Field Identification Accuracy for White Bass and Hybrid Striped Bass

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Abstract: We estimated the accuracy of field identification of white bass *(Morone chrysops)* and palmetto bass *(M. chrysops × M. saxatilis)* by Texas fisheries workers and evaluated the reliability of meristic and morphometric characteristics commonly used to differentiate between these 2 fishes. Electrophoretic and isoelectric focusing analyses of diagnostic proteins were used to verify the fisheries workers' identification of fish (1,087) sampled from 16 reservoirs thoughout Texas. Overall, accuracy of field identification was high and fisheries workers correctly identified all sampled white bass; however, 5% of hybrid striped bass were incorrectly identified as white bass, and 12% of these fish were found to be F_X hybrids. The majority of white bass (78%) exhibited 1 basihyal tooth patch while most hybrid striped bass (89%) had 2 patches. Hybrid striped bass had a significantly higher number of lateral stripes extending to the tail, and a significantly higher incidence of broken lateral stripes than did white bass. Genetic analysis showed a low incidence (1.8%) of F_X hybrids, indicating reproduction of hybrid striped bass is an uncommon event in Texas reservoirs. Although isoelectric focusing was not able to detect any F_X hybrids outright, this method, when used in conjuction with protein electrophoresis, served as an additional diagnostic locus which enabled us to detect backcrosses. Mangers desiring to regulate white bass and palmetto bass with different harvest restrictions should consider basing regulations on a single characteristic and accepting the consequent harvest of some unprotected individuals, since identification based on a single characteristic or combination of characteristics does not result in 100% accuracy. Alternatively, managers might consider setting *Morone* harvest regulations based on length and bag limits, without regard to species to reduce angler confusion and the concerns of law enforcement.

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Palmetto bass and the reciprocal cross, sunshine bass *(M. saxatilis × M. chrysops),* are commonly stocked in reservoirs to develop put-grow-and-take fisheries.

These accounted for 23% of the estimated 141 million warmwater fishes stocked by U.S. and Canadian government agencies during 1995 and 1996 (Heidinger 1999). However, introductions of these fish into reservoirs containing populations of white bass have resulted in identification problems for anglers, biologists, and law enforcement personnel (Williams 1972, 1976). Differentiation between white bass and hybrid striped bass is fundamental for accurate stock assessments and stocking evaluations in waters where they co-exist and are managed using different harvest regulations.

Field identification of white bass and hybrid striped bass is commonly based on meristic (basihyal tooth patch, number of stripes extending to the tail) and morphometric (body depth) characteristics. However, attempts to separate fish using these characteristics have met with only limited success (Harrell and Dean 1988, Muoneke et al. 1991). The number of basihyal tooth patches has been reported unreliable for differentiation of these fishes (Bishop 1968, Williams 1976, Waldman 1986). Nevertheless this characteristic is still widely used by anglers and biologists alike.

To further confuse the issue, natural reproduction of hybrid striped bass has been reported (Avise and Van Den Avyle 1984, Forshage et al. 1986). The production of non-F_1 (F_X) hybrids by backcrossing makes reliable identification even more difficult because the external characteristics of most hybrids are intermediate between parental types and considerable within-hybrid variation exists (Campton 1987, Kerby and Harrell 1990).

The primary objectives of this study were to estimate the accuracy of professional fisheries workers' identification of genetically verified white bass and hybrid striped bass (palmetto bass and their offspring or backcrosses combined), and to compare the reliability of meristic and morphometric characteristics commonly used for differentiation. Also, we estimated the frequency of F_X hybrids in the sampled reservoirs to assess whether backcrossing was a likely factor complicating identification. Additionally, we evaluated the ability of isoelectric focusing to serve as a stand-alone technique to identify F_X hybrids compared to traditionally used protein electrophoresis.

