Descriptions of Walleye Stocks in High-elevation Reservoirs, Wyoming

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ABSTRACT - We evaluated growth, age and length structure, and body condition of walleye (*Stizostedion vitreum*) stocks in five Wyoming reservoirs at elevations exceeding 1342 m above mean sea level. Proportions of old fish were high, growth rates were low to moderate, and body condition was fair to good relative to other regional walleye stocks. Length structure showed considerable variability with two reservoirs having substantial proportions of fish 510 mm or greater in total length (TL) and one reservoir dominated by fish smaller than 380 mm TL.

Key words: Walleye, *Stizostedion vitreum*, reservoirs, Wyoming

Walleye (*Stizostedion vitreum*) is a coolwater fish species that has a natural range extending north to Great Bear Lake, Northwest Territories, Canada (Regier et al. 1969). Walleyes have been widely introduced into reservoirs of the Rocky Mountains and Great Plains, some at elevations exceeding 1300 m above mean sea level (AMSL). There is limited information on the dynamics of walleye stocks in high-elevation reservoirs where trout (*Oncorhynchus* spp. or *Salmo trutta*) are often the primary sport fishes (Jones et al. 1994).

The mainstem reservoirs on the North Platte River in Wyoming have provided trout fisheries maintained by stocking fingerling trout (75-102 mm; McMillan 1984). Walleyes from an unknown origin were first observed in this system in 1961 (McMillan 1984). Naturally reproducing stocks are now found throughout the North Platte River system in Wyoming. Because of walleye predation, the trout fisheries are now maintained by stocking catchable-size trout (>200 mm; McMillan 1984). Walleye fisheries have developed in these mainstem reservoirs, but exploitation is low relative to other North American stocks (Marwitz 1994).

We evaluated walleye stocks in four mainstem reservoirs and one tributary reservoir in the North Platte River drainage with elevations of 1342-1938 m AMSL. Our objectives were to: (1) describe the growth, stock structure, and condition of walleyes in high-elevation reservoirs; (2) determine if differences occur among reservoirs; (3) compare these stocks to other regional walleye stocks; and (4) identify factors that influence the dynamics of walleye stocks in these reservoirs.

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STUDY AREA

Seminoe, Pathfinder, Alcova, and Glendo reservoirs are mainstem impoundments on the North Platte River and Grayrocks Reservoir is on the Laramie River, 16 km upstream from the confluence with the North Platte River (Fig. 1). Walleyes were introduced by the Wyoming Game and Fish Department (WGFD) into Glendo and Grayrocks reservoirs but developed without stocking by WGFD in Seminoe, Pathfinder, and Alcova reservoirs. The reservoirs are variable in their physical characteristics (Table 1).

METHODS

We sampled walleyes in all five reservoirs from late August through October 1993. Grayrocks Reservoir was also sampled in September 1992 and samples from both years were combined in this analysis. We sampled using sinking (45.7 X 1.8 m) and floating (45.7 X 2.4 m) monofilament gill nets having six progressively ordered panels (32-, 38-, 45-, 51-, 57-, and 64-mm bar mesh). We also used sinking gill nets (48.8 x 1.8 m) with eight randomly ordered panels (19-, 25-, 32-, 38-, 45-,

