T09-07805	0	119	37.4	HSB	HSB	125	219	170	186	138	174	157	205	106	152	bc
Calamus	T09-07806	0	120	41.6	HSB	HSB	125	219	166	186	130	174	157	199	106	150	bc
Calamus	T09-07807	0	113	33.7	HSB	HSB	125	219	166	186	130	174	157	199	106	150	bc
Calamus	T09-07808	0	115	36.3	HSB	HSB	125	219	166	190	130	174	157	199	106	150	bc
Calamus	T09-07809	0	105	28.6	HSB	HSB	125	219	168	192	122	174	157	207	106	150	bc
Calamus	T09-07810	0	111	30.4	HSB	HSB	125	219	166	192	130	174	157	199	106	160	bc
Calamus	T09-07811	0	108	26.4	HSB	HSB	125	213	166	186	130	174	157	207	106	150	bc
Calamus	T09-07812	0	116	36.0	HSB	HSB	125	219	166	192	130	174	157	199	106	160	bc
Calamus	T09-07813	0	106	25.7	HSB	HSB	125	219	166	192	130	174	157	199	106	160	bc
Calamus	T09-07814	0	113	31.8	HSB	HSB	125	149	166	186	130	174	157	199	106	150	bc
Calamus	T09-07815	0	105	26.5	HSB	HSB	125	165	166	192	122	174	157	201	106	150	bc
Calamus	T09-07816	0	105	24.9	HSB	HSB	125	225	166	186	122	174	157	207	106	150	bc
Calamus	T09-07817	0	100	20.6	HSB	HSB	125	219	166	190	130	174	157	199	106	150	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T09-07818	0	99	21.1	HSB	HSB	125	219	166	186	144	174	157	199	106	150	bc
Calamus	T09-07819	0	99	21.2	HSB	HSB	125	219	166	190	130	174	157	199	106	150	bc
Calamus	T09-07820	0	93	17.3	HSB	HSB	125	155	166	190	134	172	157	199	106	150	bc
Calamus	T09-07821	0	97	17.3	HSB	HSB	125	219	166	192	138	174	157	207	106	150	bc
Calamus	T09-07822	0	91	14.7	HSB	HSB	125	149	168	192	144	174	157	199	106	160	bc
Calamus	T09-07823	0	93	16.8	HSB	HSB	125	149	166	192	144	174	157	199	106	160	bc
Calamus	T09-07824	0	87	14.4	HSB	HSB	125	165	166	186	122	174	157	207	106	152	bc
Calamus	T09-07825	0	86	12.3	HSB	HSB	125	155	166	190	134	174	157	199	106	150	bc
Calamus	T09-07826	0	87	13.2	HSB	HSB	125	155	166	192	130	174	157	199	106	160	bc
Calamus	T09-07827	0	86	13.8	HSB	HSB	125	219	166	192	134	174	157	199	106	160	bc
Calamus	T09-07828	0	87	12.8	HSB	HSB	125	165	168	186	122	174	157	201	106	152	bc
Calamus	T09-07829	0	86	12.7	HSB	HSB	125	219	166	190	130	172	157	199	106	150	bc
Calamus	T09-07830	0	81	10.8	HSB	HSB	125	155	166	190	130	174	157	199	106	150	bc
Calamus	T09-07831	0	79	9.0	HSB	HSB					130	174	157	199			bc
Calamus	T09-07832	0	60	4.2	HSB	HSB	125	213	166	186	130	174	157	207	106	150	bc
Calamus	T09-07833	0	68	5.7	HSB	HSB	125	149	166	192	144	174	157	199	106	160	b
Calamus	T09-07834	0	54	2.9	HSB	HSB	125	149	170	186	144	174	157	199	106	150	bc
Calamus	T09-07835	0	78	7.7	HSB	HSB	125	225	166	186	122	174	157	199	106	150	b
Calamus	T09-07836	0	77	9.4	HSB	HSB	125	219	170	186	144	174	157	199	106	150	bc
Calamus	T09-07837	0	67	5.6	HSB	HSB	125	213	166	186	122	174	157	199	106	150	b
Calamus	T09-07838	0	62	4.2	HSB	HSB	125	155	166	190	130	174	157	199	106	150	b
Calamus	T09-07839	0	64	4.9	HSB	HSB	125	225	166	186	130	174	157	207	106	150	b
Calamus	T09-07840	0	67	5.5	HSB	HSB	125	213	166	186	130	174	157	207	106	144	bc
Calamus	T09-07841	0	70	6.4	HSB	HSB	125	165	166	186	122	174	157	201	106	152	bc
Calamus	T09-07842	0	65	5.3	HSB	HSB	125	219	166	190	134	174	157	199	106	150	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T09-07843	0	77	8.5	HSB	HSB	125	165	166	186	122	174	157	201	106	152	b
Calamus	T09-07844	0	76	8.7	HSB	HSB	125	219	170	192	144	174	157	199	106	160	bc
Calamus	T09-07845	0	77	9.0	HSB	HSB	125	225	166	186	122	174	157	207	106	144	bc
Calamus	T09-07846	0	77	8.7	HSB	HSB	125	225	166	186	122	174	157	207	106	150	b
Calamus	T09-07847	0	69	6.4	HSB	HSB	125	225	166	186	122	174	157	207	106	150	b
Calamus	T09-07848	0	70	7.4	HSB	HSB	125	213	166	186	130	174	157	207	106	150	b
Calamus	T09-07849	0	67	5.8	HSB	HSB	125	155	166	192	134	172	157	199	106	160	b
Calamus	T09-07850	0	64	4.8	HSB	HSB	125	155	166	192	130	174	157	199	106	160	b
Calamus	T09-07851	0	63	4.8	HSB	HSB	125	155	166	190	130	174	157	199	106	150	b
Calamus	T09-07852	0	56	3.3	HSB	HSB	125	155	166	190	130	172	157	199	106	150	b
Calamus	T09-07853	0	53	3.0	HSB	HSB							157	207	106	152	u
Calamus	T09-07854	0	56	3.3	HSB	HSB	125	219	166	192	134	174	157	199	106	160	bc
Calamus	T09-08206	0	51	2.3	HSB	HSB	125	213	166	186	130	174	157	207	106	144	u
Calamus	T09-08207	0	48	1.9	HSB	HSB	125	213	166	186							u
Calamus	T09-08208	0	43	1.3	HSB	HSB	125	219	166	190	144	174	157	199	106	160	u
Calamus	T09-08209	0	47	1.8	HSB	HSB	125	213	166	186	122	174	157	207	106	150	u
Calamus	T09-08210	0	41	1.1	HSB	HSB	125	155	166	190	134	172	157	199	106	160	u
Calamus	T09-08211	0	41	1.2	HSB	HSB	125	155	166	190	134	174	157	199	106	160	u
Calamus	T09-08212	0	37	1.0	HSB	HSB	125	155	166	190	130	172	157	199	106	160	u
Calamus	T09-08213	0	45	1.5	HSB	HSB	125	225	170	186	122	174	157	199	106	150	u
Calamus	T09-08214	0	44	1.6	HSB	HSB	125	155	166	190	130	174	157	199	106	150	u
Calamus	T09-08215	0	39	1.1	HSB	HSB	125	213	166	186	130	174	157	199	106	144	u
Calamus	T09-08216	0	43	1.4	HSB	HSB	125	149	166	186	144	174	157	199	106	150	u
Calamus	T09-08217	0	43	1.5	HSB	HSB	125	155	166	190	130	172	157	199	106	160	u
Calamus	T09-08218	0	41	1.0	HSB	HSB	125	155	166	190	130	172	157	199	106	160	u

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T09-08219	0	44	1.3	HSB	HSB	125	219	168	190	144	174	157	199	106	160	u
Calamus	T09-08220	0	44	1.4	HSB	HSB	125	213	166	186	130	174	157	207	106	150	u
Calamus	T09-08221	0	41	1.3	HSB	HSB	125	219	168	186	122	174	157	201	106	152	u
Calamus	T09-08222	0	42	1.2	HSB	HSB	125	219	166	188	134	174	157	199	106	150	u
Calamus	T09-08223	0	46	1.8	HSB	HSB	125	149	166	190	130	174	157	199	106	160	u
Calamus	T09-08224	0	42	1.2	HSB	HSB	125	213	170	186	130	174	157	207	106	150	u
Calamus	T09-08225	0	43	1.5	HSB	HSB	125	213	166	186	122	174	157	199	106	150	u
Calamus	T09-08226	0	44	1.5	HSB	HSB	125	219	166	190	134	174					u
Calamus	T09-08227	0	44	1.5	HSB	HSB			166	186	122	174					u
Calamus	T09-08228	0	44	1.6	HSB	HSB	125	149	166	186	130	174	157	199	106	150	u
Calamus	T09-08229	0	40	1.2	HSB	HSB	125	219	166	190	138	174	157	201	106	150	u
Calamus	T09-08230	0	42	1.4	HSB	HSB	125	213	166	186	122	174	157	207	106	150	u
Calamus	T09-08231	0	46	1.8	HSB	HSB	125	225	166	186	130	174	157	207	106	144	u
Calamus	T09-08232	0	44	1.5	HSB	HSB	125	225	166	186	130	174	157	207	106	150	u
Calamus	T09-08233	0	42	1.5	HSB	HSB	125	155	166	190	130	174	157	199	106	160	u
Calamus	T09-08234	0	46	1.8	HSB	HSB	125	213	170	186	130	174	157	199	106	150	u
Calamus	T09-08235	0	42	1.4	HSB												y
Calamus	T09-08236	0	42	1.4	HSB	HSB	125	225	166	186	130	174	157	207	106	150	u
Calamus	T09-08237	0	43	1.6	HSB	HSB	125	219	166	192	134	172	157	199	106	160	u
Calamus	T09-08238	0	41	1.2	HSB	HSB	125	213	166	186	130	174	157	207	106	150	u
Calamus	T09-08239	0	41	1.2	HSB	HSB	125	149	166	186	130	174	157	199	106	150	u
Calamus	T09-08240	0	43	1.4	HSB	HSB	125	219	166	190	130	172	157	199	106	160	u
Calamus	T09-08241	0	44	1.5	HSB	HSB	125	225	170	186	122	174	157	207	106	144	u
Calamus	T09-08242	0	41	1.2	HSB	HSB	125	225	166	186	122	174	157	207	106	144	u
Calamus	T09-08243	0	45	1.8	HSB	HSB	125	213	166	186	130	174	157	199	106	150	u

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T09-08244	0	41	1.4	HSB	HSB	125	219	166	188	130	174	157	199	106	150	u
Calamus	T09-08245	0	41	1.2	HSB	HSB	125	225	166	186	122	174	157	207	106	150	u
Calamus	T09-08246	0	46	1.8	HSB	HSB	125	213	166	186	130	174	157	199	106	144	u
Calamus	T09-08247	0	38	1.1	HSB	HSB	125	155	166	190	130	172	157	199	106	160	u
Calamus	T09-08248	0	38	1.0	HSB	HSB	125	219	166	190	134	174	157	199	106	160	u
Calamus	T09-08249	0	40	1.3	HSB	HSB	125	155	166	190	130	174	157	199	106	160	u
Calamus	T09-08250	0	46	2.0	HSB	HSB	125	219	166	188	134	174	157	199	106	150	u
Calamus	T09-08251	0	45	1.6	HSB	HSB	125	219	166	190	144	174	157	199	106	160	u
Calamus	T09-08252	0	45	1.7	HSB	HSB	125	213	166	186	130	174	157	199	106	150	u
Calamus	T09-08253	0	46	1.4	HSB	HSB	125	213	166	186	122	174	157	199	106	150	u
Calamus	T09-08254	0	43	1.7	HSB	HSB	125	165	166	190	138	174	157	201	106	150	u
Calamus	T09-08255	0	41	1.5	HSB	HSB	125	155	166	188	130	174	157	199	106	150	u
Calamus	T09-08256	0	45	1.8	HSB	HSB	125	149	166	190	144	174	157	199	106	160	u
Calamus	T09-08257	0	46	1.9	HSB	HSB	125	219	166	190	144	174	157	199	106	160	u
Calamus	T09-08258	0	44	1.5	HSB	HSB	125	225	166	186	122	174	157	207	106	144	u
Calamus	T09-08259	0	36	1.0	HSB	HSB	125	155	166	188	130	172	157	199	106	150	u
Calamus	T09-08260	0	36	0.9	HSB	HSB	125	219	166	188	130	174	157	199	106	150	u
Calamus	T09-08261	0	44	1.7	HSB	HSB	125	155	166	188	130	174	157	199	106	150	u
Calamus	T09-08262	0	46	1.9	HSB	HSB	125	219	166	190	130	172	157	199	106	160	u
Calamus	T09-08263	0	34	0.8	HSB	HSB	125	155	166	190	130	174	157	199	106	160	u
Calamus	T09-08264	0	35	0.8	HSB	HSB	125	219	166	190	134	174	157	199	106	160	u
Calamus	T09-08265	0	42	1.5	HSB	HSB	125	219	166	186	144	174	157	199	106	160	u
Calamus	T09-08266	0	44	1.7	HSB	HSB	125	213	166	186	122	174	157	199	106	144	u
Calamus	T09-08267	0	44	1.7	HSB												y
Calamus	T09-08268	0	43	1.6	HSB												y

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Calamus	T09-08269	0	41	1.3	HSB												y
Enders	T08-05930	0	87	14.8	HSB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T08-05931	1	193	111.1	WHB	WHB	125	125	170	170	176	176	157	157	106	106	b
Enders	T08-05932	1	180	89.4	WHB	WHB	125	125	170	170	174	176	157	157	106	106	b
Enders	T08-05933	0	102	18.3	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T08-05934	1	174	103.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T08-05935	0	100	23.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-05936	0	107	26.4	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-05937	1	180	108.9	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Enders	T08-05938	0	95	19.4	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-05950	0	103	25.9	HSB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-05951	0	100	22.0	HSB	WHB	125	125	170	170	174	176	157	157	106	106	bc
Enders	T08-05952	0	100	22.2	HSB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T08-05953	0	83	13.0	WHB	WHB	125	125	166	168	174	176			106	106	bc
Enders	T08-05959	0	98	19.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T08-05960	0	90	15.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-05961	0	102	20.7	HSB	WHB	125	125	166	166	176	176	157	157	106	106	b
Enders	T08-05962	0	102	21.3	HSB	WHB	125	125	166	168							bc
Enders	T08-05966	0	107	28.2	HSB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T08-05967	0	90	15.1	HSB	WHB	125	125	168	170	174	174	157	157	106	106	bc
