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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM.

ANNUAL PROGRESS REPORT

APRIL 2006 - MARCH 2007

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In Cooperation With:

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EXECUTIVE SUMMARY

We report on our progress from April 2006 through March 2007 on determining the effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and on determining the status and habitat requirements of white sturgeon populations in the Columbia and Snake rivers upstream from McNary Dam. The study is a cooperative effort by the Oregon Department of Fish and Wildlife (ODFW; Report A), Washington Department of Fish and Wildlife (WDFW; Report B), U.S. Geological Survey Biological Resources Division (USGS), Columbia River Inter-Tribal Fish Commission (CRITFC; Report C), and Montana State University (MSU; Report D).

This is a multi-year study with many objectives requiring more than one year to complete; therefore, findings from a given year may be part of more significant findings yet to be reported. Highlights of results of our work are:

Report A

- The total population of white sturgeon (≥ 54 cm FL) in Bonneville Reservoir in 2006 was estimated at 205,392 fish. The previous estimate completed in 2003 was 120,000 fish.
- The 2006 stock assessment indicated a 73% increase in sub-legal sized fish, a 9% reduction in sport-legal sized fish, a 1% reduction in commercial-legal sized fish, and a 33% reduction in over-legal sized fish from 2003 levels.
- The size distribution of white sturgeon in Bonneville Reservoir was estimated to be: 99.4% <110 cm FL, 0.3% 110-137 cm FL, and 0.3% >137 cm FL.
- The overall recapture rate of PIT-tagged sturgeon was 3.2%.
- Catch per effort for all reservoir sections and weeks combined was 7.62 white sturgeon per setline-day.
- Catch was distributed throughout the reservoir, however, there was a significant difference in mean CPUE between reservoir sections (ANOVA, F= 3.2, P= 0.026).
- Of the 207 sturgeon that were marked and recaptured during sampling periods 1-4, 173 (or 84%) were recovered within 10 kilometers of the original marking location.
- The median relative weight of fish captured in 2006 was 95.3, slightly higher than the past two stock assessments in Bonneville Reservoir (1999 and 2003).
- We estimated the age of 111 white sturgeon captured from Bonneville Reservoir during the 2006 stock assessment. Age estimates ranged from 1-42 years, with a median age of 10 years.
- White sturgeon captured and aged during the 2006 stock assessment were estimated to be older than white sturgeon of similar sizes captured and aged during the 2003 stock assessment. The estimated ages from 2006 may reflect an unintentional bias towards older age estimates due to our awareness that past estimates tended to underestimate the age of individual fish (Rien and Beamesderfer 1994).

- Data collected from recaptured fish in Bonneville Reservoir reveal a different pattern of annual growth than was predicted from the 2006 age estimates and the derived von Bertalanffy growth function. Recaptured small fish (41-60 cm FL) grew less than a quarter of the rate predicted from the von Bertalanffy growth function. Additionally, recaptured white sturgeon between 80 and 160 cm FL in Bonneville Reservoir grew faster than predicted while the annual growth rate for fish larger than 160 cm FL declined again. The von Bertalanffy growth function assumes that annual growth increments decline linearly throughout the life of the fish.
- Recruitment of age-0 white sturgeon was detectable in all reservoirs samples during 2006; this level of recruitment has not been seen since 1999.

Report B

- The 2006 white sturgeon harvest (recreational, commercial, and subsistence) in Management Zone 6 was 2,025 fish. This is the lowest total harvest since 1991, and is reflective of the guideline reductions (2002-2006) in all three pools, and a low recreational harvest in all three pools this year. Recreational retention seasons were closed on 24 July in Bonneville Reservoir, 8 April in The Dalles Reservoir, and 1 July in John Day Reservoir.
- Compliance with the Sturgeon Management Task Force (SMTF) annual harvest guidelines was addressed through in-season management actions. Harvest in Bonneville Reservoir during the past five seasons (2002-2006) has averaged 99% of the recreational guideline and 55% of the commercial guideline. Harvest in The Dalles Reservoir for the same period averaged 117% of the recreational guideline and 97% of the commercial guideline. Harvest in John Day Reservoir averaged 103% of the recreational guideline and 94% of the commercial guideline.
- With two exceptions (2000 and 2003) harvest per angler trip in Bonneville Reservoir has decreased each year since 1995. Harvest per angler trip in The Dalles Reservoir trended downward since 2001 (the highest recorded since 1987) to the lowest since 1995. During 2006, harvest per angler trip in John Day Reservoir was the highest since 1998.
- The handle of oversize white sturgeon in the John Day recreational fishery has decreased since 2004, averaging 9% of white sturgeon handled during 2001-2006. The handle of oversize white sturgeon in the John Day Reservoir recreational fishery is the lowest among the three reservoirs below McNary dam.

Report C

- River discharge and water temperatures that occurred during April through July 2006 provided conditions suitable for spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams.
- Spawning conditions in 2006 were among the best seen over the past 22 years.
- Successful recruitment of age-0 white sturgeon was verified.

