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[Article]

Yellow Perch in South Dakota: Population Variability and Predicted Effects of Creel Limit Reductions and Minimum Length Limits

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Abstract.—We collected annual gill-net samples of yellow perch *Perca flavescens* in six South Dakota lakes over 4–5 years. We also simulated the effects of reductions in daily creel limits for yellow perch (i.e., from 25 fish/angler to 5, 10, or 15 fish/angler) and use of minimum total length limits (229 and 254 mm). Population indices varied widely among lakes and among years within lakes to the extent that indices from any individual year were largely uninformative. Creel surveys indicated that few anglers typically achieved a daily creel limit of 25 yellow perch. Except in Waubay Lake, lowering the creel limit from 25 to 5 fish/angler would be necessary to achieve harvest reductions of 25% or more within most of the fisheries we examined. Minimum length limits were projected to improve size and age structure, but harvest reductions often exceeded 50% and yield declined or only slightly increased (by $\leq$13%). Yellow perch in these lakes had achieved much of their full growth potential by the time they reached 229 and 254 mm. Consequently, although length limits were predicted to increase age and size structures, asymptotic growth prevented yellow perch from attaining substantially larger sizes. Length limits were predicted to be most beneficial when fishing mortality represented most of the total mortality in each population and when growth occurred at median or fast rates. A 229-mm length limit was predicted to improve size and age structures with less-severe reductions in harvest or yield than a 254-mm limit. Population dynamics and the harvest-oriented nature of yellow perch anglers may dictate that yield maximization is still a reasonable management goal for many South Dakota yellow perch fisheries. Increasing the number of yellow perch that attain 229 mm is possible for certain fisheries if angler harvest represents the dominant source of mortality.

Efforts to regulate angler harvest of panfishes (e.g., bluegill *Lepomis macrochirus*, crappies *Pomoxis* spp., and yellow perch *Perca flavescens*) have primarily focused on reducing daily creel limits (Colvin 1991; Webb and Ott 1991; Radomski 2003; Jacobson 2005). Reductions in daily creel limits have often been deemed insufficient to measurably reduce angler harvest (Webb and Ott 1991; Larscheid 1992; Cook et al. 2001), because most anglers frequently catch or harvest few or no fish (Snow 1982; Webb and Ott 1991; Baccante 1995; Cook et al. 2001) and therefore do not regularly harvest a daily limit (Snow 1982; Webb and Ott 1991; Cook et al. 2001). Nonetheless, reductions in daily creel limits that are unlikely to measurably reduce harvest are often implemented to assign value to a fishery, and some anglers may use these limits as a goal (Fox 1975; Snow 1982). Furthermore, anglers are frequently supportive of creel limit reductions (Quinn 1992; Currie and Fulton 2001; Radomski et al. 2001; Boxrucker 2002), possibly because they assume that the regulations are important in conservation (Currie and Fulton 2001) and will result in improved fishing.

The use and evaluation of restrictive length limits as tools for managing panfish populations have increased over the past 20 years (Allen and Miranda 1995; Beard et al. 1997; Boxrucker 2002; Paukert et al. 2002). In some cases, length limits can alleviate the effects of growth overfishing by shifting harvest to older fish, consequently increasing yield from the fishery (Colvin

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1991; Webb and Ott 1991; Boxrucker 2001), but high natural mortality rates or slow growth may preclude yield benefits expected from delayed harvest (Hale et al. 1999; Bister et al. 2002; Boxrucker 2002). Furthermore, in harvest-oriented fisheries, yield increases that may be realized under a length limit may not outweigh associated declines in the number of fish harvested by anglers.

Yellow perch provide important harvest-oriented fisheries across much of their range, including South Dakota, where they have been ranked as the second-most popular sport fish among the state's anglers (Mendolsohn 1994). High-water periods across the Dakotas during the mid-1990s resulted in an expansion of yellow perch populations into recently flooded basins and increased abundance in lakes where yellow perch previously existed. High-quality yellow perch populations— those consisting of relatively large numbers of fish exceeding 229 mm total length (TL)—existed in many waters after this expansion. The boom in quality yellow perch fishing attracted increased angling pressure, and several lakes in North Dakota and South Dakota gained national attention as prime destinations for catching large yellow perch. Some fisheries diminished after one or two seasons of relatively intense fishing effort, which led to concerns regarding overharvest and an increased interest in altering yellow perch harvest restrictions.

The majority of recreational yellow perch fisheries in the USA are regulated solely by creel limits, many of which allow anglers to legally harvest 25 fish or more daily (McShane and Bowman 2003). Similarly, most yellow perch fisheries in South Dakota are currently regulated by a daily creel limit of 25 fish/angler (South Dakota angling regulations; www.sdgfp.info/Publications/FishingHandbook.pdf). However, daily creel limits on some lakes have recently been reduced to 10 fish/angler in response to concerns about overharvest. Similarly, in 2000 the daily creel limit on Lake Winnibigoshish, Minnesota, was reduced from 100 to 20 fish/angler because of concerns over excessive harvest (Radomski 2003). Cook et al. (2001), however, demonstrated that daily creel limits for yellow perch must generally be 5 fish/angler or lower to significantly reduce harvest within many Minnesota fisheries. The potential for lower daily creel limits to reduce yellow perch harvest in South Dakota lakes has not been thoroughly examined.

Harvest regulations beyond creel limits might better meet the desires of yellow perch anglers in South Dakota. Size structure of yellow perch caught by winter anglers was important to angler satisfaction on two South Dakota lakes (Isermann et al. 2005). Theoretically, improvements in size structure might be achieved using minimum length limits. Minimum length limits have been used to regulate commercial harvest of yellow perch (Hushak et al. 1986; Kraft and Johnson 1992) but have seen little use in managing recreational fisheries (Lucchesi 1988; McShane and Bowman 2003). Previous studies have shown that yellow perch population dynamics vary substantially across waters (Lucchesi 1991; Paukert and Willis 2001; Purchase et al. 2005); hence, length limits are unlikely to be universally effective. Furthermore, natural mortality rates in some yellow perch populations may limit the effectiveness of length limits (Boe 1984; Bronte et al. 1993). Identifying the potential response of yellow perch populations to length limits before their application would provide useful information for fishery managers.

TABLE 1.—Physical and biological information for six South Dakota lakes where yellow perch were collected in annual gill-net surveys. Trophic states are based on Carlson's (1977) index.

Lake	Area (ha)	Mean depth (m)	Trophic state	Annual effort (net-nights)
East 81	440	5	Eutrophic	6
Enemy Swim	884	4.8	Mesotrophic	6
Madison	1,145	2.7	Eutrophic	5–6
Pickerel	386	6.1	Mesotrophic	6
Sinai	697	5.2	Eutrophic	5–6
Waubay	6,293	4.9	Eutrophic	8

The objectives of our investigation were to (1) describe yellow perch population dynamics across a range of South Dakota lakes, (2) evaluate whether daily creel limits of less than 25 fish/angler would result in measurable reductions in harvest, and (3) simulate the potential effects of two minimum TL limits (229 and 254 mm) on South Dakota yellow perch fisheries based on observed recruitment patterns and under varying ranges of growth, natural mortality, and fishing mortality.

Study Lakes

This study was conducted on six glacial lakes located in eastern South Dakota (Table 1). Enemy Swim, Pickerel, and Waubay lakes were all located within 5 km of one another in Day County in northeastern South Dakota. East 81 Slough and Lake Sinai are located less than 1 km from one another in the western portion of Brookings County, approximately 147 km south of Enemy Swim, Pickerel, and Waubay lakes. Lake Madison is located approximately 35 km south of East 81 Slough and Lake Sinai and approximately 3 km southeast of the town of Madison in Lake County. Maps depicting basin shape and morphometry of the study lakes (excluding East 81

Slough) can be found at www.sdgfp.info/Wildlife/fishing/Lakemaps/Index.htm.