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Methods

Target reservoirs were distributed throughout Texas and were selected according to the following criteria: 1) they contained populations of white bass, 2) they contained populations of palmetto bass and had been stocked with fingerlings in spring 1993 and/or 1994, and 3) they were scheduled for routine population sampling in 1995 or 1996. White bass and hybrid striped bass populations were sampled by TPWD Inland Fisheries District crews with standard gill nets according to TPWD fishery assessment procedures (TPWD 1998) in 10 reservoirs during spring 1995. In spring 1996, 4 of these reservoirs were re-sampled and 6 additional reservoirs were sampled.

At each reservoir, crews of full-time fisheries workers, including technicians and biologists, separated the captured white bass and hybrid striped bass using whatever techniques they had employed in the past. Because we were evaluating the ability of fisheries workers to correctly identify these fish, we did not provide any information on identification of these fishes. Total length (mm TL) and weight (g) were recorded from a stratified subsample (5 per 25.4-mm class) of what they had identified as white bass and hybrid striped bass.

Fisheries workers recorded the number and shape (from a checklist) of basihyl tooth patches, the number of stripes extending to the caudal peduncle and the presence of broken lateral stripes. Tooth patch patterns were divided into 3 groups: absent, single (with no obvious divisions or separations) and double (2 tooth patches arranged in 2 separate sections).

Separate rates of accuracy and frequencies of occurrence of these characteristics were calculated for all lengths of fish and for fish within the 254–456-mm TL length range. White bass and hybrid striped bass are managed using different minimum length limits in Texas (254 mm TL, and 457 mm TL, respectively). Misidentification of fish within this length range has the greatest potential negative impact on the effectiveness of the hybrid striped bass length limit Chi-square goodness of fit tests (Sall and Lehman 1996) were used to evaluate the relationship between frequencies of occurrence of characteristics and fish identification (white bass and hybrid striped bass). Student's *t*-tests (Sall and Lehman 1996) were used to test for differences in white bass and hybrid striped bass mean TL for fish having different tooth patch counts. Kolmogorov-Smirnov (KS) tests (SAS 2000) were used to test cumulative frequency distributions (CDFs) of the number of stripes to the tail for white bass vs. hybrid striped bass, using formulae derived from Numerical Recipes (Press et al. 1990).

Genetic analysis of white skeletal muscle (from the dorsal surface just below the dorsal fin) and liver tissue was used to verify the identity of each field-identified specimen. These tissue samples were placed in separate numbered cryogenic vials, stored on dry ice and shipped overnight to the genetics laboratory at the A. E. Wood State Fish Hatchery, San Marcos, Texas, for analysis using isoelectric focusing (IEF) and conventional protein electrophoresis.

The white skeletal muscle was subjected to IEF using a pH gradient of 3–5 and following the methods described by Forshage et al. (1986), except that tissue was prepared simply by thawing and placing approximately 0.5–1.0 μL of exudate directly onto the gel using a 1 × 10-mm mask. Samples were assigned an identification using diagnostic proteins for white bass, striped bass, and their hybrids (Harvey and Fries 1989).

Liver tissue was prepared for electrophoresis by homogenizing in equal volumes of grinding solution (0.01 M Tris and 0.001 M EDTA pH 6.8) and centrifuging for 1 minute at 13,000 revolutions per minute. Three of the diagnostic loci described by Otto (1975) and Avise and Van Den Avyle (1984) (SORD, EST, and PGI) were evaluated using 0.5-mm thick agarose gels cast onto the hydrophilic side of 124 × 258 mm Gelbond® support film. Running conditions included buffers and histochemical staining described by Selander et al. (1971).

Fish that were homozygous for white bass alleles at each locus and also displayed an IEF banding pattern consistent with white bass were considered white bass. Those that were heterozygous for white bass and striped bass alleles at each locus and displayed a hybrid pattern on IEF gels were considered hybrid striped bass. Fish with contradictory patterns at 1 or more loci, including IEF banding patterns, were considered F_X hybrids. Discrepancies in identification of F_X hybrid striped bass between the 2 biochemical methods were used to evaluate the effectiveness of isoelectric focusing as a stand-alone technique for identification of F_X hybrid striped bass.