Report D

- From 5 December to 30 December 2005 Tribal fishers set 433 overnight gillnet sets. This effort captured a total of 3,853 white sturgeon (including recaptures). Tribal fishers marked 3,034 white sturgeon by removing the twelfth right lateral scute and they applied PIT tags to 1,933 of these fish.
- White sturgeon captured in these efforts were 22 - 242 cm FL (mean 74.0 cm). This is a 14.0 cm decrease from the mean FL in 2002-03.
- Catch per net was higher in 2005-06 (8.9) than in 2002-03 (4.8), the previous Bonneville Reservoir sampling year.
- About 98.5% of the white sturgeon caught were smaller than 48 inches TL (minimum legal size).
- We observed similar proportions of sub-legals (<48 inches TL) and over-legal sized fish (>60 inches TL) from 2002-03 to 2005-06 and an increase in the proportion of legal sized (48-60 inches) fish during the same time period. Proportions of sub-legals, legals, and over-legals in 2002-03 were 98.8%, 0.6%, and 0.6% respectively, and in 2005-06 the proportions were 98.5%, 1.0 %, and 0.4% respectively.

Report E

- Montana State University researchers performed gonadal biopsies on adult white sturgeon captured with set-lines below The Dalles and Bonneville dams. Gonad samples were processed histologically.
- Since 2000, a total of 602 adult white sturgeon have been marked with a combination of spaghetti tags, scute marks, and PIT tags below Bonneville Dam. Gonadal tissue samples have been collected from 493 of these fish.
- In 2006, a total of 105 fish were caught, 27 of which were tagged in previous years and 67 of which were new to the study.
- A total of 93 gonad samples were collected for histological analysis. Of these, 53 were collected from females, 30 were collected from males and one was collected from a hermaphrodite.
- The reproductive structure of the oversize white sturgeon population below Bonneville Dam was determined using the 2000-2006 data. Of the females sampled, 58% were pre-vitellogenic (Stages 1 and 2), 28% were vitellogenic (Stages 3 and 4), 4% were post-vitellogenic or ripe (Stage 5), 6% were postovulatory (Stage 7), and 4% were atretic (Stage 8). Of the males sampled, 58% were non-reproductive (Stage 2), 17% were mid-spermatogenic (Stage 3 and 4), 20% were spermiating (Stage 5), and 5% were post-spermiation (Stage 6).

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

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APRIL 2006 - MARCH 2007

Report A

Evaluate the success of developing and implementing a management plan for enhancing production of white sturgeon in reservoirs between Bonneville and McNary dams

This report includes: 1) An update of abundance, life history parameters, and population dynamics of white sturgeon in Bonneville Reservoir, and 2) a summary of annual recruitment of age-0 white sturgeon in four Columbia River reservoirs.

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ABSTRACT

This report summarizes data collected from 1 April 2006 through 31 March 2007 and provides: 1) an update of abundance, life history parameters, and population dynamics for white sturgeon *Acipenser transmontanus* in Bonneville Reservoir, and 2) an evaluation of annual recruitment of age-0 white sturgeon in four Columbia River reservoirs.

Sampling to estimate the abundance of white sturgeon in Bonneville Reservoir was coordinated with staff from the Oregon Department of Fish and Wildlife (ODFW), the Columbia River Inter-Tribal Fish Commission (CRITFC), and the Washington Department of Fish and Wildlife (WDFW). From 5 December through 30 December 2005 CRITFC staff contracted with tribal commercial fishers who set 433 nets and captured 3,853 white sturgeon. From 5 June through 31 August 2006 staff from ODFW and WDFW set 674 setlines and captured 5,134 white sturgeon. Combined effort of both winter and summer sampling resulted in the capture of 8,987 white sturgeon, of which 6,771 (75%) were tagged with passive integrated transponder (PIT) tags. A total of 291 PIT-tagged white sturgeon were recaptured during the summer sampling periods; 103 were from this year's marking efforts and 188 were marked in previous years. The recapture rate of all marked fish was 3.2%. The recapture rate of fish marked in 2006 was 1.5%. White sturgeon were captured throughout Bonneville Reservoir with catch rates averaging 640 fish per section. Between marking and subsequent recapture, white sturgeon in Bonneville Reservoir moved an average of 0.2 river kilometer (rkm) downstream. Using multiple mark-recapture estimates, the total population of white sturgeon ≥ 54 cm (24 inches) fork length (FL) in Bonneville Reservoir in 2006 was estimated at 205,392 fish. The size distribution of the population was estimated to be 44.7% 54-69 cm FL, 54.7% 70-109 cm FL, 0.3% 110-137 cm FL, 0.2% 138-166 cm FL, and 0.1% ≥ 166 cm FL.

We assessed 2006 recruitment of age-0 white sturgeon in Bonneville, The Dalles, John Day, and McNary reservoirs. Sampling gear consisted of small mesh gill nets fished at standard locations within each reservoir. We set 151 nets and captured 679 white sturgeon, of which 277 (41%) were classified as age-0. The recruitment index was higher in 2006 than it has been since 1999. Age-0 white sturgeon were caught in all reservoirs sampled.

Due to budget constraints, transplant supplementation activities, i.e., Trawl-and-Haul, conducted since 1994 were not conducted in 2006.

INTRODUCTION

White sturgeon *Acipenser transmontanus* is the largest species of North American sturgeon and is found from southern California to the Gulf of Alaska (Scott and Crossman 1973). White sturgeon inhabit approximately 1600 kilometers of the main stem Columbia River from the estuary to Idaho and Canada. Overfishing during the late 1800s resulted in substantial population declines, warranting the cessation of all sturgeon harvest. By the mid 1900s, sturgeon numbers had improved enough to once again support limited commercial and recreational fisheries. With continuing declines in anadromous salmonid abundance, there has been increased participation in the white sturgeon fishery. Total harvest of sturgeon doubled in the 1970s and again in the 1980s (Tracy 1993). Since 1986, ODFW and other tribal, state and federal agencies have worked to monitor sturgeon populations, determine the cause of their declines, and take actions that will maintain a balance between conservation and productive white sturgeon fisheries. Over time, project goals have changed as new information has clarified potential restoration actions.