Enders	T08-05968	0	98	21.4	HSB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T08-05969	0	99	18.8	HSB	WHB	123	125	170	170	176	176	157	157	106	106	b
Enders	T08-05970	0	103	23.7	HSB	WHB	125	125	170	170	174	176			106	106	bc
Enders	T08-05971	0	92	17.5	HSB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-05972	0	103	24.8	HSB	WHB	127	127	168	170	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Enders	T08-05975	0	102	21.8	HSB	WHB	125	125	166	166			157	157	106	106	b
Enders	T08-05976	0	96	20.1	HSB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T08-05978	0	89	15.7	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T08-05979	0	95	16.0	WHB	WHB	125	125	168	170	174	174	157	157	106	106	bc
Enders	T08-05983	0	98	21.0	HSB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-05984	0	102	20.4	HSB	WHB	125	125	168	168	174	174	157	157	106	106	b
Enders	T08-05999	0	87	14.7	HSB												y
Enders	T08-06000	0	97	20.7	HSB	WHB							157	157	106	106	bc
Enders	T08-06001	0	94	19.2	HSB	WHB							157	157	106	106	b
Enders	T08-06002	0	85	15.2	HSB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06003	0	90	15.8	HSB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Enders	T08-06004	0	94	18.4	HSB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T08-06011	0	91	16.3	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-06012	0	85	14.1	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T08-06013	0	99	20.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T08-06016	0	91	16.3	WHB	WHB							157	157	106	106	bc
Enders	T08-06017	0	88	12.9	WHB	WHB	125	127	166	170	174	174	157	157	106	106	b
Enders	T08-06022	0	87	14.3	HSB	WHB	125	125	166	168	174	176	157	157	106	106	b
Enders	T08-06023	0	96	18.6	HSB	WHB	125	125	166	170	174	174	157	157	106	106	b
Enders	T08-06026	0	83	13.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Enders	T08-06027	0	83	12.8	WHB	WHB	125	125	166	168	174	176			106	106	b
Enders	T08-06028	1	185	138.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T08-06029	0	81	12.4	WHB	WHB							157	157	106	106	bc
Enders	T08-06048	0	100	20.0	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06049	1	180	124.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Enders	T08-06050	1	181	129.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T08-06051	1	177	109.0	WHB	WHB	125	125	170	170	176	176	157	157	106	106	bc
Enders	T08-06070	1	180	118.2	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-06071	0	108	29.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06072	0	119	35.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06073	0	108	27.4	WHB												y
Enders	T08-06074	0	108	26.5	WHB	WHB	125	125	162	166	174	176	157	157	106	106	bc
Enders	T08-06075	0	121	38.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06077	1	174	112.8	WHB	WHB							157	157	106	106	bc
Enders	T08-06078	1	192	158.4	WHB	WHB			166	166	176	176	157	157	106	106	bc
Enders	T08-06079	1	197	173.2	WHB	WHB	125	125	162	170	174	174	157	157	106	106	bc
Enders	T08-06080	1	178	114.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Enders	T08-06081	1	167	94.2	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06082	1	187	146.3	WHB	WHB	125	125	170	170	174	176	157	157	106	106	bc
Enders	T08-06083	1	186	127.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T08-06084	1	200	183.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T08-06085	0	111	27.8	WHB	WHB							157	157	106	106	bc
Enders	T08-06086	0	100	22.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06131	1	182	158.3	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Enders	T08-06132	1	189	170.5	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06133	1	187	155.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06134	1	167	116.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06135	1	185	138.5	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Enders	T08-06136	1	169	116.6	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Enders	T08-06137	1	176	142.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Enders	T08-06138	1	165	106.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Enders	T08-06139	1	178	153.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Enders	T08-06140	1	186	178.7	WHB	WHB	125	125	166	168	176	176	157	157	106	106	b
Enders	T08-06141	1	181	166.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Enders	T08-06142	1	192	180.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Enders	T08-06143	1	173	115.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-06144	1	164	107.1	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Enders	T08-06145	1	185	164.4	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06146	1	175	161.6	WHB	WHB	125	125	170	170	176	176	157	157	106	106	b
Enders	T08-06147	1	165	103.1	WHB	WHB	125	125	170	170	174	174	157	157	106	106	b
Enders	T08-06148	1	174	157.5	WHB	WHB	125	125	166	170	176	176			106	106	b
Enders	T08-06149	1	181	156.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-06150	1	176	137.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Enders	T08-06151	1	169	120.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06152	1	189	184.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Enders	T08-06153	1	169	115.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06154	1	190	187.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Enders	T08-06155	1	172	125.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T08-06156	1	163	111.0	WHB	WHB	125	125	168	170	174	176	157	157	106	106	b
Enders	T08-06157	1	166	117.7	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Enders	T08-06158	1	174	129.1	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06159	1	176	148.2	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Enders	T08-06160	1	166	113.4	WHB	WHB	125	125	168	170	174	174	157	157	106	106	bc
Enders	T08-06161	1	186	163.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Enders	T08-06162	1	187	169.9	WHB	WHB	125	127	166	168	174	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Enders	T08-06163	1	178	139.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Enders	T08-06164	1	182	129.9	WHB	WHB							157	157	106	106	bc
Enders	T08-06165	1	166	109.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Enders	T08-06166	1	166	100.2	WHB	WHB	125	125	168	170	176	176	157	157	106	106	b
Enders	T08-06167	1	208	226.7	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T08-06168	1	189	190.6	WHB	WHB							157	157	106	106	bc
Enders	T08-06169	1	183	141.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Enders	T09-07855	0	71	6.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T09-07856	0	69	6.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07857	0	82	11.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07858	0	98	21.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T09-07859	0	82	11.3	WHB	WHB	125	125	170	170	176	176	157	157	106	106	bc
Enders	T09-07860	0	90	15.4	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07861	0	106	25.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T09-07862	0	110	29.1	WHB	WHB	125	125	170	170	174	176	157	157	106	106	bc
Enders	T09-07863	0	121	41.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07864	0	102	25.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T09-07865	0	146	80.0	WHB	WHB	125	125	170	170	174	176	157	157	106	106	bc
Enders	T09-07866	0	133	60.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07867	0	127	49.0	WHB	WHB	125	125	168	170	174	176	157	157	106	106	bc
Enders	T09-07868	0	140	63.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T09-07869	0	142	76.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T09-07870	0	101	22.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07871	0	134	59.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Enders	T09-07872	0	102	23.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Enders	T09-07873	0	137	61.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Enders	T09-07874	0	123	45.8	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07875	0	122	42.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07876	0	127	51.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07877	0	108	28.1	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07878	0	133	56.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07879	0	130	53.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07880	0	130	54.8	WHB	WHB	125	125	170	170	174	174	157	157	106	106	bc
Enders	T09-07881	0	111	30.6	Fx	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T09-07882	0	100	23.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07883	0	128	51.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07884	0	104	28.5	WHB	WHB	125	125	162	166	174	174	157	157	106	106	bc
Enders	T09-07885	0	119	40.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Enders	T09-07886	0	120	43.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07887	0	129	53.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07888	0	140	65.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Enders	T09-07889	0	104	30.5	WHB	WHB	125	125	168	170	174	176	157	157	106	106	bc
Enders	T09-07890	0	137	69.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07891	0	119	40.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07892	0	135	59.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07893	0	118	40.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07894	0	133	59.7	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T09-07895	0	133	60.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07896	0	118	38.2	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T09-07897	0	111	34.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Enders	T09-07898	0	115	33.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07899	1	225	268.2	Fx	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T09-07900	0	122	40.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Enders	T09-07901	0	112	32.7	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Enders	T09-07902	0	159	100.7	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Enders	T09-07903	0	130	48.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07904	0	153	87.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07905	0	163	113.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Enders	T09-07906	0	130	55.8	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07907	0	148	77.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Enders	T09-07908	0	135	60.2	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Enders	T09-07909	0	145	73.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07910	0	118	35.1	WHB	WHB	125	125	162	170	174	176	157	157	106	106	bc