Results

Accuracy of Field Identification

A total of 517 white bass and 570 hybrid striped bass were collected from 16 reservoirs (Table 1). All white bass collected during the study were correctly identified, as field and genetic identifications corresponded. Of the 535 hybrid striped bass sampled, genetic analysis revealed 25 were incorrectly identified as white bass. Three of the incorrectly identified fish were genetically verified as F_X hybrids. The accuracy of field identification was 95% for the total sample. Of the 236 hybrid bass collected in the 254–456-mm length range, 226 fish (96%) were identified correctly.

Table 1. Sample sizes of white bass and hybrid striped bass collected from Texas reservoirs.

Reservoir	Year	*N* White bass	*N* Hybrid striped bass
Arlington	1995	20	18
Belton	1996	25	45
Benbrook	1996	30	30
Cedar Creek	1995	39	23
Cedar Creek	1996	30	29
Corpus Christi	1995	36	9
Fort Phantom Hill	1995	38	35
Fort Phantom Hill	1996	2	30
Lake O' the Pines	1996	39	65
Mackenzie	1996	17	34
Miller Creek	1996	20	19
Nasworthy	1995	9	12
Nocona	1996	0	20
Palestine	1995	35	69
Palestine	1996	15	31
Pat Mayse	1995	25	35
Sam Rayburn	1995	52	20
Sam Rayburn	1996	30	6
Somerville	1995	47	8
Walter E. Long	1995	8	32

Table 2. Rates of accuracy in identification of hybrid striped bass from Texas reservoirs where fish were incorrectly identified. Estimates are shown for all sampled fish and fish 254–456 mm TL.

		All lengths		254–456 mm	
Reservoirs	Year	*N*	Accuracy (%)	*N*	Accuracy (%)
Cedar Creek	1995	24	91.3	16	87.5
Mackenzie	1996	34	88.2	31	93.5
Miller Creek	1996	21	52.6	10	80.0
Nocona	1996	20	65.0	14	92.9
Palestine	1995	71	98.6	30	96.7
Walter E. Long	1995	32	93.7	17	88.2

TPWD fisheries workers encountered identification problems at 6 reservoirs (Table 2). The lowest accuracy rates, 53 and 65%, were observed at Miller Creek reservoir, and Lake Nocona, respectively. For 254- to 456-mm fish, the lowest recorded accuracy rate (80%) was observed at Miller Creek Reservoir.

Analysis of Meristic and Morphometric Characteristics

Basihyal Tooth Patches—A range of basihyal tooth patch patterns was observed in white bass and hybrid striped bass (Fig. 1). One specimen, a white bass, did not possess a discernable tooth patch. The number of tooth patches (1 or 2) was significantly related to fish identification (white bass or hybrid striped bass) for all sampled fish (χ^2; $P < 0.001$). The majority of white bass (78%) possessed 1 basihyal tooth patch whereas most hybrid striped bass (90%) had 2 tooth patches. For fish ranging in length from 254 to 456 mm, a similar significant relationship existed between number of tooth patches and fish identification (χ^2; $P < 0.001$). The majority of white bass in this length range also had 1 tooth patch (76%) and the majority of hybrid striped bass had 2 tooth patches (89%). Further, a significant relationship was observed between tooth patch count and fish length in hybrid striped bass. Mean TL of hybrid striped bass with 1 tooth patch (344 mm) was significantly less than mean TL of hybrid striped bass with 2 tooth patches (423 mm TL) (t; $P < 0.001$). In white

Table 3. Frequency of occurrence of different numbers of lateral stripes extending to the tail of white bass and hybrid striped bass for all sampled fish and 254- to 456-mm fish. White bass and hybrid striped bass were collected from 16 Texas reservoirs, 1995–1996.