The primary goal of the current project is to implement and evaluate measures previously identified to protect and enhance white sturgeon populations and to mitigate for effects of the Federal Columbia River Power System on production of white sturgeon in Columbia River impoundments upstream of Bonneville Dam.

To ensure that white sturgeon populations remain healthy and stable, we have developed protocols to monitor white sturgeon abundance and recruitment throughout the basin. To assess white sturgeon abundance and population dynamics we conduct annual mark-recapture surveys in the reservoirs between Bonneville Dam and McNary Dam on the Columbia River, known collectively as Zone 6. Data collected during these surveys allow us to update the abundance and population characteristics of white sturgeon, and assess management and mitigation approaches on a three year basis. To evaluate the relative success of spawning by white sturgeon, we conduct annual age-0 indexing. We sample for young-of-year (age-0) white sturgeon at specific index sites in four Columbia River reservoirs. By sampling these areas annually we can describe distribution and relative density of age-0 white sturgeon in each reservoir. This information is then used to identify recruitment trends among years and among reservoirs.

This report summarizes work performed from 1 April 2006 through 31 March 2007 for the Bonneville Power Administration Project 198605000. During this period, we participated in two distinct efforts to assess and/or enhance populations of white sturgeon in the Columbia River upstream from Bonneville Dam:

1) From June through August 2006 we collected data to assess abundance and population characteristics of white sturgeon in Bonneville Reservoir.
2) From October through November 2006 we collected data to assess annual recruitment of age-0 white sturgeon in Bonneville, The Dalles, John Day, and McNary reservoirs in the Columbia River.

Since 2001, stock assessment surveys have been conducted every year, rotating between the three reservoirs in Zone 6; prior to 2001, stock assessment surveys were conducted on a five-year rotation. Since its 1997 inception, age-0 indexing has been conducted on an annual basis.

METHODS

Stock Assessment

Sampling for white sturgeon in Bonneville Reservoir was divided into four distinct periods (periods 1-4). During period 1, gill nets were used to capture white sturgeon; during periods 2-4, we used baited set lines.

Sampling during period 1 took place from 5 December 2005 to 30 December 2005. During this time, CRITFC staff, working with tribal commercial fishers, used gill nets distributed throughout the reservoir to capture white sturgeon. Gill nets ranged from 61-122 m in length and 4.5-9 m in height. Gill nets were constructed of 17-23 cm stretched-measure nylon mesh and were fished on the river bottom for approximately 24 hours per set.

Sampling during periods 2-4 took place from 5 June 2006 through 31 August 2006, and was conducted jointly by ODFW and WDFW. Period 2 was from 5 June to 29 June, period 3 from 10 July to 3 August, and period 4 from 7 August to 31 August. Bonneville Reservoir was divided into eight sections, excluding boat restricted zones. Sections ranged between 9 and 10 km in length (Figure A-1). Sampling effort was distributed equally throughout the reservoir, and all reservoir sections were sampled during each period.

During periods 2-4, setlines were used to capture white sturgeon. (Reasons for using setlines are outlined in Elliot and Beamesderfer (1990)). Setlines measured 183 m in length and were equipped with 12/0, 14/0, and 16/0 barbed circle hooks. Each setline contained 13 hooks of two sizes and 14 hooks of the remaining size (selected randomly for each line), for a total of 40 hooks per line. All hooks were baited with pickled squid (*Loligo* spp.), which has been shown to yield higher catch rates than other baits (North et al., 1998). Setlines were set on Mondays and checked and reset on Tuesdays and Wednesdays. All gear was checked and pulled on Thursdays. Hooks were re-baited with fresh squid when necessary, or every 48 hours.

All white sturgeon were measured to the nearest 1.0 cm FL and examined for external tags, lost tag scars, pectoral fin scars (from previous aging samples), and scute removal scars. A subsample of up to 30 fish per 20 cm length interval was used to obtain weights and aging structures. Total weight was measured to the nearest 1.0 kg. All recaptured fish were also weighed. White sturgeon that did not already have one, were tagged with a 134.2 MHz ISO passive integrated transponder (PIT) tag and externally marked by removing the second left lateral scute (to indicate a PIT-tagged fish) and the twelfth right lateral scute (to indicate the fish was captured in 2006).