Enders	T09-07911	0	102	22.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Enders	T09-07912	0	86	14.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T08-06296	1	161	80.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06297	0	129	41.9	HSB	WHB	125	127	162	168	174	176	157	157	106	106	z
Harlan County	T08-06298	1	151	75.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06299	1	152	72.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06300	1	153	72.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06301	1	153	73.9	WHB	WHB	125	125	162	166	174	174	157	157	106	106	b
Harlan County	T08-06302	0	115	34.8	WHB	HSB	125	247	168	192	142	174	157	191	106	138	z
Harlan County	T08-06303	0	131	45.3	HSB	WHB	125	125	166	170	174	176			106	106	z
Harlan County	T08-06304	1	152	71.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06305	1	147	66.3	WHB	WHB	125	125	162	166	174	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T08-06306	1	156	78.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Harlan County	T08-06307	1	151	69.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Harlan County	T08-06308	1	160	81.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Harlan County	T08-06309	1	162	81.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06310	1	152	69.0	HSB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06311	0	119	39.1	WHB	HSB	125	179	170	192	142	174			106	138	z
Harlan County	T08-06312	0	115	36.2	WHB	WHB	125	125	166	168	176	176			106	106	bc
Harlan County	T08-06313	0	109	31.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06314	0	109	33.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06315	0	111	32.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06316	0	113	34.7	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Harlan County	T08-06317	0	111	29.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06318	1	156	75.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06319	1	153	77.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06320	1	154	79.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Harlan County	T08-06321	1	163	84.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06322	1	147	62.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Harlan County	T08-06323	1	154	72.5	WHB	WHB	125	125	162	168	174	176	157	157	106	106	b
Harlan County	T08-06324	1	154	76.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06325	1	155	72.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06337	1	150	69.7	WHB	WHB	125	127	166	168	174	176	157	157	106	106	b
Harlan County	T08-06338	1	153	74.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06339	1	152	77.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06340	0	107	28.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06341	0	114	35.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T08-06342	0	107	31.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06343	0	103	28.2	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Harlan County	T08-06344	0	126	46.3	HSB	HSB	125	185	166	186	122	174	157	199	106	160	b
Harlan County	T08-06345	0	135	49.5	HSB	HSB	125	179	170	194	142	174	157	191	106	150	b
Harlan County	T08-06346	1	147	71.3	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Harlan County	T08-06347	1	153	74.4	WHB	WHB	125	127	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06348	1	155	81.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06349	0	109	30.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06350	0	110	31.4	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Harlan County	T08-06351	0	117	37.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Harlan County	T08-06352	0	107	28.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T08-06353	0	126	46.0	HSB	HSB	125	179	166	192	142	174	157	191	106	138	b
Harlan County	T08-06354	0	122	42.2	HSB	HSB	125	185	166	186	122	174	157	199	106	144	b
Harlan County	T08-06355	0	137	59.5	HSB	HSB	125	179	170	194	142	174	157	199	106	150	b
Harlan County	T08-06356	0	110	31.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06357	0	98	24.9	WHB	WHB	125	125	162	166	174	174	157	157	106	106	b
Harlan County	T08-06358	0	97	22.5	WHB	WHB	125	125	162	166	174	176	157	157	106	106	bc
Harlan County	T08-06359	0	113	37.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06360	0	114	40.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06361	0	134	57.4	HSB	HSB	125	185	166	186	130	174	157	205	106	138	b
Harlan County	T08-06362	0	108	34.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06363	0	105	30.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06364	0	102	29.1	WHB	WHB	125	125	166	170	174	174			106	106	b
Harlan County	T08-06365	0	100	26.3	WHB	WHB	125	125	170	170	174	176	157	157	106	106	b
Harlan County	T08-06366	0	107	33.6	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T08-06367	0	106	32.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Harlan County	T08-06368	0	105	30.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06369	0	130	48.1	HSB	HSB	125	185	166	186	130	174	157	199	106	138	b
Harlan County	T08-06370	0	105	31.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06371	0	103	28.8	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06372	0	107	36.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06373	0	130	52.5	HSB	HSB	125	247	166	194	142	174					b
Harlan County	T08-06374	0	132	50.7	HSB	F_x	125	185	166	192	138	174			106	106	w
Harlan County	T08-06375	0	104	30.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06376	0	120	46.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06377	0	116	42.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06378	0	117	36.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06379	0	108	31.5	WHB	WHB	125	125	168	168	176	176	157	157	106	106	b
Harlan County	T08-06380	0	133	49.7	HSB	HSB	125	179	170	194	142	174	157	199	106	148	b
Harlan County	T08-06381	0	129	49.7	HSB	HSB	125	247	166	194	142	174					b
Harlan County	T08-06382	0	126	46.3	HSB	F_x	125	125							106	156	w
Harlan County	T08-06383	1	154	93.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06384	1	139	64.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T08-06385	1	151	79.8	WHB	WHB	125	125	166	168	174	174					b
Harlan County	T08-06386	1	150	82.4	WHB	WHB	125	125	168	170	176	176	157	157	106	106	b
Harlan County	T08-06387	1	146	79.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Harlan County	T08-06388	1	151	79.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Harlan County	T08-06389	1	149	82.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T08-06390	1	150	74.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T08-06391	1	150	79.1	WHB	WHB	125	125	162	166	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T08-06392	1	148	76.5	WHB	WHB	125	125	168	170	174	174	157	157	106	106	b
Harlan County	T08-06393	1	147	76.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Harlan County	T08-06394	1	145	68.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06395	1	150	78.3	WHB	WHB	125	125	168	170	174	176	157	157	106	106	bc
Harlan County	T08-06396	1	143	67.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T08-06397	1	154	82.6	WHB	WHB	125	125	162	168	174	174	157	157	106	106	bc
Harlan County	T08-06398	1	141	75.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06399	1	145	72.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Harlan County	T08-06400	1	143	67.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Harlan County	T08-06401	1	146	73.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Harlan County	T08-06402	1	138	63.0	WHB	WHB	125	125	168	170	174	176	157	157	106	106	b
Harlan County	T08-06403	1	148	77.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T08-06404	1	150	76.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Harlan County	T08-06405	1	144	75.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06406	1	154	82.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Harlan County	T08-06458	1	180	88.2	WHB	WHB	125	125	166	166	174	174			106	106	t
Harlan County	T08-06459	1	183	103.1	WHB	WHB	125	125	166	170	174	174			106	106	t
Harlan County	T08-06460	1	190	124.4	WHB	WHB	125	125	166	166	174	174	157	157	106	106	t
Harlan County	T08-06461	1	183	108.6	WHB	WHB	125	125	166	168	174	174	157	157	106	106	t
Harlan County	T09-07703	2	187	113.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Harlan County	T09-07704	2	177	99.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Harlan County	T09-07705	2	176	104.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	a
Harlan County	T09-07706	2	172	95.8	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Harlan County	T09-07707	2	180	108.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Harlan County	T09-07708	2	166	74.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T09-07709	2	180	114.5	WHB	WHB	125	127	166	166	174	174	157	157	106	106	a
Harlan County	T09-07710	2	181	105.9	WHB												y
Harlan County	T09-07711	2	173	116.3	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Harlan County	T09-07712	2	182	116.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Harlan County	T09-07713	2	183	109.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Harlan County	T09-07714	1	184	102.4	HSB	HSB	125	247	166	194	142	174	157	199	106	150	abc
Harlan County	T09-07715	1	183	105.3	HSB	HSB	125	247	168	192	142	174	157	199	106	138	abc
Harlan County	T09-07716	1	184	101.1	HSB	HSB	125	185	166	194	142	174	157	199	106	150	abc
Harlan County	T09-07717	1	193	114.9	HSB	HSB	125	185	166	194	142	174	157	199	106	150	abc
Harlan County	T09-07718	2	170	87.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Harlan County	T09-07719	2	181	100.4	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Harlan County	T09-07720	2	199	162.6	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Harlan County	T09-07721	1	203	151.1	HSB	HSB	125	179			142	174	157	199	106	138	abc
Harlan County	T09-07722	2	190	132.8	WHB	WHB	125	125	162	168	174	176	157	157	106	106	a
Harlan County	T09-07723	2	181	111.8	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Harlan County	T09-07724	2	200	169.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Harlan County	T09-07725	2	162	92.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Harlan County	T09-07726	2	183	142.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Harlan County	T09-07727	2	182	120.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	a