Fish communities in all study lakes primarily consist of percids (yellow perch and walleyes *Sander vitreus*), black bullheads *Ameiurus melas*, northern pike *Esox lucius*, white suckers *Catostomus commersonii*, and common carp *Cyprinus carpio*. Enemy Swim and Pickerel lakes also support populations of black basses *Micropterus* spp., sunfishes *Lepomis* spp., black crappies *Pomoxis nigromaculatus*, white bass *Morone chrysops*, and rock bass *Ambloplites rupestris*. Creel data used in analyzing the potential effects of creel limit reductions came from the following lakes located in the eastern portion of the state: Bitter (Day County), Brandt (Lake County), Cattail (Marshall County), Poinsett (Hamlin County), and Thompson (Kingsbury County). Before December 2001, all yellow perch fisheries in South Dakota were regulated only by a daily creel limit of 25 fish/angler (i.e., no size limit was used). Beginning in December 2001, yellow perch fisheries (including Bitter, Cattail, Enemy Swim, Pickerel, Poinsett, and Waubay lakes) in 11 northeastern South Dakota counties were regulated by a daily creel limit of 10 fish/angler (no size limit); the 25-fish/angler limit remained in effect for the other study lakes.

Methods

Population characteristics.—Yellow perch were collected annually from the six study lakes with experimental gill nets (six 7.6-m long panels; bar meshes of 13, 19, 25, 32, 38, and 51 mm) during South Dakota Department of Game, Fish, and Parks (SDGFP) standard summer surveys conducted from late June to August during 2001–2005; East 81 Slough was not sampled in 2005, however. In some cases, sampling effort varied among years within lakes (Table 1). Total lengths (mm) and weights (g) were recorded for the entire sample or for subsamples. We attempted to remove sagittal otoliths for age estimation from a minimum of 10 fish per 25-mm length-group; however, fewer than 10 fish were collected within some length-groups. Ages were applied to entire samples by use of age–length keys (Ricker 1975). Age at full recruitment (age_r) was designated as the age at which a descending limb in gill-net catch per unit effort (CPUE; fish/net-night) at age was first evident (Ricker 1975). Mean CPUE at age_r was used as an index of recruitment; the coefficient of variation (CV; calculated as [SD/mean] $\times$ 100) in mean CPUE at age_r was used as a measure of recruitment variation. Percentage of fully recruited yellow perch that were age 5 and older in each sample and observed maximum age were used to describe age structure. To account for recruitment variation and annual variation in sampling efficiency, we pooled CPUE values at each fully recruited age across annual gill-net samples (Ricker 1975) and used catch curves to generate estimates of instantaneous total mortality (*Z*) and total annual mortality (*A*) for each population.

Growth was described using mean lengths at age 3 (mean of annual means observed across the 4- or 5-year sampling period). Size structure in each sample was described using the median of annual estimates of proportional size structure of preferred-length fish (PSS-P; formerly relative stock density; Guy et al. 2006) (stock length = 130 mm; preferred length = 250 mm; PSS-P = number of preferred length fish/total number of stock-length fish; Gabelhouse 1984). Annual estimates of maximum TL attained in each population were described using the mean TL of the five largest fish captured in each annual gill-net sample; these annual means were then averaged over the 4- or 5-year sampling period.

Daily creel limit reductions.—To evaluate the potential effects of reductions in daily creel limits on yellow perch harvest, we employed an approach similar to that of Cook et al. (2001), utilizing harvest information from creel surveys conducted by SDGFP on eight eastern South Dakota lakes. Only creel surveys conducted during periods when yellow perch harvest was regulated by a daily creel limit of 25 fish/angler were used in analyses. Only completed trip interviews of anglers that kept at least one yellow perch were utilized in assessing creel limit reductions, because anglers who harvested no yellow perch would not be affected by such reductions. Information for a particular creel survey was used only if at least 25 of the completed trip interviews reported the harvest of one yellow perch. Creel surveys were interpreted on a seasonal basis when data for open-water and ice periods were available, because Isermann et al. (2005) demonstrated that yellow perch harvest followed seasonal trends on some South Dakota lakes, which could result in seasonal variation in creel limit effectiveness.

We calculated (1) the percentage of angler parties that achieved a limit of 25 fish/angler based on party size (i.e., a group of three anglers could legally harvest a limit of 75 yellow perch) and (2) the percentage of harvested fish that would have been released by interviewed anglers under hypothetical daily creel limits of 15, 10, and 5 fish; complete angler compliance with the regulations was assumed. For example, a group of three anglers that harvests 75 yellow perch under a 25-fish creel limit would have to release 30 of the fish under a 15-fish limit. Percentage reduction in harvest associated with reduced daily creel limits was calculated as the total number of fish that would have been released under limits of 15, 10, or 5 fish divided by the total actually harvested under the 25-fish limit. A hypothetical creel reduction was deemed effective if it reduced harvest by at least 25%. Finally, we also calculated the percentage of angler groups whose harvest under a 25-fish limit would have been reduced by each hypothetical creel reduction.

Length limit modeling.—We conducted length limit modeling for four of the six lakes where yellow perch population characteristics were described. We excluded East 81 Slough and Enemy Swim Lake from length limit modeling because fishing mortality may not be a significant source of mortality in these populations (Blackwell 2005a; Isermann et al. 2005) and because growth of yellow perch in these systems is slow. Dynamic-pool models utilizing Jones' (1957) modification to the equilibrium yield equation of Beverton and Holt (1957), as available in Fishery Analyses and Simulation Tools (FAST version 2.0; Slipke and Maceina 2002) were used to predict the effects of 229- and 254-mm minimum length limits on yield (kg harvested), number harvested, PSS-P, and number surviving to age 5 and older. The Beverton–Holt model is a relatively simple age-structured model that assumes constant mortality and growth across years and year-classes (Beverton and Holt 1957; Ricker 1975; Slipke and Maceina 2002) and that has been previously used to predict population responses to minimum length limits (e.g., Allen and Miranda 1995; Boxrucker 2002; Paukert et al. 2002). Models were run over 59-year periods; the first 9 years of each simulation were used to populate the models and were not included in reporting results. Yellow perch were assumed to enter the fishery at 178 mm based on creel surveys conducted on East 81 Slough (Isermann et al. 2005) and Waubay Lake (Blackwell and Hubers 2003). Mean intercepts and slopes resulting from $\log_{10}$(weight)–$\log_{10}$(TL) regressions based on yellow perch collected from 2001 to 2005 were used to describe weight–length relationships for each population. Annual values of PSS-P, total number harvested, yield, and total number of age-5 and older fish were calculated and were averaged over the final 50 years of each simulation. To synthesize model results, the percent change in average values between length limit simulations (229 and 254 mm) and no-limit simulations (178 mm) was used to describe the effects of the length limits.

Similar to the approach used by Allen and Miranda (1995), three different growth scenarios were used in model simulations: (1) median growth, based on the median of mean lengths observed at each age, (2) fast growth, based on the 75th percentile of mean lengths observed at each age, and (3) slow growth, based on the 25th percentile of mean lengths observed at each age. Each set of lengths was used in a von Bertalanffy growth model to derive growth coefficients (k) and asymptotic maximum TLs (L_{inf}) that were used as input parameters in dynamic-pool models. Fitting von Bertalanffy models with only mean lengths for those ages fully recruited to gill nets resulted in nonsensical intercept (t_0) estimates due to the lack of mean length data for ages 0 and 1. Consequently, t_0 was fixed at zero when deriving k and L_{inf} from the von Bertalanffy model and in all length limit simulations. Our length limit modeling assumed that growth remained constant at the designated level across year-classes and that density-dependent growth responses did not occur. To further describe growth, we used von Bertalanffy models to estimate the time (years) required to reach lengths of 178 (t_{178}), 229 (t_{229}), 254 (t_{254}), and 279 mm (t_{279}).