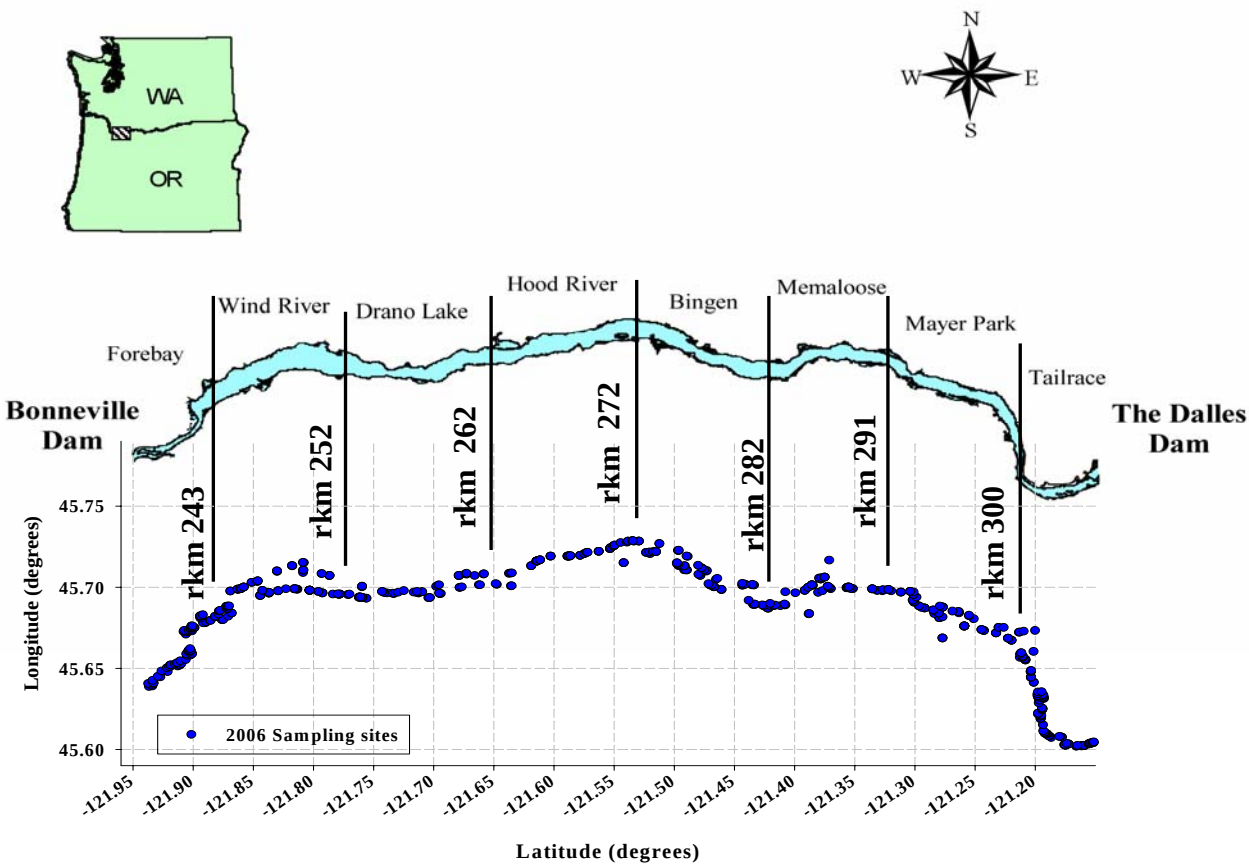

Figure A-1. Stock assessment sampling sections and sampling sites, Bonneville Reservoir 2006. Scale is approximate (RKm = River Kilometers).

Ages of captured white sturgeon were estimated from thin cross-sections of pectoral fin spines following procedures outlined in Beamesderfer et al. (1989). Up to 20 fish from each 20 cm length interval were aged. Fin-spine sections were aged two times by each of two experienced readers, with one of the readers being assigned the role of primary reader. In the cases where the age assigned to an individual fish did not match between readers, the primary reader assigned a final age to the fish.

The relationship between white sturgeon fork length (L) and age (x) in Bonneville reservoir was described by the von Bertalanffy growth function:

$$L_x = L_\infty[1 - e^{-k(x-t_0)}]$$

where, L_∞ = length at infinity, k= growth coefficient, and t_0= age at length zero (von Bertalanffy, L. 1938). Parameters for the von Bertalanffy growth function were derived from the length and age data using nonlinear regression (SigmaStat 3.5, Jandel Scientific, San Rafael, CA).

The relationship between fork length (L) and weight (W) was described by the exponential function, $W_L = exp[a*ln(L)-b]$. Parameters for the length-weight function were

derived using nonlinear regression (SigmaStat 3.5, Jandel Scientific, San Rafael, CA). The condition of white sturgeon ≥70 cm FL was assessed using estimates of relative weight (W_r) based on the standard weight equation from Beamesderfer (1993), $W_s = 2.735\ E\text{-}6 * L^{3.232}$. Analysis-of-variance (ANOVA) and a Tukey's pairwise comparison (SigmaStat 3.5, Jandel Scientific, San Rafael, CA) were used to test for significant differences in relative weights of fish between 2003 (when the last stock assessment was completed in Bonneville Reservoir) and 2006, and among the 2006 sampling periods.

Annual growth increments (AGIs) for white sturgeon in Bonneville Reservoir were calculated from: 1) the 2003 and 2006 von Bertalanffy growth function predictions, and 2) data from all marked and recaptured sturgeon in Bonneville Reservoir that were at large for at least one year. AGIs derived using each method were compared to examine differences between predicted and actual growth.

Overall population abundance (N) of white sturgeon in Bonneville Reservoir was estimated using a Schnabel population estimator based on the number of PIT-tags applied and recaptured. The Schnabel estimate was calculated as:

$$N = \sum_{i=1}^{m} \frac{C_i - M_i}{R+1}$$

where m = the number of sampling periods, M_i = total number of marked fish at the start of the ith sampling period (i = 1,..., m), C_i = total samples taken in period i, R_i = number of recaptures in the sample C_i, and R = total recaptures during the experiment (sum of R_i) (Borchers et al., 2002). Although not noted in the above equation, the total number of marked fish at the start of a given period was adjusted to account for removals. Removals included mortalities during sampling and estimated harvest from sport and commercial fisheries.

The Schnabel estimator was used to estimate the overall abundance of sturgeon in the <70 cm FL and the 70-109 cm FL size classes (the mark groups with the largest sample sizes). The length-frequency distribution of the setline catch was then used to apportion the Schnabel population estimate by one cm increments within the <70 cm FL and the 70-109 cm FL size classes. The Schnabel estimate was expanded to estimate abundance of the remaining size groups (110-166 cm FL and >166 cm FL) based on the relative frequency of these size classes in the total 2006 setline catch and adjusting for differences in gear vulnerability for size of fish (Beamesderfer et al., 1995). This method precludes the estimation of 95% CIs for these groups.