Harlan County	T09-07728	1	197	130.9	HSB	HSB	125	247	170	192	142	174	157	199	106	138	ab
Harlan County	T09-07729	2	193	149.7	WHB	WHB	125	125	166	170	174	174	157	157	106	106	a
Harlan County	T09-07730	0	104	27.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	abc
Harlan County	T09-07913	0	121	43.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07914	0	134	58.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07915	0	127	52.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T09-07916	0	117	39.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Harlan County	T09-07917	0	125	51.4	WHB	WHB	125	127	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07918	0	125	52.4	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Harlan County	T09-07919	0	120	42.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Harlan County	T09-07920	0	119	43.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07921	0	116	41.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Harlan County	T09-07922	0	116	39.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07923	0	112	37.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Harlan County	T09-07924	0	118	44.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Harlan County	T09-07925	0	133	55.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07926	0	121	45.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07927	0	118	42.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07928	0	123	47.6	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Harlan County	T09-07929	0	132	55.9	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Harlan County	T09-07930	0	130	57.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07931	0	118	42.0	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Harlan County	T09-07932	0	114	37.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Harlan County	T09-07933	0	111	36.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07934	0	111	34.3	WHB	WHB	125	125	162	168	174	176	157	157	106	106	bc
Harlan County	T09-07935	0	114	39.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07936	0	123	53.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07937	0	120	45.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07938	0	112	38.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07939	0	119	42.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07940	0	124	48.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T09-07941	0	113	38.2	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07942	0	122	47.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07943	0	122	49.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07944	0	119	44.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07945	0	119	41.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07946	2	165	102.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	x
Harlan County	T09-07947	1	154	82.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07948	2	154	77.1	WHB	WHB	125	125	166	168	174	176	157	157	106	106	x
Harlan County	T09-07949	2	174	110.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	x
Harlan County	T09-07950	1	149	77.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Harlan County	T09-07951	2	168	103.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	x
Harlan County	T09-07952	2	167	96.3	WHB	WHB	125	125	168	168	174	174	157	157	106	106	x
Harlan County	T09-07953	2	162	94.3	WHB	WHB	125	125	168	168	174	176	157	157	106	106	x
Harlan County	T09-07954	2	172	105.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	x
Harlan County	T09-07955	2	177	121.7	WHB	WHB	125	125	166	168	176	176	157	157	106	106	x
Harlan County	T09-07956	2	156	90.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	x
Harlan County	T09-07957	2	163	96.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	x
Harlan County	T09-07958	1	172	100.0	HSB	HSB	125	179	166	194	142	174	157	199	106	150	bc
Harlan County	T09-07959	2	169	101.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	x
Harlan County	T09-07960	2	175	111.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	x
Harlan County	T09-07961	1	155	80.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07962	2	160	86.2	WHB	WHB	125	125	166	170	174	176	157	157	106	106	x
Harlan County	T09-07963	1	162	92.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Harlan County	T09-07964	2	172	98.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	x
Harlan County	T09-07965	1	170	97.8	HSB	HSB	125	247	170	194	142	174	157	191	106	138	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Harlan County	T09-07966	0	130	55.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07967	0	117	40.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Harlan County	T09-07968	1	140	55.3	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Harlan County	T09-07969	1	170	90.0	HSB	HSB	125	247	166	194	142	174	157	199	106	150	bc
Harlan County	T09-07970	1	170	93.2	HSB	HSB	125	179	168	194	142	174	157	199	106	150	bc
Harlan County	T09-07971	1	189	137.3	HSB	HSB	125	179	170	194	142	174	157	191	106	150	bc
Harlan County	T09-07972	1	185	125.2	HSB	HSB	125	185	166	194	138	174	157	199	106	150	bc
Harlan County	T09-07973	2	166	96.4	WHB	WHB	125	125	166	166	174	174	157	157	106	106	x
Harlan County	T09-07974	2	168	101.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	x
Johnson	T09-07731	0	115	31.9	HSB	HSB	125	219	166	186	138	174	157	207	106	152	a
Johnson	T09-07732	0	126	41.9	HSB	HSB	125	155	166	192	134	174	157	199	106	160	a
Johnson	T09-07733	0	98	22.9	WHB	WHB	125	125	166	170	176	176	157	157	106	106	a
Johnson	T09-07734	0	92	16.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	a
Johnson	T09-07735	0	104	26.1	WHB	WHB	125	125	168	168	174	174	157	157	106	106	a
Johnson	T09-07736	0	98	23.7	WHB	WHB	125	125	168	170	174	174	157	157	106	106	a
Johnson	T09-07737	0	115	34.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Johnson	T09-07738	0	98	22.4	WHB	WHB	125	125	170	170	174	176	157	157	106	106	a
Johnson	T09-07739	0	91	18.9	WHB	WHB	125	125	166	168	176	176	157	157	106	106	a
Johnson	T09-07740	0	95	20.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	a
Johnson	T09-07741	0	92	20.5	WHB	WHB	125	125	162	166	174	176	157	157	106	106	a
Johnson	T09-07742	0	112	30.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07743	0	116	25.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07744	0	100	22.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07745	0	114	33.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Johnson	T09-07746	0	97	20.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Johnson	T09-07747	0	96	21.5	WHB	WHB	125	127	162	168	174	174	157	157	106	106	a
Johnson	T09-07748	0	92	18.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Johnson	T09-07749	0	107	26.8	WHB	WHB	125	127	166	168	174	176	157	157	106	106	a
Johnson	T09-07750	0	102	23.1	WHB	WHB	125	125	166	170	174	176	157	157	106	106	a
Johnson	T09-07751	0	93	20.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Johnson	T09-07752	0	99	23.4	WHB	WHB	125	127	168	170	174	176	157	157	106	106	a
Johnson	T09-07753	0	108	29.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07754	0	103	26.5	WHB	WHB	125	125	168	168	174	174	157	157	106	106	a
Johnson	T09-07755	0	92	19.2	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Johnson	T09-07756	0	107	28.7	WHB	WHB	125	125	162	166	176	176	157	157	106	106	a
Johnson	T09-07757	0	110	31.8	WHB	WHB							157	157	106	106	a
Johnson	T09-07758	0	107	26.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Johnson	T09-07759	0	110	31.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07760	0	104	26.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Johnson	T09-07761	0	107	28.7	WHB	WHB	125	125	162	166	174	174	157	157	106	106	a
Johnson	T09-07762	0	108	29.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07763	0	95	20.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07764	0	92	17.9	WHB	WHB	125	125	162	166	174	176	157	157	106	106	a
Johnson	T09-07765	0	120	35.9	WHB	WHB	125	125	166	170	174	174	157	157	106	106	a
Johnson	T09-07766	0	102	24.1	WHB	WHB	125	125	166	168	174	176			106	106	a
Johnson	T09-07767	0	115	35.0	WHB	WHB	125	125	166	170	176	176	157	157	106	106	a
Johnson	T09-07768	0	123	41.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07769	0	111	31.6	WHB	WHB	125	125	166	170	176	176	157	157	106	106	a
Johnson	T09-07770	0	91	18.8	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07771	0	107	26.9	WHB	WHB	125	125	162	170	174	176	157	157	106	106	a

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID$_f$	ID$_g$	1137		1138		1144		1067		1085		A
Johnson	T09-07772	0	95	20.1	WHB	WHB	125	125	166	168	176	176	157	157	106	106	a
Johnson	T09-07773	0	105	28.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07774	0	105	25.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	a
Johnson	T09-07775	0	97	22.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07776	0	102	24.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	a
Johnson	T09-07777	0	108	31.8	WHB	WHB	125	125	166	170	174	176	157	157	106	106	a
Johnson	T09-07778	0	98	24.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	a
Johnson	T09-07779	0	113	29.5	HSB	HSB	125	149	166	192	130	174	157	199	106	160	a
Johnson	T09-07780	0	103	22.9	HSB	HSB	125	225	166	186	130	174	157	199	106	150	a
Johnson	T09-07781	0	117	30.7	HSB	HSB	125	155	166	190	130	172	157	199	106	150	a
Johnson	T09-07782	0	137	48.8	HSB	HSB	125	149	168	192	144	174	157	199	106	160	a
Johnson	T09-07783	0	116	28.7	HSB	HSB	125	213	166	186	130	174	157	205	106	150	a
Johnson	T09-07784	0	106	27.0	WHB	WHB	125	125	168	168	176	176	157	157	106	106	a
Johnson	T09-07785	0	112	29.8	WHB	WHB	125	125	162	166	174	174	157	157	106	106	a
Johnson	T09-07786	0	104	24.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	a
Johnson	T09-07787	0	111	30.3	WHB	WHB	125	125	168	168	174	174	157	157	106	106	a
Johnson	T09-07788	0	95	20.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Johnson	T09-07789	0	107	27.9	WHB	WHB	125	125	168	170	174	176	157	157	106	106	a
Johnson	T09-07790	0	97	22.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07791	0	111	29.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	a
Johnson	T09-07792	0	105	24.0	WHB	WHB	125	125	162	170	174	176	157	157	106	106	a
Johnson	T09-07793	0	97	21.7	WHB	WHB	125	125	162	166	176	176	157	157	106	106	a