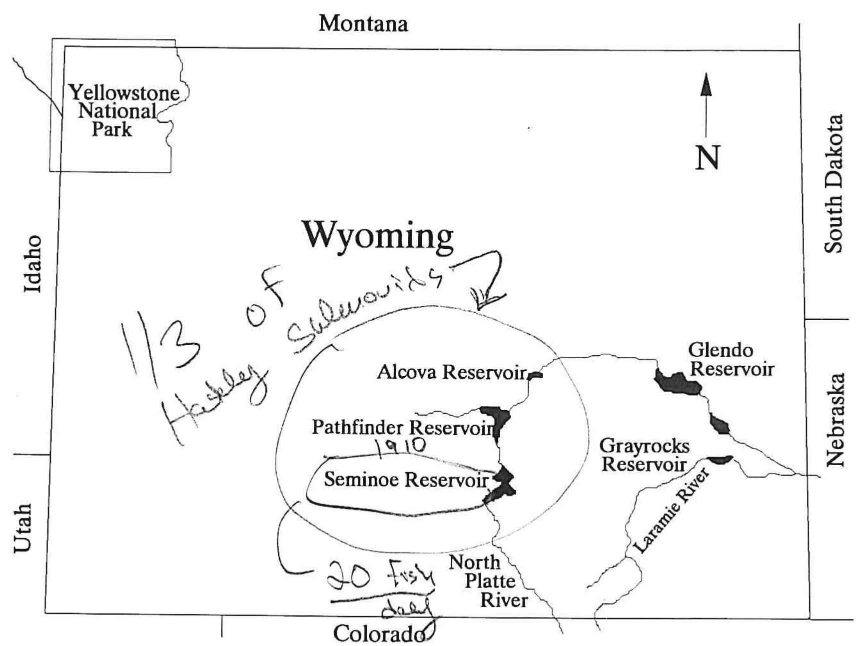

Figure 1. Map of Wyoming showing the location of the North Platte River drainage and the five study reservoirs.

Table 1. Locations, surface elevations, and morphometric data of study reservoir in the North Platte River drainage of Wyoming.

Reservoir	Location	Maximum surface elevation (m)	Maximum surface areaf (ha)	Maximum depth at ull pool (m)	Mean depth at full pool (m)	Mean annual water level fluctuation (m)
Seminoe	42°09'N 106°50'W	1937.6	8215.4	61.0	15.3	9.7[a]
Pathfinder	42°28'N 106°53'W	1783.1	8908.1	54.9	14.1	7.8[a]
Alcova	42°32'N 106°45'W	1676.4	1000.0	51.8	22.7	4.5[a]
Glendo	42°36'N 105°04'W	1412.7	4856.4	44.2	13.4	19.2[a]
Grayrocks	42°09'N 104°44'W	1342.3	1435.5	22.6	8.9	2.1[b]

[a] Calculated from U.S. Bureau of Reclamation data (1969-1992).
[b] Calculated from Laramie River Power Station data (1983-1992).

51-, 57-, and 70-mm bar mesh). We set gill nets overnight (approximately 12 hr duration) and during daylight (2 hr) and positioned them perpendicular to the shoreline at sites throughout each reservoir. Trap nets were set overnight in conjunction with gill nets in Grayrocks Reservoir.

We weighed (g) and measured (mm TL) captured walleyes, removed the anterior three dorsal spines from all fish (Carnevale 1977), and extracted sagittal otoliths from mortalities. We prepared and sectioned dried spines following Carnevale (1977) and Mackay et al. (1990), and otoliths following Maceina (1988). To determine age of individual fish, we viewed dorsal spine and otolith sections under a dissecting microscope (30x) using transmitted light. Annuli were identified following the criteria of Jearld (1983) and Mackay et al. (1990). Annuli of dorsal spines and otoliths were independently counted twice, and sections yielding different numbers of annuli were read a third time. If disagreement persisted, we omitted the section from analysis.

Back-calculations of total lengths (mm) at age were made using otolith sections and the Optical Pattern Recognition System (Biosonics 1985). Otolith radius was linearly related to total length of walleyes ($P < 0.0001$; $r^2 = 0.721$; $n = 298$), indicating that back-calculations using otolith sections were possible. We used the direct proportion method (Lea 1910 in Schramm et al. 1992) to back-calculate total lengths at age, and mean total lengths at age were computed for each stock. One-way analysis of variance (ANOVA) was performed to evaluate differences in mean total lengths at ages 1-8 among stocks. If significant differences were found, a Tukey multiple-comparison test was applied.

Age structure of each stock was determined by estimating age of individual walleyes and calculating relative frequency for each age group. Chi-square analysis was performed to assess differences in age frequencies among stocks.

We calculated relative stock density (RSD; Gabelhouse 1984) using the incremental method (percentage of stock-length fish consisting of individuals between minimum lengths). Minimum stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) lengths were 250, 380, 510, 630, and 760 mm, respectively (Gabelhouse 1984). Ninety-five percent confidence intervals were calculated following Gustafson (1988). Chi-square analysis was used to assess differences in incremental RSD values among stocks.

Relative weight (W_r; Wege and Anderson 1978) was used to describe the condition of walleyes. We used the standard weight equation proposed by Murphy et al. (1990) and calculated mean W_r values by RSD length increments for each stock. One-way ANOVA was used to assess differences in mean W_r values among (and within) stocks. When differences were found, a Tukey multiple-comparison test was applied.

Statistical analyses were performed using SPSS/PC+ (SPSS Inc. 1991). Significance was determined at $P \leq 0.05$ for all tests.