Age-0 Indexing

During October and November of 2006, staff from ODFW, WDFW, and CFITFC conducted sampling in Bonneville, The Dalles, John Day, and McNary reservoirs to evaluate annual recruitment of age-0 white sturgeon (Figure A-2). Sampling took place in The Dalles Reservoir from 9 October to 12 October and 16 October to 19 October, in McNary Reservoir from 23 October to 26 October, in John Day Reservoir from 30 October to 3 November, and in Bonneville Reservoir from 13 November to 16 November.

Gill nets were used to sample for age-0 white sturgeon. A single gill net was deployed at predetermined, standard sites within each reservoir. Sampling sites in Bonneville, The Dalles, and John Day reservoirs were kept standard to allow for a comparison of catch between years

(Parsley et al., 2001). Sampling sites in McNary Reservoir were originally chosen in the field based on their fishability at the time. Sampling methodology and locations were consistent with past years, and involved fishing nets overnight at the same sites throughout each week. Gill nets measured 91.4 m in length and 3.7 m in height and were constructed with 5.1 cm stretched-measure multifilament nylon mesh. Nets were fished overnight on the river bottom for approximately 24 hours. Because nets were deployed during daylight hours and most catch of white sturgeon is believed to occur during darkness (McCabe and Tracy 1994), all nets were considered to have been sampling for equal amounts of "effective fishing time". Therefore, each overnight set was treated as a single sampling effort and not standardized by number of total hours fished.

With the exception of live salmonids, which were released immediately to reduce possible stress or injury from handling, all fish captured in the nets were removed and placed in a livewell, filled with river water at ambient temperature and dissolved oxygen levels, until they could be examined. All bycatch was identified to species, with the exception of sculpin *Cottus spp.* and crayfish *Pacifastacus spp.*, which were identified only to genus. Any salmonid that had expired in the net was examined for marks, measured to the nearest 1 mm, and returned to the river. All white sturgeon were measured to the nearest 1 mm FL and weighed to the nearest 0.1 or 0.001 kg, depending on size. For aging purposes, a pectoral fin spine section was taken from a subsample of up to 30 fish per 20 cm length interval for white sturgeon less then 90 cm FL in each reservoir. Classification of age-0 white sturgeon in McNary and John Day reservoirs was made by ageing. Classification of age-0 white sturgeon in Bonneville and The Dalles reservoirs was made by length frequency analysis after ageing a subsample of 112 white sturgeon from Bonneville and 73 white sturgeon from The Dalles. No marks or tags were applied to any captured fish. After examination, all fish were immediately returned to the river.

For white sturgeon, both the proportion of positive efforts (E_p; proportion of all sets that captured at least one sturgeon) and the catch-per-unit-effort (CPUE; number of white sturgeon caught per overnight set) were calculated. For small numbers of fish, the estimate of E_p may provide a better measure of relative density than CPUE (Counihan et al., 1999). E_p and CPUE were estimated for age-0 white sturgeon, and for all white sturgeon captured.

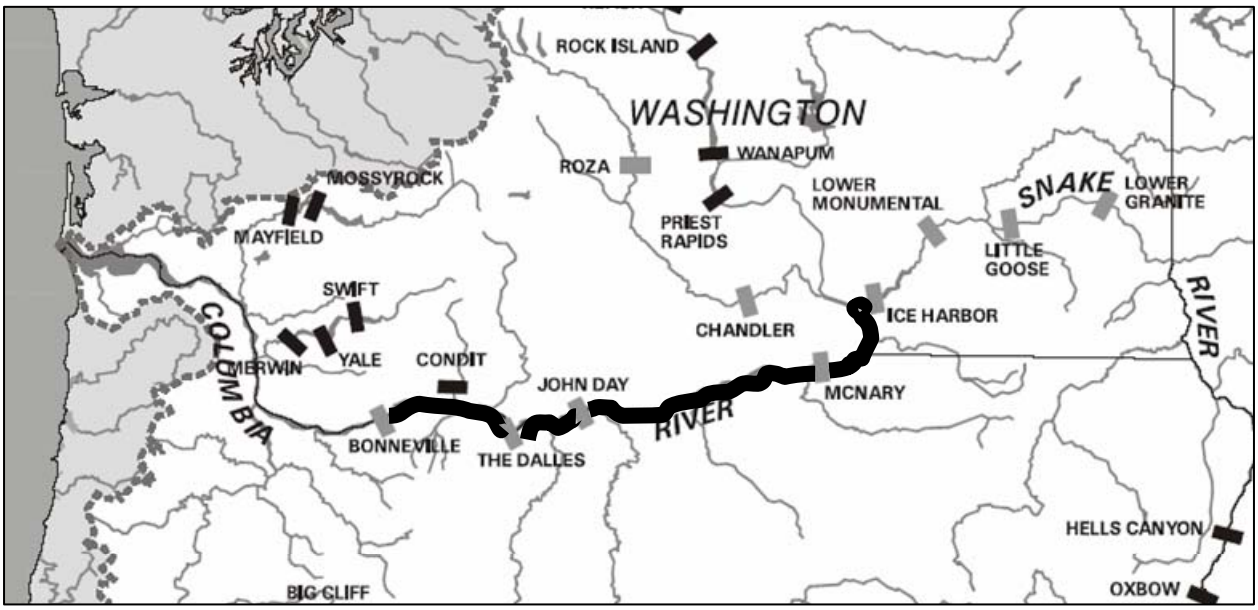

Figure A-2. Map of age-0 sampling locations in the Columbia River. Highlighted river sections indicate the reservoirs in which age-0 sampling took place during October and November of 2006.