Using the customized recruitment option available in FAST (Slipke and Maceina 2002), we allowed recruitment to vary based on trends in CPUE of age$_r$ yellow perch observed in each population. We designated maximum age$_r$ CPUE observed for each lake to represent recruitment of 10,000 fish at time $t = 0$ in model simulations. Annual estimates of age$_r$ CPUE were scaled to derive the corresponding number of model recruits expected at each observed value of age$_r$ CPUE: Recruits = 10,000 × (age$_r$ CPUE/maximum CPUE at age$_r$). Using the scaled data, trends in recruitment observed over the time series of gill-net data for each lake (4–5-year periods) were allowed to repeat during the 59-year simulation period in each model.

Information concerning exploitation (u) and natural mortality rates within South Dakota yellow perch populations is lacking for most lakes. Consequently, we ran our models using three scenarios for partitioning estimates of A into u and the expectation of natural death (v). All three scenarios assumed that (1) our empirical estimates of Z and A were reasonable, (2) mortality rates were constant across ages and year-classes, and (3) no compensation would occur (i.e., reductions in fishing mortality would not result in subsequent increases in natural mortality). High fishing mortality scenarios assumed that 75% of A for each population resulted from u and 25% of A was a result of v. Equal mortality scenarios assumed that A was evenly divided between u and v, and low fishing mortality scenarios assumed that 25% of A resulted from u. Using the equations for type II fisheries provided by Ricker (1975), we converted u and v in each scenario to conditional rates of fishing (f; denoted m by Ricker [1975]) and natural mortality (n), respectively, based on the estimate of Z for each

TABLE 2.—Yellow perch age at recruitment (age$_r$; years), total fish captured (N), median proportional size structure of preferred-length fish (PSS-P; ≥250 mm TL), CV in mean CPUE at age$_r$, mean percentage of fully recruited fish age 5 and older (age 5+), pooled total annual mortality rate (A), mean maximum age, mean TL (mm) at age 3 (mean of means), and mean maximum TL in gill-net collections from six South Dakota lakes during 2001–2005 (2001–2004 for East 81 Slough). Ranges associated with each metric (excluding pooled A) appear in parentheses; under pooled A, age ranges used in catch curves are presented.

Lake	Age$_r$	N	Median PSS-P	CV in mean CPUE at age$_r$	Mean age 5+ (%)	Pooled A (%)
East 81	2	1,507 (116–695)	7 (0–20)	43 (21–60)	2 (0.002–5)	69 (2–5)
Enemy Swim	3	1,563 (122–465)	5.6 (0–12)	12 (5–7)	59 (40–87)	40 (3–11)
Madison	2	2,273 (184–780)	15 (0–47)	148 (0–156)	1 (0.006–3)	69 (2–7)
Pickerel	3	1,120 (175–305)	21 (8–50)	66 (3–16)	48 (21–68)	34 (3–9)
Sinai	2	1,580 (239–592)	12 (0–28)	119 (5–76)	2 (0–3)	76 (2–6)
Waubay	2	2,002 (243–686)	37 (11–47)	152 (0.1–18)	54 (0–75)	39 (2–8)

population. Maximum age in model simulations was set at the maximum observed within each population.

Recognizing the harvest-oriented nature of yellow perch fisheries, we assumed the following in interpreting model results: (1) length limit scenarios resulting in average PSS-P values of less than 10 would not justify reductions in harvest; (2) predicted improvements in average PSS-P of less than 25% (e.g., improvement in average PSS-P from 20 to 25 is [25 − 20]/20, or 25%) would be largely unnoticed by anglers and would not justify application of a length limit; (3) regardless of age and size structure improvements, harvest reductions of 75% or more would not be acceptable to anglers; and (4) regardless of age and size structure improvements, a yield reduction of 50% would not be acceptable to managers because too many fish would be lost to natural causes before recruiting to the fishery. Results from length limit simulations that did not meet these criteria were considered to be clearly undesirable from a management perspective and are not explicitly reported here.

Results

Population Characteristics

Yellow perch population metrics varied widely among lakes (Table 2). Age at recruitment to gill nets varied between 2 and 3 years among lakes because of differences in growth rates. Median PSS-P was 15 or less within four of the six populations sampled. However, with the exception of Enemy Swim Lake, annual estimates of PSS-P varied widely in each lake (range ≥ 20), and PSS-P was 20 or higher in at least 1 year of sampling. The highest median values of PSS-P were observed for Waubay (median PSS-P = 37) and Pickerel (median PSS-P = 21) lakes. Similarly, annual estimates of maximum TL were also highly variable among years within each lake (range > 25 mm; Table 2). The highest mean maximum TLs (mean of means; hereafter, grand mean) were observed in Waubay (298 mm) and Pickerel (277 mm) lakes.

Yellow perch populations in Enemy Swim and Pickerel lakes were long lived (mean maximum age > 9 years) and exhibited relatively low rates of pooled A (40% or less). Age-5 and older fish consistently constituted a relatively large portion of gill-net catch in the two lakes (mean = 48–59%, range = 21–87%; Table 2). Enemy Swim Lake yellow perch exhibited the most stable recruitment (CV in $\text{CPUE}_{\text{age 3}} = 12\%$) and the slowest growth (grand mean TL at age 3 = 162 mm TL). Recruitment variability (CV in $\text{CPUE}_{\text{age 3}} = 66\%$) and growth (grand mean TL at age 3 = 200 mm TL) were moderate for Pickerel Lake yellow perch. East 81 Slough yellow perch exhibited relatively stable recruitment (CV in $\text{CPUE}_{\text{age 3}} = 43\%$) and moderate growth (grand mean TL at age 3 = 198 mm); however, they exhibited relatively high A (69%) and low mean maximum age (4.5 years), and on average, few reached age 5 or beyond (2% of gill-net catch). Age-5 and older fish were also rare in lakes Madison and Sinai (≤ 2% of gill-net catch), estimates of pooled A were high (≥69%), and mean maximum age was 5.2 years or less. Growth in lakes Madison and Sinai was fast (grand mean TL at age 3 ≥ 225 mm), and recruitment varied substantially in both lakes (CV in $\text{CPUE}_{\text{age 2}} > 115\%$). Recruitment was most variable in Waubay Lake (CV in $\text{CPUE}_{\text{age 2}} = 152\%$), where growth was also fast (grand mean TL at age 3 = 226 mm), but on average, over half (54%) of the fully recruited yellow perch sampled there were age 5 and older, and mean maximum age (6.4 years) was 1.2–2.0 years higher than those in lakes Madison and Sinai. Although using pooled CPUE-at-age values resulted in reasonable catch curves in terms of linear fit ($r^2 \geq 0.80$; model df = 1; error df range = 3–11; $P < 0.05$) for five of the six populations examined, estimation of A in Waubay Lake was confounded by highly variable recruitment and obvious variation in sampling effectiveness across years (i.e.,

TABLE 2.—Extended.

Lake	Mean maximum age	Mean TL at age 3	Mean maximum TL
East 81	4.5 (3–5)	198 (174–216)	260 (226–303)
Enemy Swim	9.4 (7–12)	162 (157–172)	262 (246–275)
Madison	4.4 (2–7)	251 (205–290)	276 (256–304)
Pickerel	9.8 (8–13)	200 (181–224)	277 (266–292)
Sinai	5.2 (4–6)	225 (210–249)	261 (236–283)
Waubay	6.4 (4–9)	226 (214–233)	298 (278–315)

catch of a particular year-class increased over time in a few instances); this resulted in poor catch curve fit ($r^2 = 0.52$; df = 1,7; $P = 0.04$) and a questionable estimate of pooled A (39%).

Creel Limit Reductions

Data from 19 creel surveys on eight lakes were used to analyze the potential effect of creel limit reductions (Table 3). Few angling parties that kept at least one yellow perch achieved a daily creel limit of 25 fish/angler. In only two instances (Waubay Lake) did more than 10% of angler parties (i.e., those harvesting at least one yellow perch) achieve the 25-fish/angler limit. Harvest reductions of 0–21% were projected to occur in response to a creel limit reduction from 25 to 15 fish/angler. When the daily creel limit was further lowered to 10 fish/angler, the projected harvest reductions were 0–38%; harvest reductions of at least 25% were projected for 6 of 19 cases (4 of the ≥25% reductions were for Waubay Lake). A reduced daily creel limit of 5 fish/angler yielded harvest reductions ranging from 6% to 63% (13 of 19 cases had ≥25% reductions). For Waubay Lake, creel limit effectiveness varied seasonally for two of three years: harvest reductions were greater for winter than for the previous summer. The percentage of angler parties (those harvesting at least one yellow perch) whose harvest would have been affected by creel limit reduction was 0–29% for the 15-fish/angler limit, 0–49% for the 10-fish limit, and 2–69% for the 5-fish limit.