RESULTS

We captured 121 walleyes from Seminoe Reservoir, 95 from Pathfinder Reservoir, 101 from Alcova Reservoir, 96 from Glendo Reservoir, and 139 (77 in 1992 and 62 in 1993) from Grayrocks Reservoir. Mean lengths at ages 1-6 of fish from Seminoe and Pathfinder reservoirs were significantly less than those from the other three reservoirs and, with the exception of age-1 fish, mean lengths at age of walleyes from Pathfinder Reservoir were significantly less than those from Seminoe Reservoir (Fig. 2). Age-frequency distributions differed significantly among the

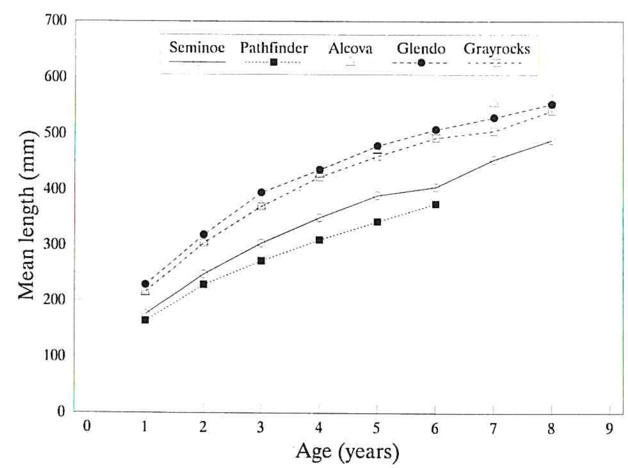

Figure 2. Mean back-calculated total lengths at ages 1-8 of walleyes from study reservoirs, as derived from otolith sections.

five stocks (P<0.0001; Table 2). Incremental RSD values (Fig. 3) were significantly different between all possible pairs of reservoirs.

Mean W_r for S-Q, Q-P, and M-T length walleyes differed significantly among reservoirs (P<0.0001; Fig. 4), but differences in mean W_r of P-M length walleyes were not significant. Significant differences in mean W_r occurred among length categories of walleyes from Pathfinder, Alcova, and Grayrocks reservoirs (P<0.0001).

Table 2. Age-frequency distributions (percentages) of walleye stocks from the North Platte River drainage (bold) and other North American waters.

Water (Source)	Age 1	2	3	4	5	6	7	8	9	10+
Seminoe Reservoir, WY (Current study)	**1**	**28**	**20**	**12**	**9**	**11**	**6**	**6**	**0**	**7**
Pathfinder Reservoir, WY (Current study)	**4**	**31**	**14**	**23**	**10**	**13**	**1**	**0**	**0**	**4**
Alcova Reservoir, WY (Current study)	**9**	**14**	**21**	**12**	**8**	**5**	**13**	**5**	**3**	**10**
Glendo Reservoir, WY (Current study)	**10**	**52**	**17**	**3**	**3**	**5**	**1**	**1**	**1**	**7**
Grayrocks Reservoir, WY (Current study, 1993 data)	**7**	**29**	**7**	**3**	**27**	**15**	**5**	**5**	**2**	**0**
Lake Sharpe, SD (Johnson et al. 1992)	37	41	15	2	3	1	1	<1	0	0
Lake Francis Case, SD (Johnson et al. 1992)	32	28	29	7	2	<1	<1	0	0	0
Lake Oahe, SD (Johnson et al. 1992)	36	37	10	10	3	2	<1	<1	<1	0
Branched Oak Lake, NB (Schainost 1983)	23	23	22	16	12	2	<1	<1	<1	<1
Hoover Reservoir, OH (Tucker and Taub 1970)	0	42	29	16	9	2	2	<1	<1	0
Lake Gogebic, MI (Eschmeyer 1950)	25	3	5	18	22	11	6	6	3	2
Lake Nipissing, Ont. Can. (Anthony and Jorgensen 1977)	<1	3	21	34	23	12	5	1	<1	<1
Lake Sakakawea, ND (Hiltner 1983)	1	<1	25	6	9	19	30	5	3	1