RESULTS

Stock Assessment

Effort and Catch

During period 1, tribal commercial fishers set 433 gill nets in Bonneville Reservoir and caught 3,853 white sturgeon. Of the 3,853 white sturgeon captured, 1,933 (50%) received PIT tags. During periods 2-4, staff from ODFW and WDFW set 674 setlines in Bonneville Reservoir and caught 5,134 white sturgeon (Tables A-1 and A-2). We placed PIT tags in 4,838 (94%) white sturgeon, 291 (6%) had a PIT tag at capture. Of the 291 recaptures, 103 (35%) were from this marking season. All recaptured white sturgeon from the 2006 season measured <110 cm FL. The overall recapture rate of white sturgeon PIT tagged during 2006 was 1.5%.

White sturgeon were captured in all reservoir sections during all sampling periods. For all sections and weeks combined (periods 2-4), CPUE was 7.62 white sturgeon per setline (Table A-3). There was no significant difference in mean CPUE between sampling periods (ANOVA, F=0.5, P=0.57). There was, however, a significant difference in mean CPUE between sampling sections (ANOVA, F= 3.2, P= 0.026). Mean CPUE was highest in sections 3 and 5 (10.9 and 10.1 respectively). Mean CPUE was lowest in sections 6 and 7 (5.4 and 4.2 respectively).

White sturgeon in Bonneville Reservoir exhibited limited movement between mark and recapture events during the 2006 stock assessment. Of the 207 white sturgeon that were marked and recaptured during sampling periods 1-4, 173 (84%) were recovered within ± 5 rkm of the

original marking location (Table A-4). The average movement of recaptured fish was 0.2 km downstream from where they were originally marked. The furthest upstream movement observed was 40 rkm, and the furthest downstream movement observed was 50 rkm.

Table A-1. Sampling effort (number of setline sets) for white sturgeon in Bonneville Reservoir by week and sampling section, June through August 2006.

		Sampling Section								
	Week	1	2	3	4	5	6	7	8	Total
Period 2	23			24	23					47
	24					29	24			53
	25							24	30	54
	26	29	31							60
Period 3	28			20	26					46
	29					34	24			58
	30							28	27	55
	31	30	35							65
Period 4	32			29	26					55
	33					34	32			66
	34							26	27	53
	35	32	30							62
	All	91	96	73	75	97	80	78	84	674

Table A-2. Catches of white sturgeon with setlines in Bonneville Reservoir by calendar week and sampling section, June through August 2006.

		Sampling Section								
	Week	1	2	3	4	5	6	7	8	Total
Period 2	23			136	241					377
	24					192	129			321
	25							119	269	388
	26	232	209							441
Period 3	27			268	222					490
	28					434	161			595
	29							129	256	385
	30	269	168							437
Period 4	31			393	160					553
	32					370	131			501
	33							76	206	282
	34	193	171							364
	All	694	548	797	623	996	421	324	731	5134

Table A-3. Catch per unit effort of white sturgeon with setlines in Bonneville Reservoir by week and sampling section, June through August 2006.

		Sampling Section								
	Week	1	2	3	4	5	6	7	8	Total
Period 2	23			5.67	10.48					8.02
	24					6.62	5.38			6.06
	25							4.96	8.97	7.19
	26	8.00	6.74							7.35
Period 3	27			13.40	8.54					10.65
	28					12.76	6.71			10.26
	29							4.61	9.48	7.00
	30	8.97	4.80							6.72
Period 4	31			13.55	6.15					10.05
	32					10.88	4.09			7.59
	33							2.92	7.63	5.32
	34	6.03	5.70							5.87
	All	7.63	5.71	10.92	8.31	10.27	5.26	4.15	8.70	7.62

Table A-4. Frequency of movement of fish between marking and recapture events. Negative numbers indicate the recapture event was downstream of the marking event. Multiple recaptures of individual fish are included.

Number of River KM Moved	Frequency of Recaptures	% Frequency of Recaptures
-45 to -50	2	0.97%
-40	0	0.00%
-35	2	0.97%
-30	1	0.48%
-25	1	0.48%
-20	2	0.97%
-15	5	2.42%
-10	6	2.90%
-5	112	54.11%
5	61	29.47%
10	2	0.97%
15	4	1.93%
20	3	1.45%
25	2	0.97%
30	2	0.97%
35	1	0.48%
40	1	0.48%
Total	207	100.00%

Size, Age, and Growth

Lengths of white sturgeon captured using setlines ranged from 35-153 cm FL, with a median length of 66.0 cm FL (Figure A-3). The length distribution of the setline catch was: 99.7% <110 cm FL, 0.2% 110-137 cm FL, and 0.1% >137 cm FL.