Length Limit Modeling

Model input parameters used for each yellow perch population are reported in Table 4. Deriving von Bertalanffy parameters to represent different growth scenarios in model simulations was difficult for Lake Madison yellow perch because of the lack of gill-net captures of age-5 and older fish (Table 2). Consequently, only mean lengths at ages 2–4 were used to simulate different growth scenarios. For Pickerel Lake, we did not conduct simulations combining slow growth and a 254-mm TL limit because 254 mm exceeded the estimated L_{inf} (252 mm TL; Table 4).

Regardless of growth rate, our four management

TABLE 3.—Predicted reductions (%) in yellow perch harvest based on hypothetical daily creel reductions from 25 fish to 15, 10, or 5 fish. Data are taken from creel surveys on eight eastern South Dakota lakes, 1998–2002, and are based on completed trip interviews for only those angling parties that kept at least one yellow perch (N). The percentage of N that harvested a limit of 25 fish/angler is reported for each winter (W) and summer (S) survey. Numbers below each reduced limit represent the percentage of fish harvested under a 25-fish limit that would have had to be released under the reduced limit, and the numbers in parentheses represent the percentage of N angling parties that would have been affected by the reduced limit.

Lake	Period	N	Parties with 25-fish limit (%)	Reduced limit		
				15 fish	10 fish	5 fish
Bitter	W 1999–2000	46	9	15 (13)	24 (13)	36 (22)
Brandt	S 2002	74	7	15 (18)	30 (27)	55 (45)
Cattail	S 2000	46	0	0	2 (2)	6 (2)
East 81 Slough	W 2000–2001	103	0	5 (8)	15 (14)	35 (31)
Enemy Swim	S 2000	36	0	0	0	14 (11)
Poinsett	S 1998	31	0	0	0	8 (6)
	W 1998–1999	33	3	15 (27)	33 (33)	54 (42)
	S 2000	33	3	13 (3)	20 (3)	34 (12)
Thompson	S 1998	175	0	2 (1)	5 (1)	13 (5)
	W 1998–1999	28	0	0	3 (4)	28 (22)
	S 1999	66	0	0	0	9 (5)
	S 2000	55	2	7 (4)	17 (5)	36 (13)
	S 2001	46	0	0	0	6 (4)
Waubay	S 1998	225	1	6 (2)	12 (4)	25 (9)
	W 1998–1999	52	15	17 (21)	31 (33)	59 (69)
	S 1999	301	2	8 (3)	14 (4)	29 (11)
	W 1999–2000	41	17	21 (29)	38 (49)	63 (66)
	S 2000	147	7	19 (12)	33 (16)	52 (27)
	W 2000–2001	115	7	14 (10)	28 (14)	52 (23)

TABLE 4.—Input parameters used in yellow perch length limit models for four South Dakota lakes. Intercepts (a) and slopes (b) from regressions of $\log_{10}$(weight) on $\log_{10}$ TL represent 5-year means. Based on estimates of total annual mortality rate (pooled A; Table 3) and instantaneous total mortality rate (Z), different combinations of conditional fishing (f) and natural (n) mortality rates were used to simulate three mortality scenarios: high (exploitation $u = 75\%$ of A and natural death $v = 25\%$), equal ($u = v = 50\%$), and low ($u = 25\%$; $v = 75\%$). Growth coefficients (k) and asymptotic maximum TL estimates (L_{inf}) from von Bertalanffy growth models (fixed intercept $t_0 = 0$) were used to simulate growth for each population based on the 75th (fast growth), 50th (median growth), and 25th percentiles (slow growth) of mean TLs observed at each age. Von Bertalanffy equations were also used estimate the time (years) required to reach TLs of 178 (t_{178}), 229 (t_{229}), 254 (t_{254}), and 279 mm (t_{279}) for each growth scenario. Missing entries represent cases where values of t_{254} and t_{279} could not be estimated because L_{inf} was less than 254 or 279 mm.

Lake	a	b	u	f	n	Growth	k	L_{inf}	t_{178}	t_{229}	t_{254}	t_{279}
Madison	−4.68	2.92	High	0.58	0.25	Fast	0.47	301	1.9	3.0	4.0	5.7
			Equal	0.44	0.44	Median	0.49	277	2.1	3.6	5.1	
			Low	0.25	0.58	Slow	0.49	272	2.2	3.8	5.5	
Pickerel	−5.35	3.23	High	0.25	0.10	Fast	0.48	272	2.2	3.8	5.6	
			Equal	0.18	0.18	Median	0.51	259	2.3	4.2	7.7	
			Low	0.10	0.25	Slow	0.47	252	2.6	5.1		
Sinai	−5.19	3.15	High	0.66	0.30	Fast	0.49	297	1.9	3.0	3.9	5.7
			Equal	0.51	0.51	Median	0.44	298	2.1	3.3	4.3	6.3
			Low	0.30	0.66	Slow	0.41	298	2.2	3.6	4.7	6.7
Waubay	−5.14	3.14	High	0.30	0.11	Fast	0.65	271	1.6	2.9	4.3	
			Equal	0.21	0.21	Median	0.64	265	1.7	3.1	5.0	
			Low	0.11	0.30	Slow	0.66	257	1.8	3.4	6.7	

criteria were not met in any simulation where f was low, because the numbers of fish lost to natural causes offset the reductions in f realized under each length limit. In slow-growth simulations for Waubay Lake, management criteria were met under 229- and 254-mm TL limits only when f was high; in lakes Madison and Sinai, management criteria were also met when growth was slow and when f was equal to n (Table 5). In all simulations, age and size structures were predicted to improve under both length limits; largest predicted improvements occurred when f was high and when growth was modeled at slow to median levels. We observed few improvements in yield under 229- and 254-mm TL limits; when they occurred, predicted yield improvements were 13% or less. With the exception of Lake Sinai and Waubay Lake, slight yield improvements associated with length limits were only observed when growth occurred at median or fast levels and when f was high. Under a 229-mm TL limit and slow growth, yield improvements of 5% or less were observed for Lake Sinai and Waubay Lake when f was high. No improvements in yield were observed when f was equal to n or when f was low. Despite large improvements in age and size structures, harvest was reduced under 229- and 254-mm TL limits, and in many cases the projected reductions exceeded 50% (Table 5). Compared with a 254-mm TL limit, a 229-mm limit provided smaller improvements in age and size structures and less-pronounced reductions in yield and harvest; in cases where yield was improved by length limits, a 229-mm limit provided slightly higher yield improvements than did the 254-mm limit. For all lakes, the best outcomes realized under 229- and 254-mm TL limits occurred when f was high and when growth occurred at median to fast levels.