			Frequency of occurrence (%)		
Species	Length group	*N*	1 stripe	2 or more stripes	3 or more stripes
White bass	All lengths	517	88.6	10.1	4.3
	254–456 mm	408	85.8	12.0	4.9
Hybrid striped bass	All lengths	571	6.3	93.3	77.4
	254–456 mm	351	7.1	92.0	72.9

	One tooth patch				Two tooth patches											
Pattern																Total
White bass	291	100	5	5	61	1	11	13	0	6	6	0	2	12	3	516
%	77.7				22.3											
White bass 254-456 mm	231	73	5	2	51	1	10	11	0	4	4	0	2	10	3	407
%	76.4				23.6											
Hybrid	18	24	0	17	148	233	2	98	2	6	6	11	1	3	1	570
%	10.4				89.6											
Hybrids 254-456 mm	14	15	0	9	82	127	2	87	1	3	2	7	0	3	1	353
%	10.8				89.2											

Figure 1. Frequency of occurrence of basihyal tooth pat ch patterns, grouped by number of patches, observed in white bass and hybrid striped bass (hybrid) for all sampled fish and fish 254–456 mm TL. Percentage of total number of tooth patch patterns is shown for each species for each size range. White bass and hybrid striped bass were collected from16 Texas reservoirs, 1995–1996.

bass, however, there was no significant difference between mean TL of fish with 1 tooth patch (310 mm) and 2 tooth patches (305 mm) (*t; P*=0.597).

Number of Lateral Stripes Extending to the Tail—The number of lateral stripes extending to the tail ranged from 0 to 8 for all of the collected specimens. The majority of white bass had 1 stripe extending to the tail for the entire sample (89%) as well as for 254- to 456-mm fish (86%) (Table 3). Hybrid striped bass had at least 2 stripes extending to the tail in 93% of the fish from the entire sample and 92% of the 254- to 456-mm fish. The CDFs of number of stripes to the tail were significantly different between white bass and hybrid bass (KS; $P<0.001$). The greatest absolute difference between CDFs occurred at 2 stripes.

Broken Lateral Stripes—Hybrid striped bass had a significantly higher frequency of broken lateral stripes for all sizes of fish (83%; N=571) χ^2; $P<0.001$) than white bass (48%; N=517). For 254- to 456-mm fish, hybrid striped bass also had a significantly higher frequency of broken stripes (83%; N=354) (χ^2; $P<0.001$) than white bass (49%; N=408).

Table 4. Frequency of occurrence of F_X hybrid striped bass from selected Texas reservoirs.

Reservoir	Year	*N* hybrid striped bass	F_X *N*	F_X %
Cedar Creek	1995	23	1	4.3
Ft. Phantom Hill	1995	35	2	5.7
Lake O' the Pines	1996	65	2	3.1
Miller Creek	1996	19	2	10.5
Palestine	1995	69	2	2.9
Palestine	1996	31	1	3.2

F_X Hybrid Striped Bass

A total of 10 F_X hybrid striped bass were collected from 5 reservoirs during the study (Table 4). Overall, the frequency of F_X hybrid striped bass was low (1.8%) and sample sizes were too small to test for differences between reservoirs. The highest frequency of F_X hybrids (10.5%) was observed at Miller Creek Reservoir where 2 of the 19 hybrid striped bass collected were found to be F_X hybrids.

Reliability of Isoelectric Focusing in Identification of F_X Hybrids

F_X hybrids collected during this study exhibited 5 different genotypes. Three of the 4 F_X hybrids field identified as white bass were found to be hybrid striped bass by a single diagnostic locus (2 at PGI and 1 at EST) while the fourth was found to be a hybrid striped bass at 2 of the 4 diagnostic loci (SORD and EST). Among the 10 F_X hybrids, 7 could have been identified using conventional electrophoresis alone, while the remaining 3 would have been identified as palmetto bass if IEF had not been used (Table 5). No F_X hybrid striped bass could have been identified using IEF alone.

Table 5. Comparison of field and genetic identification of F_X hybrid striped bass collected from selected Texas reservoirs. Genetic identification was made using isoelectric focusing (IEF) and conventional protein electrophoresis (EF) at 3 diagnostic loci (SORD, EST and PGI). Identification is as follows: hybrid striped bass (HYB), palmetto bass (F_1), non-F_1 hybrid striped bass (F_X) and white bass (WB).