Johnson	T09-07794	0	99	23.0	WHB	WHB	125	125	166	168	176	176	157	157	106	106	a
Johnson	T09-07795	0	103	25.2	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Johnson	T09-07796	0	93	18.5	WHB	WHB	125	125	166	168	176	176	157	157	106	106	a

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Johnson	T09-07797	0	109	30.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Johnson	T09-07798	0	99	22.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	a
Johnson	T09-07799	0	97	21.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	a
Johnson	T09-07800	0	97	20.8	WHB	WHB	125	125	166	170	174	176	157	157	106	106	a
Johnson	T09-07801	0	94	18.6	WHB	WHB	125	125	166	168	174	174	157	157	106	106	a
Johnson	T09-07802	0	107	26.9	WHB												y
Med. Creek	T08-05904	1	209	227.6	WHB	WHB	125	125	166	170	176	176	157	157	106	106	v
Med. Creek	T08-05905	1	163	104.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	v
Med. Creek	T08-05906	0	120	45.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Med. Creek	T08-05907	0	90	16.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	v
Med. Creek	T08-05908	1	217	246.6	WHB	WHB	125	125	166	170	176	176	157	157	106	106	v
Med. Creek	T08-05909	1	180	135.0	WHB	WHB	125	125	166	170	174	174	157	157	106	106	v
Med. Creek	T08-05910	1	217	224.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Med. Creek	T08-05911	1	163	90.1	WHB	WHB	125	125	170	170	174	176	157	157	106	106	v
Med. Creek	T08-05912	0	86	15.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Med. Creek	T08-05913	0	92	20.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Med. Creek	T08-05914	1	177	124.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	v
Med. Creek	T08-05915	0	127	53.6	WHB	WHB	125	125	166	170	174	176	157	157	106	106	v
Med. Creek	T08-05916	0	107	28.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Med. Creek	T08-05917	0	76	9.4	WHB	WHB	125	125	166	170	176	176	157	157	106	106	v
Med. Creek	T08-05918	1	171	106.2	WHB	WHB	125	125	166	170	174	176	157	157	106	106	v
Med. Creek	T08-05919	0	108	33.1	WHB	WHB	125	125	166	166	174	176			106	106	v
Med. Creek	T08-05920	0	120	41.3	WHB	WHB	125	125	166	170	174	176	157	157	106	106	v
Med. Creek	T08-05921	0	109	32.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Med. Creek	T08-05922	0	99	22.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T08-05923	0	115	33.1	HSB	HSB	125	225	166	186	142	174	157	199	106	156	v
Med. Creek	T08-05945	0	103	22.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-05946	0	81	11.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-05947	1	174	118.4	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Med. Creek	T08-05948	0	121	42.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-05949	0	91	14.8	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-05954	0	88	15.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-05955	0	84	12.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-05956	1	170	114.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T08-05957	0	99	21.7	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-05958	0	98	20.0	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T08-05973	0	97	18.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Med. Creek	T08-05974	0	97	18.8	WHB	WHB	127	127	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-05988	1	185	139.2	WHB	WHB	125	125									bc
Med. Creek	T08-05989	1	210	226.4	WHB	WHB	125	125	166	170	174	174			106	106	u
Med. Creek	T08-05990	0	94	20.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-05991	0	106	28.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-05992	1	219	241.1	WHB	WHB	125	125									x
Med. Creek	T08-05994	0	81	11.2	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Med. Creek	T08-05995	0	85	14.6	WHB	WHB	125	125	166	170	174	174	157	157	106	106	b
Med. Creek	T08-05996	0	86	12.6	WHB	WHB	125	125	166	170	176	176			106	106	b
Med. Creek	T08-06018	1	176	118.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Med. Creek	T08-06019	1	178	143.6	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06020	0	103	24.9	WHB	WHB							157	157	106	106	b
Med. Creek	T08-06021	0	90	16.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T08-06030	1	155	90.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	u
Med. Creek	T08-06031	1	168	111.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	u
Med. Creek	T08-06032	0	93	19.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06033	0	84	14.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06036	0	93	20.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	u
Med. Creek	T08-06037	1	207	214.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	x
Med. Creek	T08-06038	1	199	177.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06039	0	88	12.4	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06040	0	74	9.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	u
Med. Creek	T08-06041	0	107	25.8	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06042	0	81	13.2	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06043	0	78	10.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	u
Med. Creek	T08-06044	0	97	20.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	u
Med. Creek	T08-06045	0	127	48.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	u
Med. Creek	T08-06046	1	167	98.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06087	0	111	30.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06088	0	111	32.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06089	0	102	24.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06090	0	101	24.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06198	0	112	35.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Med. Creek	T08-06199	0	115	38.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06200	0	117	36.8	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Med. Creek	T08-06201	0	112	31.9	WHB	WHB	125	125	168	170	174	176	157	157	106	106	bc
Med. Creek	T08-06202	0	134	50.5	HSB	HSB	125	247	166	194	142	174	157	191	106	150	bc
Med. Creek	T08-06203	0	110	30.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T08-06204	0	117	27.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06205	0	101	22.8	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06206	0	107	30.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06207	0	112	33.5	WHB	WHB	125	125	170	170	174	176	157	157	106	106	b
Med. Creek	T08-06208	0	108	30.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06209	0	103	27.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T08-06210	0	142	66.8	HSB	HSB	125	225	166	194	138	174	157	199	106	150	b
Med. Creek	T08-06211	0	111	33.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06212	0	110	29.9	WHB	WHB	125	125	162	170	174	176	157	157	106	106	b
Med. Creek	T08-06213	0	113	35.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06214	0	121	44.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06215	0	100	25.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Med. Creek	T08-06216	1	172	139.8	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06217	1	183	147.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06218	1	179	141.5	WHB	WHB							157	157	106	106	bc
Med. Creek	T08-06219	1	178	132.5	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Med. Creek	T08-06220	1	177	142.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06221	1	193	170.8	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06222	1	197	178.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T08-06223	1	183	156.4	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Med. Creek	T08-06224	1	181	144.2	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T08-06225	1	182	151.7	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06226	1	191	165.4	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Med. Creek	T08-06227	1	181	128.6	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Med. Creek	T08-06228	1	195	187.7	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T08-06229	1	193	169.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06230	1	179	137.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06231	1	164	105.1	WHB	WHB	125	125	162	170	174	176	157	157	106	106	b
Med. Creek	T08-06232	1	190	177.7	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06233	1	173	126.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06234	1	170	117.3	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Med. Creek	T08-06235	1	206	202.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Med. Creek	T08-06236	1	179	134.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06237	1	185	160.9	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T08-06238	1	170	113.8	WHB	WHB	125	125	166	166	174	176					bc
Med. Creek	T08-06239	1	183	144.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T08-06240	1	194	173.3	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T08-06241	1	177	135.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06242	1	187	152.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T08-06243	1	191	186.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06244	1	167	111.5	WHB	WHB	125	125	170	170	174	174	157	157	106	106	b
Med. Creek	T08-06245	1	186	166.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06246	0	171	113.2	HSB	HSB	125	185	166	192	138	172	157	207	106	158	b
Med. Creek	T08-06247	1	186	149.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T08-06248	1	190	176.1	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T08-06249	1	190	167.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06250	1	210	228.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06251	1	193	190.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T08-06252	1	178	141.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06253	1	175	138.2	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T08-06254	1	194	147.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T08-06255	1	171	120.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T08-06256	1	212	215.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Med. Creek	T09-07975	0	99	24.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-07976	0	76	9.8	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-07977	0	66	6.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-07978	0	77	10.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07979	0	80	10.7	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07980	0	93	18.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-07981	0	83	12.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07982	0	95	21.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07983	0	105	26.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-07984	0	105	29.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07985	1	158	77.0	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Med. Creek	T09-07986	0	97	23.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-07987	0	92	18.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-07988	0	86	14.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07989	0	91	18.6	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-07990	1	163	97.6	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-07991	1	166	102.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-07992	0	71	9.3	WHB	WHB	125	125	170	170	174	176	157	157	106	106	bc