Discussion

Similar to findings by Purchase et al. (2005), our results demonstrated that yellow perch populations differ substantially among water bodies. Our results also demonstrated that selected metrics commonly used to describe fish populations (Table 2) differed substantially among years within individual yellow perch populations. Single-year estimates of mean TL at age 3, PSS-P, or maximum TL of yellow perch in many South Dakota lakes would prove largely uninformative because these metrics fluctuated widely on annual basis for most populations. Although we did not statistically explore relationships among population metrics because of the low number of lakes we sampled, there were no clear associations except that growth variation among lakes was at least partly linked to recruitment variation. Similarly, Lott (1991) and Lucchesi (1991) characterized yellow perch populations exhibiting consistent recruitment as slow growing, whereas faster growth rates were observed in lakes where recruitment was considered more variable. Variable recruitment, although providing an inconsistent fishery, may promote yellow perch growth, possibly through density-dependent interactions (e.g., Nelson and Walburg 1977; Henderson 1985; Staggs and Otis 1996; Pierce et al. 2006). Larval and juvenile sampling indicated that East 81 Slough and Enemy Swim and Pickerel lakes consistently supported relatively high

TABLE 5.—Results of models used to simulate the effects of TL limits (229 or 254 mm) on four South Dakota yellow perch populations. Models were run under different conditional fishing mortality (f; high, equal, low) and growth (slow, median, fast) scenarios (Table 4). Variables used to describe TL limit effects were total number harvested, yield (kg), proportional stock structure of preferred length (≥250 mm) fish (PSS-P), and percent age-5 or older; variables were averaged over 50-year simulation periods. Values represent the percent change in average value of the variable when the TL limit was compared with no length limit (178 mm) under the same rates of growth and f. Results for a specified TL limit are only reported for a simulation if (1) average PSS-P under the limit was 10 or more, (2) predicted improvement in average PSS-P was 25% or more, (3) harvest reduction was less than 75%, and (4) predicted yield reduction was less than 50%.

Lake	f	Growth	Limit compared with 178 mm	Change in selected response variable (%)			
				Harvest	Yield	PSS-P	Age 5+
Madison	High	Fast	229	−28	10	50	169
			254	−45	2	85	490
	Equal	Fast	229	−48	−21	37	94
			254	−70	−44	61	228
	High	Median	229	−23	13	156	260
			254	−37	11	359	1,163
	Equal	Median	229	−58	−34	95	136
	High	Slow	229	−37	−2	225	299
			254	−64	−32	656	1,270
Pickerel	Equal	Slow	229	−61	−39	138	152
	High	Fast	229	−17	9	35	60
			254	−33	1	80	154
	Equal	Fast	254	−51	−27	50	90
	High	Median	229	−20	5	57	75
			254	−49	−23	174	236
Sinai	Equal	Median	229	−33	−12	35	47
	High	Fast	229	−34	9	142	243
			254	−53	−4	307	840
	Equal	Fast	229	−56	−28	88	125
	High	Median	229	−36	6	126	288
			254	−57	−9	290	1,070
	Equal	Median	229	−59	−15	92	145
	High	Slow	229	−39	4	167	329
			254	−60	−14	371	1,300
Waubay	Equal	Slow	229	−62	−36	105	162
	High	Fast	254	−30	1	46	154
	Equal	Fast	254	−49	−26	31	85
	High	Median	254	−36	−7	53	216
	Equal	Median	254	−57	−37	31	114
	High	Slow	229	−19	5	29	75
			254	−55	−34	78	337

densities of small yellow perch, whereas the abundance of small fish fluctuated widely in lakes Madison and Sinai and in Waubay Lake (Isermann 2003; Ward et al. 2004). In lakes with consistent recruitment, multiple yellow perch year-classes may compete for the same food resources, but in populations exhibiting variable recruitment the presence of measurably weaker year-classes might reduce competition among year-classes. However, differences in growth rates observed among populations may merely reflect differences in lake productivity or fish community complexity (Boisclair and Leggett 1989). For example, Enemy Swim and Pickerel lakes are less productive than the other study lakes and support more complex fish communities (e.g., large centrarchid components), which may result in competition for food and habitat resources; by comparison, lakes Madison and Sinai and Waubay Lake are highly fertile and support relatively simple fish communities that are dominated by percids.

Reductions in daily creel limits may have some value from a social perspective, but our results provide reasonable evidence that a 25-fish/angler limit would not be effective in reducing yellow perch harvest in many South Dakota lakes because few angling parties achieve the daily limit. Similarly, Cook et al. (2001) demonstrated that approximately 74% of Minnesota anglers targeting yellow perch harvested no more than 10 fish/trip. As noted by Larscheid (1992) and Cook et al. (2001), daily creel limits for yellow perch would generally have to be 5 fish/d or less to significantly reduce harvest within most of the fisheries we examined; Waubay Lake was the exception, as a daily creel limit reduction from 25 to 10 fish/angler generally resulted in predicted harvest reductions greater than 25%. Evidence from Waubay Lake creel surveys suggested that the effectiveness of daily creel limits varied seasonally, which may also be the case in other yellow perch fisheries exhibiting seasonal harvest trends (Isermann et al. 2005).

Beginning in December 2001, the daily yellow perch creel limit was reduced to 10 fish/angler within 11 counties in northeastern South Dakota; Waubay Lake was among the lakes regulated by the new limit. In numerous other fisheries included under the new reduced limit (including Bitter, Cattail, and Enemy Swim lakes), harvest reductions may not occur or low angler harvest may make such limits unnecessary. Conversely, blanket application of creel limit reductions may restrict harvest in the intensive yellow perch fisheries that occur sporadically in some lakes as strong year-classes recruit to the fishery, resulting in large numbers of fish available for angler harvest and conceivably more anglers achieving a daily limit. However, this was not the case for the yellow perch fishery on Pelican Lake, South Dakota, where large numbers fish exceeding 254 mm became available for harvest during 2001–2002; in that case, a reduced daily creel limit of 10 fish/angler did not prevent high exploitation (estimated $u = 61\%$; Isermann et al. 2005). Despite the relatively high harvest rates in Pelican Lake during the winter fishery (>0.5 fish/angler-hour; Isermann et al. 2005), only an estimated 5% of anglers (14 of 286 completed trip interviews) achieved the 10-fish limit (D.A.I., unpublished data). Hence, although most anglers kept fewer than 10 fish/d, angler effort was sufficient to remove a large proportion of the Pelican Lake population.

Our length limit modeling was simplistic and ignored certain potential population responses that might occur after length limit implementation, such as compensatory increases in natural mortality (Boxrucker 2002), reduced growth rates (Novinger 1987; Hurley and Jackson 2002), increased longevity (Novinger 1987; Newman and Hoff 2000; Hurley and Jackson 2002), and increased fishing mortality for fish exceeding minimum legal size (Larscheid and Hawkins 2005). Additionally, some of our assumptions may not have been realistic (e.g., equal growth and mortality across years and year-classes). Yellow perch growth is density dependent within some populations (e.g., Nelson and Walburg 1977; Henderson 1985; Staggs and Otis 1996; Pierce et al. 2006), and implementation of minimum length limits could theoretically contribute to reductions in growth resulting from increased densities (e.g., Serns 1978; Carline et al. 1984; Munger and Kraai 1997). Implementation of restrictive harvest regulations could negatively affect angler use of a particular fishery as anglers choose to fish waters with less-restrictive regulations (Beard et al. 2003), possibly reducing fishing pressure and mortality in the more-restrictive fisheries. Conversely, regulations that limit harvest by individual anglers (i.e., minimum length limits) could increase angler use of a particular fishery if the regulation proves successful in creating an exceptional angling opportunity (Cox and Walters 1998). This could increase fishing mortality and negate length limit effectiveness. Our choice to exclude the aforementioned issues from our modeling was not due to a lack of concern about these issues but instead resulted from a lack of knowledge about (1) certain facets of yellow perch population dynamics and (2) the response of anglers to minimum length limits. We had insufficient data to adequately describe relationships between fish density and growth within our study lakes, and the compensatory relationships between fishing and natural mortality have been rarely examined (Allen et al. 1998; Boxrucker 2002). Also, the functional response of anglers to various harvest restriction types has not been described for most multistock fisheries.