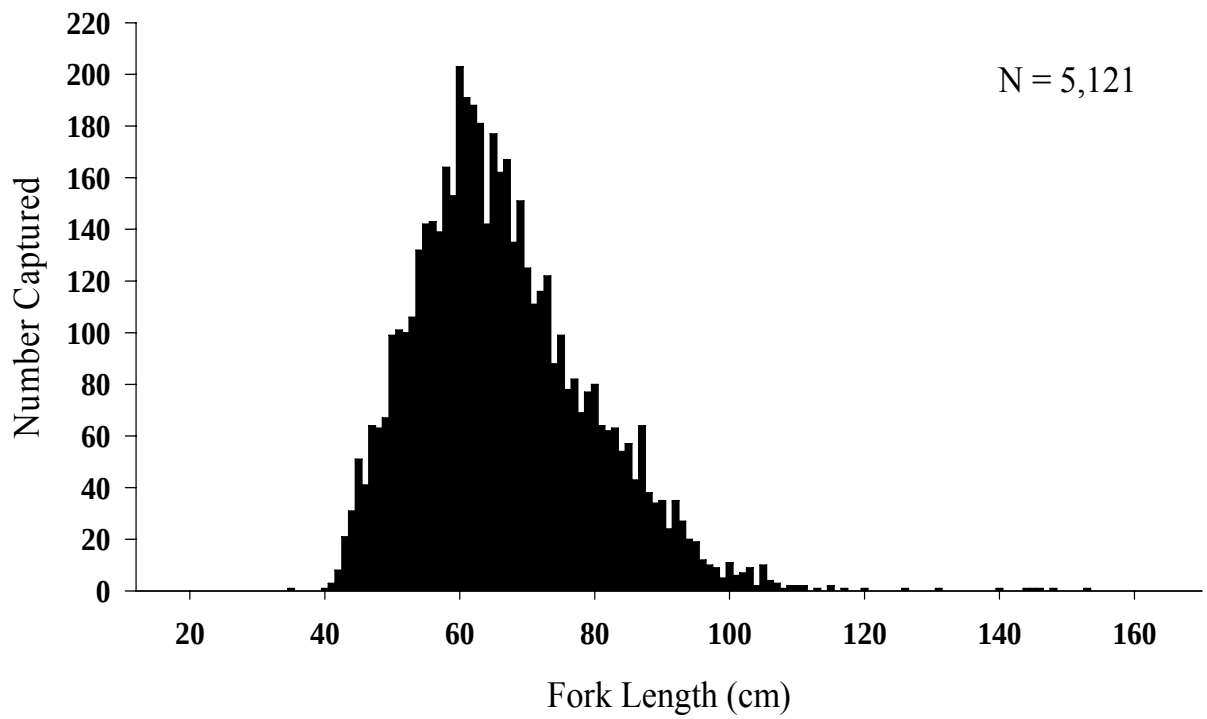

Figure A-3. Length frequency of white sturgeon captured using setlines from Bonneville Reservoir during the 2006 stock assessment.

Weights of sturgeon captured using setlines ranged from 0.3-33.0 kg, with a median weight of 2.8 kg. The relationship between fork length (L) and weight (W) was described by the exponential function:

$$W_L = e^{3.0678 \cdot \ln(L) - 12.14} \text{ (Figure A-4).}$$

Relative weights of captured white sturgeon (from periods 2-4) ranged from 33.1-194.2, with a median relative weight of 95.3 (Figure A-5). There was no significant difference (Kruskal-Wallis test, P=0.653) in relative weights of captured white sturgeon between sampling periods in 2006. The median relative weight was 94.2 during period 2, 93.7 during period 3, and 94.4 during period 4.

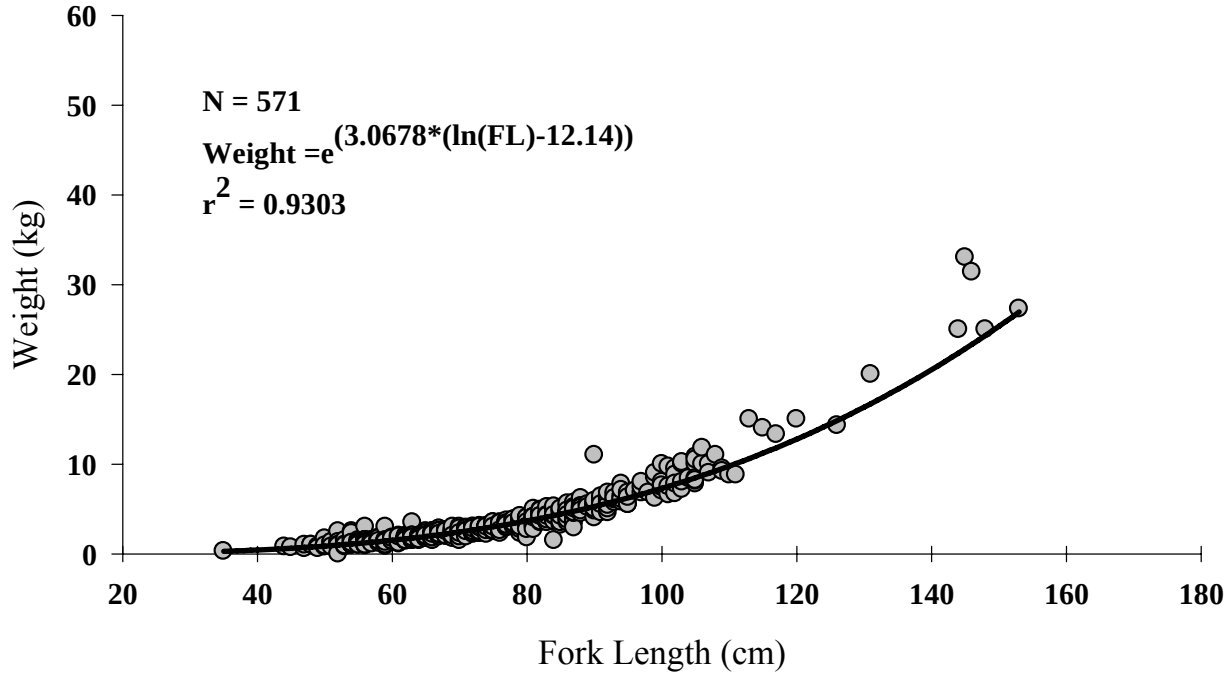

Figure A-4. Length-weight relationship of white sturgeon captured with setlines during stock assessment sampling, June-August 2006 (periods 2-4).