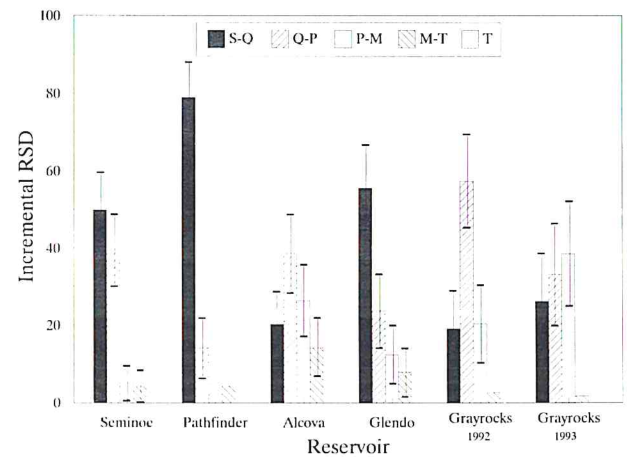

Figure 3. Incremental relative stock density (RSD) values of walleyes sampled from the five study reservoirs. Vertical lines represent 95% confidence intervals. Minimum stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) lengths for walleyes were 25, 38, 51, 63, and 76 cm total length, respectively.

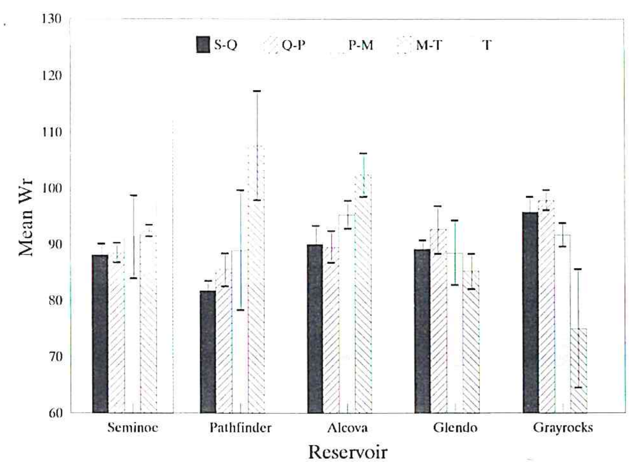

Figure 4. Mean relative weights (W_r), by length category, of walleyes sampled from the five study reservoirs. Vertical lines represent 95% confidence intervals. Minimum stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) lengths for walleyes were 25, 38, 51, 63, and 76 cm total length, respectively.

Mean W_r increased with increasing length categories in Seminoe, Pathfinder, and Alcova reservoirs. In contrast, mean W_r of P-M and M-T length walleyes from Glendo and Grayrocks reservoirs declined relative to smaller length categories.

DISCUSSION

Growth rates of the walleye stocks were slow to moderate relative to other regional stocks (Table 3), and slow compared to stocks in southern reservoirs (Hackney and Holbrook 1978). Extremes of walleye growth generally occur at the north-south range limits (Ney 1978). Although not approaching the northern range limit of the species, elevations of the upstream reservoirs (Seminoe, Pathfinder, and Alcova) were higher than any walleye fishery previously described. Length of growing season has been suggested to influence growth rates of walleyes (Ney 1978, Madenjian 1991).

We expected to see an elevational gradient in growth rates (i.e., faster growth at lower elevations). Differences in growth rates between the highest (Seminoe and Pathfinder) and lowest (Glendo and Grayrocks) reservoirs were only partly explained by variation in elevation. Walleyes from Pathfinder Reservoir exhibited significantly slower growth than those from Seminoe Reservoir, and growth of walleyes from Alcova Reservoir far exceeded those from both Seminoe and Pathfinder reservoirs and was actually similar to stocks from Glendo and Grayrocks reservoirs. The unexpected patterns are attributed to the densities of trout stocked in the three upstream reservoirs. From 1988 to 1993, an average of 20.0 kg/ha of trout was stocked into Alcova Reservoir annually, vs. 3.1 kg/ha in Seminoe Reservoir and 2.6 kg/ha in Pathfinder Reservoir (WGFD, unpublished data). Although reliable data on prey abundance are lacking for these reservoirs, it was believed that prey was limiting in the upstream reservoirs (McMillan 1984). Walleye food habit studies in Seminoe Reservoir indicated an almost complete switch in diet from indigenous fish species to trout following the stocking of trout fingerlings (McMillan 1984).