Nevertheless, we believe our modeling offered a reasonable approach for selecting lakes where length limits might be implemented, rather than merely using a blanket regulation for all waters within a specified geographic area. Our modeling approach was sufficient to capture at least some of the variation in growth observed within these populations. Potential effects of length limits are not static but fluctuate with variation in growth. In most of the populations we examined, the benefits of length limits to age and size structures might be outweighed by harvest and yield reductions during periods of slow growth, depending on angler desires. Furthermore, the size-selective nature of angler harvest in some recreational yellow perch fisheries without minimum length limits (Clady 1977; Isermann et al. 2005) suggests that predicted harvest reductions and improvements in size and age structures in our minimum length limit simulations may represent high estimates. For example, if anglers already selectively harvest yellow perch longer than 229 mm, then a 229-mm limit would be less likely to greatly influence response variables in relation to no length limit. Release mortality could also narrow the gap between no-limit and minimum-limit simulation results, under the premise that minimum length limits would require anglers to release more fish, thereby increasing release mortality. Unfortunately, the exact relationships between fishing mortality, fish length or age, and release mortality within yellow perch fisheries are not known at this time.

On two South Dakota lakes, responses of winter yellow perch anglers to questions seeking preference information indicated that the size of fish caught was important to them (Isermann et al. 2005). Our modeling suggested that length limits might meet angler desires for higher numbers of larger fish; however, in many cases, improvements in size structure were coupled with large declines in harvest and, in some cases, yield. Generally, length limits were predicted to be most beneficial when f was high and growth was modeled at median or fast levels; also, a 229-mm length limit provided more reasonable tradeoffs between improved size structure and reduced harvest than did a 254-mm limit. Although anglers may desire yellow perch that are 254 mm or longer (Isermann et al. 2005), the use of a 229-mm limit might be a more reasonable approach in suitable situations, depending on observed growth patterns and assuming that f is at least equal to n.

Despite predicted improvements in size structure, many of the predicted outcomes from length limit simulations would probably be unacceptable from a management standpoint, particularly if reductions in harvest are severe. Yellow perch fisheries are primarily harvest oriented, and analysis of winter catch and harvest data from Waubay Lake during 1999–2002 (Blackwell and Hubers 2003) indicated that anglers harvested between 60% and 94% of yellow perch caught. Although we used a 75% harvest reduction as a benchmark for an unacceptable outcome, it seems likely that a 50% or higher reduction in harvest would be unpopular among yellow perch anglers, regardless of potential improvements in size and age structures. Angler discontent would be even greater if reduced harvest is coupled with greatly reduced yields. A similar argument could probably be made regarding our choice to use a yield reduction of 50% to represent an undesirable management outcome.

In some waters, such as East 81 Slough and Enemy Swim Lake, length limits are unlikely to be useful management tools because of slow growth rates and because f is probably less than n (Blackwell 2005a; Isermann et al. 2005), which may be a product of relatively low size structure. In fast-growing yellow perch populations where few fish live beyond age 4, such as those in lakes Madison and Sinai, natural mortality might limit the effectiveness of length limits if A is primarily attributable to natural causes. Because information on angler harvest is limited for these two lakes, we can only anecdotally state that their yellow perch fisheries are sporadic: occasional periods of increased angler use coupled with potentially high rates of harvest are followed by periods in which angler use and harvest are low. If angler harvest represents a major mortality source in these populations, length limits might be effective in increasing age and size structures and might provide some improvements in yield. Despite moderate growth rates, length limits might also improve yellow perch size and age structures in Pickerel Lake if growth occurs at median or higher rates, but improvements could be limited if f is less than n.

Based on gill-net data, we initially suspected that length limits would prove most beneficial in Waubay Lake, where yellow perch growth was relatively fast and where more fish lived beyond age 4 than in lakes Sinai and Madison. Furthermore, although we do not fully know the effects of u (and consequently f) on the Waubay Lake population, the lake does support a consistently popular fishery and relatively high rates of harvest (Blackwell 2005b); thus, it is the most likely candidate to represent a situation where f is greater than n. However, improvements in mean PSS-P under a 229-mm limit were generally small (<25% in all but one instance), mean PSS-P improvements under a 254-mm limit were modest relative to those of the other lakes, and yield declined in most cases.

Some previous modeling exercises have predicted that length limits would improve yields in exploited fisheries under certain conditions (Colvin 1991; Allen and Miranda 1995; Maceina et al. 1998). Conversely, previous modeling exercises for yellow perch populations have indicated that yield would be reduced or only slightly increased under minimum length limits (Boe 1984; Lucchesi 1988; Bronte et al. 1993). Boe (1984) indicated that predicted yield reductions under 191- and 244-mm length limits in the Okoboji lakes, Iowa, resulted from moderate growth rates and high natural mortality rates. Bronte et al. (1993) reported that natural mortality was the major factor controlling the abundance of yellow perch in western Lake Superior, and they predicted that length limits of 178 or 200 mm would slightly decrease yield. Lucchesi (1988) projected small increases in yield under 178- and 203-mm length limits in the Les Cheneaux Islands of Lake Huron, whereas the number of older fish was predicted to increase substantially. In most of our model simulations, yellow perch yield was predicted to decline under length limit scenarios relative to a no-limit situation. When predicted improvements in yield were observed, they were relatively small (always < 20% and frequently < 10%); except in Lake Sinai and Waubay Lake, yield improvements only occurred when growth was modeled at median or fast rates, despite improvements in size structure and higher survival to age 5 and beyond.

The lack of larger improvements in yield and, in some cases, size structure can be attributed to growth patterns within the populations we examined. Yellow perch in most of the populations achieved much of their full growth potential upon reaching 229 or 254 mm; in several cases, older fish collected in each lake were smaller on average than their younger counterparts. Yellow perch in these lakes rarely attained TLs greater than 280 mm despite the fact that some attained TLs greater than 300 mm. For example, in Waubay Lake we observed the highest median PSS-P (Table 2) and the mean maximum TL approached 300 mm, but only 5% (99 of 1,828) of fish collected in gill nets during the 5-year sampling period exceeded 280 mm and less than 1% (14 of 1,828) of fish were 300 mm or more. The grand mean TL was 226 mm at age 3 (Table 2), 255 mm (range = 243–267 mm) at age 5, and only 257 mm (range = 252–262 mm) at age 6. Annual estimates of maximum TL occasionally exceeded 300 mm in some lakes (Table 2), but in five of the six populations (Waubay Lake was the exception) mean maximum TL was less than 280 mm over the 4–5 years of sampling (Table 2). In two of the four lakes used in length limit modeling (i.e., Pickerel and Waubay lakes) estimates of L_{inf} were always less than 279 mm. Despite relatively fast growth to 229 and 254 mm (Table 4), yellow perch in Lake Sinai would require most of their life (maximum age = 6 years) to reach 279 mm ($t_{279} = 5.7$ years) if growth was fast (Table 4); at median and slow growth, t_{279} exceeded the maximum age observed in the population ($t_{279} = 6.3$ and 6.7 years, respectively; Table 2). Hence, although more fish were predicted to reach older ages in length limit scenarios, they were not getting substantially larger. Small gains in the size of harvested fish attained by a specified length limit were offset by the number lost to natural mortality while recruiting to harvestable length, thus limiting yield improvements.

In lakes Madison and Sinai, the two populations exhibiting the fastest growth rates, high mortality rates prevented substantial yield improvements. Given the high rate of *A* in both populations, relatively few fish lived beyond age 3 in model simulations, which adequately reflected gill-net age structure (i.e., ages 3 and older were rare; Table 2). For example, fish older than age 3 represented only 5% (131 of 2,455) of all yellow perch collected over the 5-year sampling period in Lake Madison and only 12% (186 of 1,580) of those collected in Lake Sinai. Hence, while fish in both lakes had high growth potential, few lived long enough to reach larger sizes, limiting the magnitude of yield improvements. If *f* represents a major portion of the high *A* observed in these lakes and if longevity improves after length limit implementation, yield improvements could be much higher than those predicted by our models.

Some of the growth trends we observed may be related to differences in mortality between sexes. Previous assessments have suggested that recreational angler harvest is selective for females (Clady 1977; Weber and Les 1982; Ohio Division of Wildlife 2004; Purchase et al. 2005). Female yellow perch typically grow faster and reach larger maximum sizes than males (Scott and Crossman 1973; Craig 1987), making them more susceptible to size-selective angler harvest. Consequently, if only slower-growing males remain at older ages, our observations of growth rates may be biased, and overall growth potential in some populations may be higher than estimated. If female-selective harvest is occurring, the potential to maximize yield and size structure with length limits might be much greater than we predicted, but length limits may also exacerbate sex selectivity because females reach legal harvestable size faster than males.