Reservoir	Field identification	Genetic identification IEF	Genetic identification EF	*N*
Palestine (1995)	HYB	F_1	F_X	2
Fort Phantom Hill (1995)	HYB	F_1	F_X	1
Palestine (1996)	HYB	WB	F_1	1
Lake O' the Pines (1996)	HYB	WB	F_1	2
Fort Phantom Hill (1995)	WB	WB	F_X	1
Cedar Creek (1995)	WB	WB	F_X	1
Miller Creek (1996)	WB	WB	F_X	1
Miller Creek (1996)	WB	WB	F_X	1

Discussion

Our results indicated that the accuracy of field identification by fisheries workers was high, but none of the field-based characteristics we investigated for differentiation of white bass and hybrid striped bass resulted in error-free classification. It is likely that experienced fisheries workers and anglers employ a combination of these and other characteristics (e.g., color, body depth) to distinguish between these 2 fishes. At this point, differentiation may become more of an art form than a science. The ability to correctly differentiate these fishes likely increases with experience, however, we did not attempt to evaluate this variable.

The lack of a single easily identifiable characteristic limits the ability of many anglers to distinguish between white bass and hybrid striped bass. Law enforcement personnel are also hampered in their capacity to check angler compliance. Further, incorrect field identification by fisheries professionals may affect the accuracy of estimates of biological parameters such as growth rates, length-frequency distributions and condition indices used for species-based management.

The presence of backcrossed hybrid striped bass has the potential to complicate the differentiation between hybrid striped bass because external characteristics of hybrids are intermediate between those of their parents. However, the low incidence of F_X hybrid striped bass observed in this study indicates reproduction in hybrid striped bass is not a common event in Texas reservoirs, and it is unlikely to have significantly impacted the differentiation between hybrid striped bass and white bass. Although it was impossible to identify any F_X hybrid striped bass through the exclusive use of IEF, this technique did provide an additional diagnostic locus when used in conjunction with conventional protein electrophoresis for identifying F_X hybrid striped bass. Forshage et al. (1986) found that either technique would provide a conservative estimate of F_X hybrids and together were more powerful than either technique alone. Isoelectric focusing enabled us to identify F_X hybrid striped bass that would have been incorrectly identified as palmetto bass by protein electrophoresis alone.

We recommend using a single characteristic to differentiate between white bass and hybrid striped bass in reservoirs where they co-exist and are managed using different harvest regulations. Although no single characteristic or combination of characteristics was 100% accurate, the number of stripes to tail appeared to give the most reliable results. The accuracy of the number of basihyal tooth patches was similar, but it is difficult to distinguish tooth patches, and because tooth patch patterns change as hybrid striped bass grow in length, they are suspect. Problems with differentiation are likely compounded in reservoirs where striped bass *(M. saxatilis)* and yellow bass *(M. mississippiensis)* are found in combination with either or both fishes considered in this study.

In reservoirs where managers desire to regulate harvest of white bass and hybrid striped bass using different regulations, a single characteristic would be easier for anglers to use and it would prevent the confusion that arises from using a number of characteristics that provide conflicting identifications. The identification approach may be easier for game wardens to enforce and it would improve the credibility of cases filed against violators. Management under such an approach would involve loss of some hybrid striped bass as by-catch in white bass bags and would also force white bass anglers to release some white bass that displayed hybrid striped bass meristic characteristics.

An alternative management strategy involves regulating harvest of these fishes by considering them as a single *Morone* stock. This approach was recommended by Muoneke et al. (1991) and is the rationale behind an experimental regulation under evaluation on 2 reservoirs in East Texas that contain both the white bass and palmetto bass. In these reservoirs, white bass and hybrid striped bass populations are managed together under a 254-mm TL minimum length limit and 25-fish daily bag limit, of which only 5 fish may be ≥457 mm TL. Under this regulation there is the potential to harvest small hybrid striped bass which may affect size structure of the populations and reduce yield of hybrid striped bass.