Comparisons of age-frequency distributions of the five stocks to other North American stocks (Table 2) indicated that the Wyoming stocks have some of the highest proportions of older walleyes (age 9 and older) in North America. The oldest walleye captured in this study (age 16) came from Seminoe Reservoir. Longevity of walleyes has been reported at 26 years from Lake Gogebic, Michigan (Schneider et al. 1977). Various authors (Stroud 1949, Hackney and Holbrook 1978) have reported that fast growing walleyes from warmer waters do not live as long as slower growing walleyes from cooler waters. This fact, in conjunction with the relatively low exploitation rates experienced by these stocks (with the exception of Grayrocks Reservoir), may explain the high occurrence of older fish in Wyoming reservoirs.

Age-frequency distributions indicated that fluctuations in year-class strengths were common to all five walleye stocks with no apparent synchrony among stocks.

Table 3. Mean total length (millimeters) at age of walleyes from regional waters.

Water (Source)	Age (years) 1	2	3	4	5	6	7	8
Seminoe Reservoir, WY (Current study)	**176**	**248**	**304**	**350**	**390**	**405**	**454**	**489**
Pathfinder Reservoir, WY (Current study)	**164**	**229**	**272**	**310**	**343**	**375**	-	-
Alcova Reservoir, WY (Current study)	**214**	**305**	**371**	**428**	**471**	**505**	**555**	-
Glendo Reservoir, WY (Current study)	**229**	**319**	**395**	**436**	**479**	**508**	**529**	**553**
Grayrocks Reservoir, WY (Current study)	**217**	**304**	**370**	**423**	**460**	**493**	**505**	**541**
Okoboji Lakes, IA (Iowa DNR 1993)	200	262	308	346	371	402	449	467
Horsetooth Reservoir, CO (Jones et al. 1994)	172	257	332	-	-	-	-	-
Spirit Lake, IA (Iowa DNR 1993)	228	298	344	390	420	455	485	527
Lake Sharpe, SD (Johnson et al. 1992)	154	276	354	421	470	506	538	550
Lewis and Clark Lake, SD (Johnson et al. 1992)	137	288	395	458	488	512	539	-
Lake Sakakawea, ND (Hiltner 1983)	192	271	348	412	468	514	556	594
Lake Oahe, SD (Johnson et al. 1992)	148	253	335	389	472	515	551	582
Lake Francis Case, SD (Johnson et al. 1992)	164	260	329	389	452	529	592	-
Branched Oak Lake, NB (Schainost 1983)	222	378	479	545	575	604	630	645
McConaughy Reservoir, NB (McCarraher et al. 1971)	185	352	456	522	566	616	677	703

Variable year-class strengths of walleye stocks are common (Kelso and Ward 1972, Busch et al. 1975, Kempinger and Carline 1977, Wolfert 1977, Craig and Smiley 1986, Kallemeyn 1987, Hartman and Margraf 1992). Temperature, water level fluctuations, prey availability, cannibalism and predation, and spawning stock size are factors affecting year-class strength (Koonce et al. 1977). We identified factors affecting year-class strengths in Grayrocks and Alcova reservoirs.

Incremental RSD values allow the effects of strong and weak year classes to be observed (Willis et al. 1993). For example, walleyes in Grayrocks Reservoir were recruited into the S-Q length category between age 1 and age 2, and included many age-3 fish (Fig. 2). They became fully recruited into the Q-P category by age 4. The increase in RSD S-Q and decrease in RSD Q-P between 1992 and 1993 (Fig. 3) corresponds with weak year classes in 1989 and 1990 moving through the fishery. With the exception of Grayrocks Reservoir, the walleye stocks in this study were sustained solely by natural recruitment. Grayrocks Reservoir was usually stocked with walleye fry on an annual basis, but no fry were stocked in 1989 and 1990, and weak year classes were produced those years (Marwitz 1994).

Of the five walleye stocks, the stock from Seminoe Reservoir had the most balanced age structure, indicating consistent recruitment (Marwitz 1994). The North Platte River above Seminoe Reservoir provides good spawning habitat for walleyes (McMillan 1984). In contrast, Alcova Reservoir has no inflowing river in which walleyes can spawn. Water from Pathfinder Reservoir flows through a large tunnel directly into Alcova Reservoir. Spawning habitat is limited in Alcova Reservoir, due to the predominance of steep canyons. The presence of disproportionately strong year classes of walleyes from 1983 to 1986 (ages 7-10) in Alcova Reservoir suggests that walleyes from Pathfinder Reservoir passed through the tunnel into Alcova Reservoir during high spring flows. A current study using coded wire tags found that trout stocked in Pathfinder Reservoir were captured in Alcova Reservoir (Bill Wichers, WGFD, pers. commun.).