Management Implications

Given the degree of variation we observed in population metrics, annual sampling will remain important in the management of yellow perch in South Dakota waters where significant fisheries are known to exist. Partitioning total mortality into fishing and natural mortality will be critical to managing yellow perch populations. A pair of previous studies suggested that *A* observed in some South Dakota yellow perch populations is largely due to natural causes (Scholten et al. 2001; Isermann et al. 2005), a situation also observed in other yellow perch populations (Boe 1984; Bronte et al. 1993). Conversely, Isermann et al. (2005) demonstrated that fishing mortality was at least occasionally an important source of mortality for yellow perch in Pelican Lake, South Dakota. Our modeling provides a framework for identifying populations where future research on mortality factors would be most useful from a management perspective. Estimating the exact rate of fishing mortality in a particular population can be difficult (Miranda et al. 2002; Isermann et al. 2005), but we suggest that in many instances, merely describing the relative magnitude of fishing mortality in relation to natural mortality may prove beneficial from a management standpoint and is probably more informative than harvest estimates derived from time-consuming and expensive creel surveys. If most of *A* observed in yellow perch populations, such as those in lakes Sinai and Madison and Waubay Lake, is attributable to natural causes, then length limits would not be expected to provide measurable benefits. However, if the majority of total mortality is a result of angler harvest, gill-net data and modeling results justify experimenting with a 229-mm length limit.

Regardless of the harvest regulations used to manage yellow perch fisheries in South Dakota, it may remain difficult to maintain fishery quality in light of observed recruitment variation. Recruitment variation results in sporadic fisheries marked by pulses of abundant large yellow perch that can attract high levels of angler effort. In these instances, creel and length limits may not effectively regulate angler harvest of yellow perch because effort may be sufficiently high to remove large numbers of fish, regardless of the regulations (Isermann et al. 2005). Similarly, other recent studies have suggested that trends in angler effort can override efforts to use creel or length limits to effectively control angler harvest and maintain quality fishing (Johnson and Carpenter 1994; Cox and Walters 2002; Post et al. 2002; Radomski 2003). Despite angler desires for 254-mm and larger yellow perch (Isermann et al. 2005), population variability, asymptotic growth, potentially high natural mortality rates, and angler harvest orientation may dictate that yield maximization is still a reasonable management goal for many South Dakota fisheries. Increasing the number of yellow perch attaining 229 mm TL might be a reasonable objective for some populations if angler harvest represents the dominant source of mortality. Furthermore, anglers should realize that yellow perch larger than 254 mm TL are exceptional in many South Dakota populations.

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References

Allen, M. S., and L. E. Miranda. 1995. An evaluation of the value of harvest restrictions in managing crappie fisheries. North American Journal of Fisheries Management 15:766–772.

Allen, M. S., L. E. Miranda, and R. E. Brock. 1998. Implications of compensatory and additive mortality to the management of selected sportfish populations. Lakes & Reservoirs Research and Management 3:67–79.

Baccante, D. B. 1995. Assessing catch inequality in walleye angling fisheries. North American Journal of Fisheries Management 15:661–665.

Beard, T. D., Jr., S. P. Cox, and S. R. Carpenter. 2003. Impacts of daily bag limit reductions on angler effort in Wisconsin walleye lakes. North American Journal of Fisheries Management 23:1283–1293.

Beard, T. D., Jr., M. T. Drake, J. E. Breck, and N. A. Nate. 1997. Effects of simulated angling regulations on stunting in bluegill populations. North American Journal of Fisheries Management 17:525–532.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Chapman and Hall, London.

Bister, T. J., D. W. Willis, A. D. Knapp, and T. R. St. Sauver. 2002. Evaluation of a 23-cm minimum length limit for black and white crappies in a small South Dakota impoundment. North American Journal of Fisheries Management 22:1364–1368.

Blackwell, B. G. 2005a. Enemy Swim Lake, South Dakota angler use and harvest surveys December 1997–August 2004. South Dakota Department of Game, Fish, and Parks, Fisheries Division Report 05-12, Pierre.

Blackwell, B. G. 2005b. Waubay Lake, South Dakota angler use and harvest surveys December 2002–August 2004. South Dakota Department of Game, Fish, and Parks, Fisheries Division Report 05-10, Pierre.

Blackwell, B. G., and M. J. Hubers. 2003. Angler use, sport fish harvest, and fish community surveys for Waubay Lake, Day County, SD, December 1996–August 2002. South Dakota Department of Game, Fish, and Parks, Fisheries Division Report 03-06, Pierre.

Boe, S. J. 1984. Exploitation, annual mortality, and yield per recruit of yellow perch *Perca flavescens* Mitchill from the Okoboji lakes, Iowa. Master's thesis. Iowa State University, Ames.

Boisclair, D., and W. C. Leggett. 1989. Among-population variability of fish growth: III. Influence of fish community. Canadian Journal of Fisheries and Aquatic Sciences 46:1539–1550.

Boxrucker, J. 2001. Changes in crappie population structure following restrictive harvest regulations. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 53(1999):80–90.

Boxrucker, J. 2002. Rescinding a 254-mm minimum length limit on white crappies at Ft. Supply Reservoir, Oklahoma: the influence of variable recruitment, compensatory mortality, and angler dissatisfaction. North American Journal of Fisheries Management 22:1340–1348.

Bronte, C. R., J. H. Selgeby, and D. V. Swedberg. 1993. Dynamics of a yellow perch population in western Lake Superior. North American Journal of Fisheries Management 13:511–523.

Carline, R. F., B. L. Johnson, and T. J. Hall. 1984. Estimation and interpretation of proportional stock density for fish populations in Ohio impoundments. North American Journal of Fisheries Management 4:139–154.

Carlson, R. E. 1977. A trophic state index for lakes. Limnology and Oceanography 22:361–369.

Clady, M. C. 1977. Distribution and relative exploitation of yellow perch tagged on spawning grounds in Oneida Lake. New York Fish and Game Journal 24:168–177.

Colvin, M. A. 1991. Evaluation of minimum size limits and reduced daily limits on the crappie populations and fisheries in five large Missouri reservoirs. North American Journal of Fisheries Management 11:585–597.

Cook, M. F., T. J. Goeman, P. J. Radomski, J. A. Younk, and P. C. Jacobson. 2001. Creel limits in Minnesota: a proposal for change. Fisheries 26(5):19–26.

Cox, S., and C. Walters. 1998. Maintaining quality in recreational fisheries: how success breeds failure in management of open-access sport fisheries. Pages 107–119 *in* T. J. Pitcher and C. Hollingworth, editors. Recreational fisheries: ecological, economic, and social evaluation. Blackwell Scientific Publications, Oxford, UK.

Cox, S. P., and C. Walters. 2002. Modeling exploitation in recreational fisheries and implications for effort management on British Columbia rainbow trout lakes. North American Journal of Fisheries Management 22:21–34.

Craig, J. F. 1987. The biology of perch and related fish. Croom Helm, London.

Currie, L. K., and D. C. Fulton. 2001. Managing Minnesota's fishing resources: a review of angler and resort owner attitudes towards bag limits. Final Project Report to Minnesota Department of Natural Resources, St. Paul.

Fox, A. C. 1975. Effects of traditional harvest regulations on bass populations and fishing. Pages 392–398 *in* R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Gabelhouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273–285.

Guy, C. S., R. M. Neumann, and D. W. Willis. 2006. New terminology for proportional stock density (PSD) and relative stock density (RSD): proportional stock structure (PSS). Fisheries 31(2):86–87.

Hale, R. S., M. E. Lundquist, R. L. Miller, and R. W. Petering. 1999. Evaluation of a 254-mm length limit on crappies in Delaware Reservoir, Ohio. North American Journal of Fisheries Management 19:804–814.