Med. Creek	T09-07993	0	79	11.7	WHB	WHB	125	125	166	170	174	176					bc
Med. Creek	T09-07994	0	81	11.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Med. Creek	T09-07995	1	175	115.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-07996	2	217	238.0	WHB	WHB	125	125	170	170	176	176	157	157	106	106	x

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T09-07997	0	85	14.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-07998	2	214	248.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	x
Med. Creek	T09-07999	0	92	20.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08000	0	92	20.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08001	0	89	16.0	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Med. Creek	T09-08002	1	170	106.3	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Med. Creek	T09-08003	0	90	18.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08004	1	165	100.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08005	2	209	231.1	WHB	WHB	125	125	166	170	174	174	157	157	106	106	x
Med. Creek	T09-08006	0	95	19.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08007	0	106	24.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08008	0	95	20.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08009	0	94	19.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08010	1	182	131.5	WHB	WHB	125	125	170	170	176	176	157	157	106	106	bc
Med. Creek	T09-08011	1	160	87.7	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08012	1	190	164.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08013	1	174	111.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08014	1	177	113.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08015	1	168	99.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08016	1	179	119.9	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08017	1	153	77.2	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08018	1	187	145.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08019	1	172	106.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08020	0	88	15.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Med. Creek	T09-08021	1	172	107.8	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T09-08022	1	183	137.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08023	0	81	12.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08024	0	93	18.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08025	0	92	16.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08026	0	111	32.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08027	1	235	261.1	HSB	HSB	125	179	168	192	142	174	157	191	106	138	bc
Med. Creek	T09-08028	1	170	100.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08029	1	185	142.8	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08030	0	115	35.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08031	0	82	11.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08032	0	95	20.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08033	1	174	105.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Med. Creek	T09-08034	1	184	156.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08035	0	88	17.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-08036	0	92	19.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08037	1	178	140.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08038	1	161	103.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08039	1	174	130.9	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08040	1	178	141.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08041	1	174	127.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08042	1	163	106.7	WHB	WHB							157	157	106	106	bc
Med. Creek	T09-08043	1	178	159.3	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08044	1	155	97.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08045	1	161	106.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Med. Creek	T09-08046	1	169	113.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T09-08047	1	160	110.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08048	1	177	142.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08049	1	153	91.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08050	1	178	139.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08051	1	170	126.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Med. Creek	T09-08052	1	172	128.5	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08053	1	178	144.3	WHB	WHB	125	125	170	170	174	176	157	157	106	106	bc
Med. Creek	T09-08054	1	162	109.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08055	1	181	158.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08056	1	177	152.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08057	1	172	133.5	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08058	1	165	116.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08059	1	178	144.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08060	1	165	118.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08061	1	170	133.8	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08062	1	172	134.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08063	1	183	179.1	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Med. Creek	T09-08064	1	178	146.7	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08065	1	176	130.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08066	1	160	90.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-08067	1	170	122.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08068	1	154	92.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08069	0	103	27.8	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08070	0	111	34.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08071	0	98	25.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Med. Creek	T09-08072	0	100	25.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08073	0	102	27.4	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08074	0	98	23.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Med. Creek	T09-08075	0	109	34.0	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08076	0	97	23.7	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08077	0	91	18.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08078	0	97	23.1	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08079	0	94	23.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Med. Creek	T09-08080	0	105	29.8	WHB	WHB	125	125	166	170	176	176					bc
Med. Creek	T09-08081	0	92	19.7	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Med. Creek	T09-08082	0	109	30.7	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Med. Creek	T09-08083	0	90	18.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Med. Creek	T09-08084	0	98	22.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T08-05900	0	112	32.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	v
Red Willow	T08-05903	1	198	159.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	v
Red Willow	T08-05925	1	205	173.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	v
Red Willow	T08-05926	1	196	153.8	WHB	WHB	125	125	162	168	174	176	157	157	106	106	v
Red Willow	T08-05927	1	207	193.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	v
Red Willow	T08-05928	1	207	182.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	v
Red Willow	T08-05929	1	207	168.3	WHB	WHB	125	125	166	166	174	174	157	157	106	106	v
Red Willow	T08-05939	0	108	27.9	WHB	WHB	125	125	168	168	176	176	157	157	106	106	bc
Red Willow	T08-05940	0	113	32.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T08-05941	0	125	44.8	WHB	WHB	125	125	162	166	174	176	157	157	106	106	bc
Red Willow	T08-05942	0	121	37.5	WHB	WHB	125	125	168	168	174	174	157	157	106	106	bc
Red Willow	T08-05943	0	112	33.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T08-05944	0	123	42.2	WHB	WHB	125	125	166	168	174	176					bc
Red Willow	T08-05963	0	134	47.7	HSB	HSB	125	185	166	192	138	174	157	205	106	158	b
Red Willow	T08-05964	0	114	32.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-05965	0	108	27.6	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-05977	0	115	35.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-05980	0	111	30.4	WHB	WHB	127	127	162	168	174	174	157	157	106	106	bc
Red Willow	T08-05981	0	116	33.8	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Red Willow	T08-05982	0	125	41.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-05985	0	115	31.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-05986	0	124	41.6	WHB	WHB	125	125	166	168	176	176					bc
Red Willow	T08-05987	0	112	29.5	WHB	WHB	125	125	162	170	174	176	157	157	106	106	bc
Red Willow	T08-05993	1	245	294.2	HSB	F_x	125	125	170	190	142	142			106	154	w
Red Willow	T08-06056	1	194	162.6	HSB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-06057	1	207	188.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T08-06058	0	112	29.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Red Willow	T08-06059	0	125	34.5	HSB	WHB	125	125	166	166	174	176	157	157	106	106	b
Red Willow	T08-06091	1	203	158.4	HSB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-06092	0	127	45.6	WHB	WHB	125	125	166	170	176	176			106	106	bc
Red Willow	T08-06093	0	136	53.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Red Willow	T08-06094	0	130	49.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-06095	0	113	31.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06096	1	217	199.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06097	0	124	41.8	HSB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Red Willow	T08-06098	1	226	258.1	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T08-06099	0	130	49.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T08-06100	1	226	264.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06101	0	115	32.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Red Willow	T08-06102	0	126	43.1	WHB	WHB	125	125	162	168	174	174	157	157	106	106	b