Comparisons of incremental RSD values to other walleye fisheries in the region indicate that four of the five Wyoming stocks had RSD M-T values equal to or greater than those of other regional waters (Table 4). Anderson and Weithman (1978) proposed proportional stock density (PSD, proportion of stock-length fish of quality length or greater) values of 30-60% as representing "balanced" walleye populations and defined a balanced population as having "a structure that is intermediate between the extremes of a large number of small fish and a small number of large fish." Only the stocks in Seminoe and Glendo reservoirs had PSD values that would be considered balanced. Pathfinder Reservoir was dominated by small fish, while Alcova and Grayrocks reservoirs had substantial proportions of large walleyes.

Mean W_r values of the Wyoming stocks were fair to good relative to other regional walleye stocks (Table 5). Population-mean W_r values coincided closely with estimated growth rates of the stocks in this study. Pathfinder Reservoir had the lowest population-mean W_r and the slowest growth rate. Alcova, Glendo, and

Table 4. Incremental relative stock density (RSD) values of regional walleye stocks. All samples were collected during late summer to early fall.

Water (Source)	RSD				
	S-Q	Q-P	P-M	M-T	T
Seminoe Reservoir, WY (Current study)	**50**	**40**	**5**	**4**	**1**
Pathfinder Reservoir, WY (Current study)	**79**	**14**	**2**	**5**	**0**
Alcova Reservoir, WY (Current study)	**20**	**39**	**27**	**14**	**0**
Glendo Reservoir, WY (Current study)	**56**	**24**	**12**	**8**	**0**
Grayrocks Reservoir, WY (Current study)	**26**	**33**	**39**	**2**	**0**
Lake Sharpe, SD (Johnson et al. 1992)	80	18	2	0	0
Lake Francis Case, SD (Johnson et al. 1992)	77	22	1	0	0
Lake Oahe, SD (Johnson et al. 1992)	75	21	4	0	0
Lake Sakakawea, ND (Hendrickson et al. 1994)	44	51	5	0	0
Canal Lakes (GDU), ND (Kreft 1994)	41	38	17	4	0
Lewis and Clark Lake, SD (Johnson et al. 1992)	23	54	23	0	0

Grayrocks reservoirs had the highest population-mean W_r values and correspondingly higher growth rates.

Mean W_r of walleyes from Seminoe, Pathfinder, and Alcova reservoirs increased with larger incremental RSD categories, suggesting that suitable prey may have become more available as walleyes increased in length. In contrast, P-M and M-T length walleyes from Glendo and Grayrocks reservoirs showed a decline in mean W_r compared to smaller length categories, indicating limited availability of suitable prey for larger walleyes in these reservoirs.

Walleye stocks in high-elevation reservoirs in Wyoming are unique. Because of the high elevations and limited prey bases, growth rates and body condition are

Table 5. Population-mean relative weights (W_r) and mean W_r by relative stock density (RSD) length increments for regional walleye stocks. All samples were collected during late summer to early fall.

Water (Source)	Mean W_r				
	Population	S-Q	Q-P	P-M	M-T
Seminoe Reservoir, WY (Current study)	89	88	89	91	93
Pathfinder Reservoir, WY (Current study)	84	82	86	89	108
Alcova Reservoir, WY (Current study)	93	90	90	95	103
Glendo Reservoir, WY (Current study)	90	89	93	89	85
Grayrocks Reservoir, WY (Current study)	95	96	98	92	75
Lake Sharpe, SD (Johnson et al. 1992)	79	80	76	67	—
Lake Francis Case, SD (Johnson et al. 1992)	83	83	83	76	—
West Okoboji Lake, IA (Iowa DNR 1993)	83	—	—	—	—
Lake Oahe, SD (Johnson et al. 1992)	87	86	88	90	—
Spirit Lake, IA (Iowa DNR 1993)	87	—	—	—	—
East Okoboji Lake, IA (Iowa DNR 1993)	87	—	—	—	—
Canal Lakes (GDU), ND (Kreft 1994)	88	87	90	88	88
Lake Sakakawea, ND (Hendrickson et al. 1994)	95	99	99	90	82

low to moderate compared to other North American stocks. Proportions of older fish are high due to slow growth and relatively low exploitation. Increases in exploitation are likely to affect age and length structures in the future.

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