Henderson, B. A. 1985. Factors affecting growth and recruitment of yellow perch, *Perca flavescens* Mitchill, in South Bay, Lake Huron. Journal of Fish Biology 26:449–498.

Hurley, K. L., and J. J. Jackson. 2002. Evaluation of a 254-mm length limit for crappies in two southeast Nebraska reservoirs. North American Journal of Fisheries Management 22:1369–1375.

Hushak, L. J., G. W. Morse, and K. K. Apraku. 1986. Regional impacts of fishery allocation to sport and commercial interests: a case study of Ohio's portion of Lake Erie. North American Journal of Fisheries Management 6:472–480.

Isermann, D. A. 2003. Population dynamics and management of yellow perch populations in South Dakota glacial lakes. Doctoral dissertation. South Dakota State University, Brookings.

Isermann, D. A., D. W. Willis, D. O. Lucchesi, and B. G. Blackwell. 2005. Seasonal harvest, exploitation, size-selectivity, and catch preferences associated with winter yellow perch anglers on South Dakota lakes. North American Journal of Fisheries Management 25:827–840.

Jacobson, P. C. 2005. Experimental analysis of a reduced daily bluegill limit in Minnesota. North American Journal of Fisheries Management 25:203–210.

Johnson, B. M., and S. R. Carpenter. 1994. Functional and numerical responses: a framework for fish–angler interactions? Ecological Applications 4:808–821.

Jones, R. 1957. A much simplified version of the full yield equation. International Commission for Northwest Atlantic Fisheries, International Council for the Exploration of the Sea, and Food and Agricultural Organization of the United Nations, Document P.21, Lisbon.

Kraft, C. E., and B. L. Johnson. 1992. Fyke-net and gill-net size selectivities for yellow perch in Green Bay, Lake Michigan. North American Journal of Fisheries Management 12:230–236.

Larscheid, J. G. 1992. Contribution of stocked walleye and population dynamics of walleye in Spirit and East and West Okoboji lakes. Annual Report. Iowa Department of Natural Resources, Federal Aid in Sport Fish Restoration, Project F-15-R, Study 2, Des Moines.

Larscheid, J. G., and M. J. Hawkins. 2005. Evaluation of special regulations for managing walleyes in Iowa's natural lakes. Completion Report. Iowa Department of Natural Resources, Federal Aid in Sport Fish Restoration, Project F-160-R, Des Moines.

Lott, J. P. 1991. Food habits of yellow perch in eastern South Dakota glacial lakes. Master's thesis. South Dakota State University, Brookings.

Lucchesi, D. O. 1988. A biological analysis of the yellow perch population in the Les Cheneaux Islands, Lake Huron. Michigan Department of Natural Resources, Fisheries Division, Fisheries Research Report 1958, Ann Arbor.

Lucchesi, D. O. 1991. Investigation of yellow perch population dynamics in eastern South Dakota lakes. South Dakota Department of Game, Fish, and Parks, Completion Report 92–1, Pierre.

Maceina, M. J., P. W. Bettoli, S. D. Finley, and V. J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18:66–75.

McShane, L. M., and J. Bowman. 2003. A literature review of yellow perch regulations in North America. Ontario Ministry of Natural Resources, Fish and Wildlife Branch, Toronto.

Mendolsohn, R. 1994. South Dakota angler use and preference survey. South Dakota Department of Game, Fish, and Parks, Completion Report 94–14, Pierre.

Miranda, L. E., R. E. Brock, and B. S. Dorr. 2002. Uncertainty of exploitation estimates made from tag returns. North American Journal of Fisheries Management 22:1358–1363.

Munger, C. R., and J. E. Kraai. 1997. Evaluation of length and bag limits for walleyes in Meredith Reservoir, Texas. North American Journal of Fisheries Management 17:438–445.

Nelson, W. R., and C. H. Walburg. 1977. Population dynamics of yellow perch (*Perca flavescens*), sauger (*Stizostedion canadense*), and walleye (*S. vitreum vitreum*) in four main stem Missouri River reservoirs. Journal of the Fisheries Research Board of Canada 34:1748–1763.

Newman, S. P., and M. H. Hoff. 2000. Evaluation of a 16-inch minimum length limit for smallmouth bass in Pallette Lake, Wisconsin. North American Journal of Fisheries Management 20:90–99.

Novinger, G. D. 1987. Evaluation of a 15.0-inch minimum length limit on largemouth bass and spotted bass catches at Table Rock Lake, Missouri. North American Journal of Fisheries Management 7:260–272.

Ohio Division of Wildlife. 2004. Ohio's Lake Erie fisheries. Annual Status Report. Ohio Department of Natural Resources, Division of Wildlife, Lake Erie Fisheries Research Unit, Federal Aid in Fish Restoration, Project F-69-P, Sandusky.

Paukert, C. P., and D. W. Willis. 2001. Comparison of exploited and unexploited yellow perch *Perca flavescens*

(Mitchill) populations in Nebraska Sandhill lakes. Fisheries Management and Ecology 8:533–542.

Paukert, C. P., D. W. Willis, and D. W. Gabelhouse, Jr. 2002. Effect and acceptance of bluegill length limits in Nebraska natural lakes. North American Journal of Fisheries Management 22:1306–1313.

Pierce, R. B., C. M. Tomcko, and M. T. Negus. 2006. Interactions between stocked walleyes and native yellow perch in Lake Thirteen, Minnesota: a case history of percid community dynamics. North American Journal of Fisheries Management 26:97–107.

Post, J. R., M. Sullivan, S. Cox, N. P. Lester, C. J. Walters, E. A. Parkinson, A. J. Paul, L. Jackson, and B. J. Shuter. 2002. Canada's recreational fisheries: the invisible collapse? Fisheries 27(1):6–17.

Purchase, C. F., N. C. Collings, G. E. Morgan, and B. J. Shuter. 2005. Predicting life history traits of yellow perch from environmental characteristics of lakes. Transactions of the American Fisheries Society 134:1369–1381.

Quinn, S. P. 1992. Angler perspectives on walleye management. North American Journal of Fisheries Management 12:367–378.

Radomski, P. 2003. Initial attempts to actively manage recreational fishery harvest in Minnesota. North American Journal of Fisheries Management 23:1329–1342.

Radomski, P. J., G. C. Grant, P. C. Jacobson, and M. F. Cook. 2001. Visions for recreational fishing regulations. Fisheries 26(5):7–18.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Scholten, G. D., D. A. Isermann, and D. W. Willis. 2001. Simulated effects of angler harvest on an unexploited South Dakota yellow perch population. Proceedings of the South Dakota Academy of Science 80:33–37.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Serns, S. L. 1978. Effects of a minimum size limit on the walleye population of a northern Wisconsin lake. Pages 390–397 *in* R. L. Kendall, editor. Selected coolwater fishes of North America. American Fisheries Society, Special Publication 11, Bethesda, Maryland.

Slipke, J., and M. Maceina. 2002. Fishery analyses and simulation tools, version 2.0. Auburn University, Auburn, Alabama.

Snow, H. E. 1982. Hypothetical effects of fishing regulations in Murphy Flowage, Wisconsin. Wisconsin Department of Natural Resources, Technical Bulletin 131, Madison.

Staggs, M. D., and K. J. Otis. 1996. Factors affecting first-year growth of fishes in Lake Winnebago, Wisconsin. North American Journal of Fisheries Management 16:608–618.

Ward, M. J., M. R. Anderson, S. J. Fisher, D. A. Isermann Q. E. Phelps, and D. W. Willis. 2004. Relations between climatological variables and larval yellow perch abundance in eastern South Dakota glacial lakes. Journal of Freshwater Ecology 19:213–218.

Webb, M. A., and R. A. Ott, Jr. 1991. Effects of length and bag limits on population structure and harvest of white crappies in three Texas reservoirs. North American Journal of Fisheries Management 11:614–622.

Weber, J. J., and B. L. Les. 1982. Spawning and early life history of yellow perch in the Lake Winnebago system. Wisconsin Department of Natural Resources Technical Bulletin 130.