Although the difficulty of correctly differentiating between white bass and hybrid striped bass is well documented, we have provided data on the reliability of common characteristics used by anglers, biologists and law enforcement personnel. Information from our study may enable managers to develop more effective harvest regulations.

Literature Cited

Avise, J. C. and M. J. Van Den Avyle. 1984. Genetic analysis of reproduction of hybrid white bass × striped bass in the Savannah River. Trabs. Am. Fish. Soc. 113:563–570.

Bishop, R. D. 1968. Evaluation of the striped bass *(Roccus saxatilis)* and white bass *(R. chrysops)* hybrids after two years. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 21:245–254.

Campton, D. E. 1987. Natural hybridization and introgression in fishes: Methods of detection and genetic interpretations. Pages 161–192 *in* N. Ryman and F. Utter, eds. Population genetics and fishery management. Univ. Wash. Press, Seattle.

Forshage, A. A., W. D. Harvey, K. E. Kulzer, and L. T. Fries. 1986. Natural reproduction of white bass × striped bass hybrids in a Texas reservoir. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 40:9–14.

Harrell, R. M. and J. M. Dean. 1988. Identification of juvenile hybrids of *Morone* based on meristics and morphometrics. Trans. Am. Fish. Soc. 117:529–535.

Harvey, W. D. and L. T. Fries. 1989. Identification of four *Morone* species and congeneric hybrids using isoelectric focusing techniques. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 41:251–256.

Heidinger, R. C. 1999. Stocking for sport fisheries enhancement. Pages 375–401 *in* C. C. Kohler and W. A. Hubert, eds. Inland fisheries management in North America, 2nd ed. Am. Fish. Soc., Bethesda, Md.

Kerby, J. H. and R. M. Harrell. 1990. Hybridization, genetic manipulation, and gene pool conservation of striped bass. Pages 159–190 *in* R. M. Harrell, J. H. Kerby and R. V. Minton, eds. Culture and propagation of striped bass and its hybrids. Am. Fish. Soc., Bethesda, Md.

Muoneke, M. I., O. E. Maughan, and M. E. Douglas. 1991. Multivariate morphometric analysis of striped bass, white bass, and striped bass × white bass bybrids. North Am. J. Fish. Manage. 11:330–338.

Otto, R. S. 1975. Isoenzyme systems of the striped bass (*Morone saxatilis*) and cogeneric percichthyid fishes. Ph.D. Diss., Univ. Maine, Orono.

Press, W. H., B. P. Flannery, S. A. Teukolsky, and W. T. Vetterling. 1990. Numerical recipes. Cambridge Univ. Press, New York, N.Y. 702 pp.

Sall, J. and A. Lehman. 1996. JMP Start Statistics: A guide to statistics and data analysis using JMP and JMP IN Software. Duxbury Press, Wadsworth Publ. Co., Belmont, Calif. 521pp.

SAS Institute, Inc. 2000. SAS/STAT™ user's guide, release, 8.00 ed. SAS Inst., Inc., Cary, N.C. 3844pp.

Selander, R. K., M. H. Smith, S. Y. Yang, W. E. Johnson, and J. B. Gentry. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I. Variation in the old-field mouse (*Peromyscus polionotus*). Pages 49–90 *in* Studies in genetics VI. Univ. Texas, Publ. 7103, Austin.

Texas Parks and Wildlife Department (TPWD). 1998. Inland fisheries assessment procedures. Texas Parks and Wildl. Dep., Inland Fish. Div., Austin. 113pp.

Waldman, J. R. 1986. Diagnostic value of *Morone* dentition. Trans. Am. Fish. Soc. 115:900–907.

Williams, H. M. 1972. Preliminary fecundity studies of the hybrid (striped bass × white bass) in two South Carolina reservoirs. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 25:536–542.

———. 1976. Characteristics for distinguishing white bass, striped bass and their hybrid (striped bass × white bass). Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 29:168–172.