Red Willow	T08-06103	1	208	189.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T08-06104	1	249	289.6	HSB	HSB	125	211	166	190	138	174	157	199	106	154	bc
Red Willow	T08-06105	0	131	46.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Red Willow	T08-06106	1	206	179.7	WHB	WHB	125	125	168	170	176	176	157	157	106	106	bc
Red Willow	T08-06107	0	125	40.1	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b
Red Willow	T08-06108	0	128	44.1	WHB	WHB	125	125	162	166	174	174	157	157	106	106	bc
Red Willow	T08-06109	0	127	42.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Red Willow	T08-06110	1	182	125.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Red Willow	T08-06111	0	145	48.4	HSB	HSB	125	179	166	194	142	174	157	199	106	150	b
Red Willow	T08-06112	0	122	45.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06113	0	134	51.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Red Willow	T08-06114	1	208	191.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Red Willow	T08-06115	1	222	251.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06116	0	111	30.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06117	0	120	38.3	WHB	WHB	125	125	170	170	176	176	157	157	106	106	bc
Red Willow	T08-06118	0	127	42.9	WHB	WHB	125	125	162	166	174	176	157	157	106	106	bc
Red Willow	T08-06119	0	121	38.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06120	0	130	45.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-06121	0	127	43.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06122	0	121	41.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06123	0	117	36.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T08-06124	0	128	46.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T08-06125	0	128	49.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T08-06126	0	117	41.7	WHB	WHB	125	125	166	167	174	176	157	157	106	106	b
Red Willow	T08-06127	0	117	36.6	WHB	WHB	125	125					157	157	106	106	bc
Red Willow	T08-06128	0	129	48.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06129	0	122	42.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Red Willow	T08-06130	0	117	34.2	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T08-06170	1	245	297.7	HSB	HSB	125	211	168	190	138	174	157	199	106	154	bc
Red Willow	T08-06171	1	265	342.9	HSB	HSB	125	201	166	186	138	174	157	199	106	156	bc
Red Willow	T08-06172	1	204	204.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T08-06173	1	263	333.6	HSB	HSB	125	201	166	190	138	174	157	199	106	146	bc
Red Willow	T08-06174	1	270	362.5	HSB	HSB	125	211	168	190	142	174	157	199	106	154	bc
Red Willow	T08-06175	1	249	292.0	HSB	HSB	125	215	170	192	142	174	157	199	106	154	bc
Red Willow	T08-06176	1	206	195.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06177	1	201	173.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T08-06178	1	198	154.7	WHB	WHB	125	127	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06179	1	195	149.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	b
Red Willow	T08-06180	1	205	193.8	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06181	1	215	226.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06182	1	201	176.7	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T08-06183	1	202	167.7	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T08-06184	1	210	201.9	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T08-06185	1	238	247.4	HSB	HSB	125	215	170	190	138	174	157	199	106	154	bc
Red Willow	T08-06186	1	208	180.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06187	1	209	206.4	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T08-06188	1	260	321.0	HSB	HSB	125	215	170	190	142	174	157	199	106	154	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T08-06189	1	197	182.4	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T08-06190	1	215	203.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Red Willow	T08-06191	1	210	209.7	WHB	WHB	125	125	166	170	174	176	157	157	106	106	b
Red Willow	T08-06192	1	193	151.4	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06193	1	212	199.3	WHB	WHB	125	125	168	168	176	176	157	157	106	106	bc
Red Willow	T08-06194	1	215	228.1	WHB	WHB	125	125	162	166	174	174	157	157	106	106	b
Red Willow	T08-06195	1	212	217.1	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Red Willow	T08-06196	1	208	204.0	WHB	WHB	125	125	168	168	174	174	157	157	106	106	bc
Red Willow	T08-06197	1	198	167.9	WHB	WHB	125	127	166	166	174	174	157	157	106	106	b
Red Willow	T08-06257	0	123	40.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T08-06258	0	131	52.0	WHB	WHB	125	127	166	166	176	176	157	157	106	106	b
Red Willow	T08-06286	1	248	310.5	HSB												y
Red Willow	T08-06287	1	255	310.6	HSB												y
Red Willow	T08-06288	1	264	378.9	HSB												y
Red Willow	T08-06289	1	192	155.2	WHB												y
Red Willow	T08-06290	1	200	188.1	WHB												y
Red Willow	T08-06291	1	209	217.8	WHB												y
Red Willow	T08-06292	1	197	177.7	WHB												y
Red Willow	T08-06293	1	260	202.3	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Red Willow	T08-06294	1	207	174.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T08-06295	1	193	163.7	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T09-08085	0	117	35.5	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T09-08086	0	82	12.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08087	0	92	18.9	WHB	WHB	125	127	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08088	0	108	26.8	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T09-08089	0	106	24.7	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T09-08090	0	96	19.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08091	0	101	22.5	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08092	0	105	25.3	WHB	WHB	125	127	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08093	0	85	14.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Red Willow	T09-08094	0	91	16.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08095	0	109	29.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08096	0	104	27.4	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Red Willow	T09-08097	0	103	25.1	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Red Willow	T09-08098	0	130	51.8	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Red Willow	T09-08099	0	117	32.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08100	0	117	33.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T09-08101	0	117	32.3	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08102	0	113	30.2	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T09-08103	0	107	26.0	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Red Willow	T09-08104	0	115	31.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08105	0	102	22.0	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Red Willow	T09-08106	0	107	25.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T09-08107	0	119	38.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T09-08108	0	109	26.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08109	0	120	36.8	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T09-08110	0	118	36.2	WHB	WHB	125	125	166	168	174	174					bc
Red Willow	T09-08111	0	118	34.4	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08112	0	119	36.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08113	0	135	55.3	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T09-08114	0	137	55.0	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T09-08115	0	103	23.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T09-08116	0	115	33.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08117	0	117	33.8	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T09-08118	0	136	53.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T09-08119	0	120	36.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T09-08120	0	115	33.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08121	0	133	49.7	WHB	WHB	125	125	166	170	176	176	157	157	106	106	bc
Red Willow	T09-08122	0	122	38.3	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Red Willow	T09-08123	0	123	39.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Red Willow	T09-08124	0	122	39.4	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08125	0	108	27.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08126	0	105	24.6	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T09-08127	0	118	35.2	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08128	0	134	51.0	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T09-08129	0	111	35.9	WHB	WHB	125	127	166	166	174	174	157	157	106	106	bc
Red Willow	T09-08130	0	118	31.4	WHB	WHB							157	157	106	106	bc
Red Willow	T09-08131	0	111	38.4	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Red Willow	T09-08132	0	106	31.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T09-08133	0	108	31.0	WHB	WHB	125	125	166	168	174	174					bc
Red Willow	T09-08134	0	114	38.3	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Red Willow	T09-08135	0	122	45.6	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Red Willow	T09-08136	0	113	39.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T09-08137	0	106	29.9	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Red Willow	T09-08138	1	197	221.1	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Red Willow	T09-08139	1	192	202.9	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-05997	0	113	33.5	HSB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T08-05998	0	112	29.7	HSB												y
Swanson	T08-06005	0	96	19.4	WHB	WHB	125	125	168	168	174	176	157	157	106	106	b
Swanson	T08-06006	0	93	17.2	WHB	WHB	125	125	162	166	174	174			106	106	b
Swanson	T08-06007	0	97	20.4	WHB	WHB	125	125	166	166	174	174					b
Swanson	T08-06008	0	89	14.1	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Swanson	T08-06009	0	95	14.3	WHB	HSB	125	185					157	199			bc
Swanson	T08-06010	0	82	11.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b
Swanson	T08-06014	0	99	23.7	HSB	WHB	125	125	162	166	174	174	157	157	106	106	bc
Swanson	T08-06015	0	114	39.2	HSB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T08-06024	0	137	58.0	HSB	HSB	125	185	166	192	138	174	157	205	106	158	bc
Swanson	T08-06025	0	129	47.5	HSB	F_x	125	185	166	186	138	174	157	157	106	138	w
Swanson	T08-06034	0	111	31.3	HSB	WHB	125	127	162	168	174	176	157	157	106	106	bc
Swanson	T08-06035	1	226	259.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T08-06047	1	222	280.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Swanson	T08-06052	0	114	32.4	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T08-06053	1	217	225.3	WHB	WHB	125	125	162	168	174	176	157	157	106	106	bc
Swanson	T08-06054	0		12.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Swanson	T08-06055	0		12.3	WHB	WHB							157	157	106	106	b
Swanson	T08-06060	1	204	228.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Swanson	T08-06061	0	114	40.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	u
Swanson	T08-06062	0	119	44.1	WHB	WHB	125	127	166	166	174	176	157	157	106	106	bc
Swanson	T08-06063	0	118	45.6	WHB	WHB	125	125	166	166	176	176	157	157	106	106	u
Swanson	T08-06064	0	119	46.5	WHB	WHB	125	125	166	170	174	174	157	157	106	106	u

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Swanson	T08-06065	0	130	53.2	WHB	WHB	125	125	166	166	174	176	157	157	106	106	u
Swanson	T08-06066	0	132	74.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Swanson	T08-06067	0	144	79.2	HSB	HSB	125	225	166	186	138	174	157	201	106	156	u
Swanson	T08-06068	0	145	78.8	HSB	HSB	125	247	166	192	142	174	157	191	106	138	b
Swanson	T08-06069	0	146	83.7	HSB	HSB	125	247	170	192	142	174	157	199	106	138	bc
Swanson	T08-06259	0	147	71.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Swanson	T08-06260	0	132	51.6	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Swanson	T08-06261	0	126	47.1	WHB	WHB	125	125	168	168	174	176	157	157	106	106	b
Swanson	T08-06262	0	96	20.1	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Swanson	T08-06263	0	147	78.7	HSB	WHB	125	125	166	168	174	176	157	157	106	106	b
Swanson	T08-06264	0	135	56.4	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Swanson	T08-06265	0	121	37.5	WHB	WHB	123	125	166	168	176	176	157	157	106	106	bc
Swanson	T08-06266	0	104	26.1	HSB	WHB	125	125	166	166	176	176	157	157	106	106	b
Swanson	T08-06267	0	93	19.5	WHB	WHB	125	125	166	170	176	176	157	157	106	106	b
Swanson	T08-06268	0	151	85.3	WHB	WHB	125	125	166	168	174	174					bc
Swanson	T08-06269	0	122	45.4	WHB	WHB							157	157	106	106	b
Swanson	T08-06270	0	138	67.1	WHB	WHB	125	127	166	168	174	176	157	157	106	106	b
Swanson	T08-06271	0	118	37.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Swanson	T08-06272	0	102	24.5	WHB	WHB	125	125	166	166	174	176	157	157	106	106	b
Swanson	T08-06273	0	98	22.9	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Swanson	T08-06274	0	110	30.6	WHB	WHB	125	127	162	168	174	176	157	157	106	106	b
Swanson	T08-06275	0	131	57.8	HSB	WHB	125	125	166	166	174	176	157	157	106	106	b
Swanson	T08-06276	0	105	28.6	WHB	WHB	125	127	168	170	174	174	157	157	106	106	bc
Swanson	T08-06277	0	124	48.4	WHB	WHB	125	125	166	168	174	174	157	157	106	106	b
Swanson	T08-06278	0	125	55.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	b

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Swanson	T08-06279	1	221	268.0	WHB	WHB	125	127	166	166	174	174	157	157	106	106	bc
Swanson	T08-06280	1	268	405.0	HSB	HSB	125	201	166	190	142	174	157	207	106	144	bc
Swanson	T08-06281	1	219	237.1	WHB	WHB	125	127	166	168	174	174	157	157	106	106	bc
Swanson	T08-06282	1	217	221.1	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T08-06283	1	219	249.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-06284	1	225	265.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-06285	1	230	296.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-06326	0	127	58.8	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T08-06327	0	98	21.4	WHB	WHB	125	125	162	166	174	174	157	157	106	106	b
Swanson	T08-06328	0	166	111.5	WHB	HSB	125	185	166	184	138	174	157	199	106	156	bc
Swanson	T08-06329	0	112	31.9	WHB	WHB	125	125	162	166	176	176	157	157	106	106	b
Swanson	T08-06330	0	137	71.1	WHB	WHB	125	125	168	168	174	174	157	157	106	106	b
Swanson	T08-06331	1	230	305.8	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-06332	1	221	265.0	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Swanson	T08-06333	1	217	246.7	WHB	WHB	125	127	166	168	176	176	157	157	106	106	bc
Swanson	T08-06334	1	205	196.3	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Swanson	T08-06335	1	203	212.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-06336	1	284	495.1	HSB	HSB	125	215	170	192	138	174	157	199	106	154	bc
Swanson	T08-06407	1	261	443.0	HSB	HSB	125	211	166	190	142	174	157	199	106	152	bc
Swanson	T08-06462	1	265	496.0	HSB	HSB	125	213	166	190	142	174	157	199	106	152	bc
Swanson	T08-06463	1	262	457.9	HSB	HSB	125	215	170	190	142	174	157	199	106	154	bc
Swanson	T08-06464	1	211	274.1	HSB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T08-06465	1	210	280.1	WHB	WHB	125	127	168	170	174	176	157	157	106	106	bc
Swanson	T08-06466	1	210	288.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T08-06467	1	205	281.5	WHB	WHB	125	125	168	168	174	174	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Swanson	T08-06468	1	208	281.9	WHB	WHB	125	125	168	168	174	174	157	157	106	106	bc
Swanson	T08-06469	1	214	278.3	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08140	0	89	16.4	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Swanson	T09-08141	0	96	20.5	WHB	WHB	125	125	162	168	174	176					bc
Swanson	T09-08142	0	96	21.6	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08143	0	84	13.6	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08144	0	90	18.5	WHB												y
Swanson	T09-08145	0	109	33.7	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08146	0	89	17.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08147	0	77	10.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08148	0	88	17.4	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Swanson	T09-08149	0	101	27.2	WHB	WHB	125	125	162	166	174	176	157	157	106	106	bc
Swanson	T09-08150	0	100	26.2	WHB	WHB	125	125	168	168	174	174	157	157	106	106	bc
Swanson	T09-08151	0	103	28.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08152	0	79	12.0	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Swanson	T09-08153	0	102	28.7	WHB	WHB	125	127	166	170	174	174	157	157	106	106	bc
Swanson	T09-08154	0	95	18.7	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08155	0	108	30.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08156	0	105	31.0	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Swanson	T09-08157	0	85	13.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08158	0	86	15.9	WHB	WHB	125	125	168	168	174	174	157	157	106	106	bc
Swanson	T09-08159	1	212	216.1	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08160	0	94	20.3	WHB	WHB	125	125	166	168	176	176	157	157	106	106	bc
Swanson	T09-08161	0	94	21.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08162	0	103	24.8	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Swanson	T09-08163	0	103	26.4	WHB	WHB	125	125	166	170	174	174	157	157	106	106	bc
Swanson	T09-08164	0	85	15.6	WHB	WHB	125	127	166	168	174	176	157	157	106	106	bc
Swanson	T09-08165	0	92	19.5	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Swanson	T09-08166	0	112	37.8	WHB	WHB	125	127	166	166	174	174	157	157	106	106	bc
Swanson	T09-08167	0	88	14.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08168	0	89	15.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08169	0	114	36.1	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08170	1	262	385.5	HSB	HSB	125	225	166	194	138	174	157	199	106	150	bc
Swanson	T09-08171	0	80	12.3	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08172	0	131	69.3	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Swanson	T09-08173	0	90	19.3	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Swanson	T09-08174	0	126	57.9	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08175	1	206	245.8	Fx	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08176	0	131	54.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Swanson	T09-08177	0	123	42.8	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08178	0	86	13.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08179	0	109	31.9	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Swanson	T09-08180	0	115	37.8	WHB	WHB	125	125	162	166	176	176	157	157	106	106	b
Swanson	T09-08181	0	115	36.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08182	0	119	40.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08183	0	108	32.8	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08184	0	124	46.1	WHB	WHB	125	125	168	168	174	176	157	157	106	106	bc
Swanson	T09-08185	0	123	45.7	WHB	WHB	125	125	168	170	174	176	157	157	106	106	bc
Swanson	T09-08186	1	218	258.1	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08187	1	220	265.2	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc

Appendix 1. Continued.

Location	Fish Number	Age	SL	Wt	ID_f	ID_g	1137		1138		1144		1067		1085		A
Swanson	T09-08188	1	260	410.3	HSB	HSB	125	185	166	186	122	174	157	199	106	144	bc
Swanson	T09-08189	0	140	70.5	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08190	0	143	74.1	WHB	WHB	125	125	166	166	176	176	157	157	106	106	bc
Swanson	T09-08191	0	135	58.2	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08192	0	109	32.6	WHB	WHB	125	125	166	166	174	176	157	157	106	106	bc
Swanson	T09-08193	0	131	52.0	WHB	WHB	125	127	166	166	174	174	157	157	106	106	bc
Swanson	T09-08194	0	142	73.8	WHB	WHB	125	125	162	166	174	174	157	157	106	106	bc
Swanson	T09-08195	0	135	63.7	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08196	0	134	60.0	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08197	0	132	51.9	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08198	0	113	35.5	WHB	WHB	125	125	166	166	174	174	157	157	106	106	bc
Swanson	T09-08199	0	99	21.0	WHB	WHB	125	125	166	168	174	176	157	157	106	106	bc
Swanson	T09-08200	0	124	52.6	WHB	WHB	125	125	162	168	174	176	157	157	106	106	bc
Swanson	T09-08201	0	113	33.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08202	0	100	21.0	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08203	1	221	290.5	WHB	WHB	125	125	166	170	174	176	157	157	106	106	bc
Swanson	T09-08204	1	218	314.1	WHB	WHB	125	125	166	168	174	174	157	157	106	106	bc
Swanson	T09-08205	1	274	541.6	HSB	HSB	125	179	170	194	142	174	157	199	106	150	bc