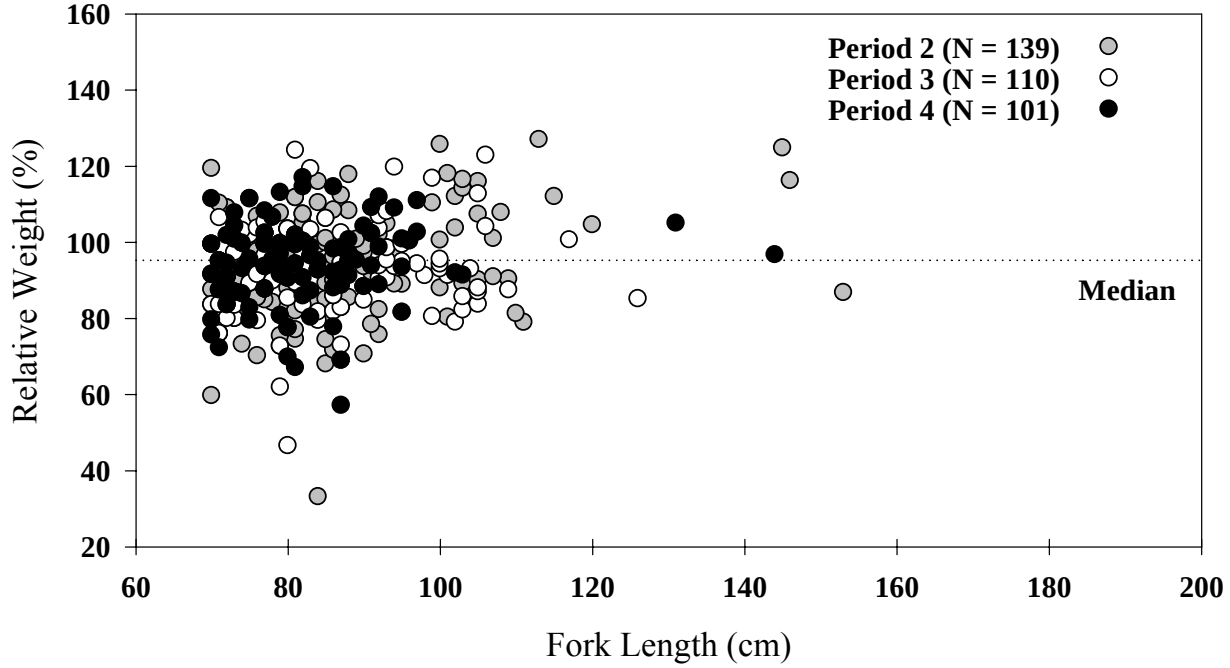

Figure A-5. Relative weights by period of white sturgeon captured with setlines during stock assessment sampling, June-August 2006.

We estimated the age of 111 white sturgeon captured from Bonneville Reservoir during the 2006 stock assessment. Age estimates ranged from 1-42 years, with a median age of 10 years. Variation between ages assigned by readers was high (Table A-5). There was 41% agreement in the final ages assigned by the two readers. The von Bertalanffy equation describing size at age for white sturgeon from Bonneville Reservoir in 2006 was:

$$L_x = 158.6[1-e^{-0.0435\,(x-2.4)}] \text{ (Figure A-6).}$$

Annual growth increments (AGI) for white sturgeon from Bonneville Reservoir were estimated from the 2003 and 2006 von Bertalanffy growth functions and from recaptures during 1987-2006 (Figure A-7). Predicted AGIs in 2006 decreased as fish size increased, ranging from approximately 4.3 cm/year for white sturgeon 41-60 cm FL, to approximately 1.2 cm/year for fish 121-140 cm FL. AGIs calculated from actual recaptured fish show varied growth throughout all sizes with an increasing trend until about 141-160 cm, after which growth decreased. Growth of individual fish ranged from a low of -1.7 cm/year to a high of 12.8 cm/year. Growth for white sturgeon 40-60 cm FL averaged 0.9 cm/year, growth increased to 8.6 cm/year for fish 141-160 cm FL, then decreased to 1.2 cm/year for white sturgeon over 200 cm FL.

Table A-5. Discrepancies in aging of white sturgeon collected from Bonneville Reservoir during the 2006 stock assessment. The shaded row indicates when the two readers assigned an identical final age.

	Final Assigned Age																	
Age Difference	1	4	5	6	7	8	9	10	11	12-14	15-17	18-20	21-23	24-26	27-29	>29	% Agreement	N
-2					2			2		1			1	1			6.3	7
-1		1	2	1	2		2	2		2				2			12.6	14
0			5	8	4	5	3	2	2	6	4	1		1	2	2	40.5	45
1	1		1	4	3	1	2			5	3	2	1	1			21.6	24
2			1					1		2	1	3	3	1	1	1	12.6	14
3							1								1		1.8	2
4												1	1				1.8	2
5												1	1				1.8	2
6																	0.0	0
7																1	0.9	1
All	1	1	9	13	11	6	8	7	2	16	8	8	7	6	4	4	100.0	111

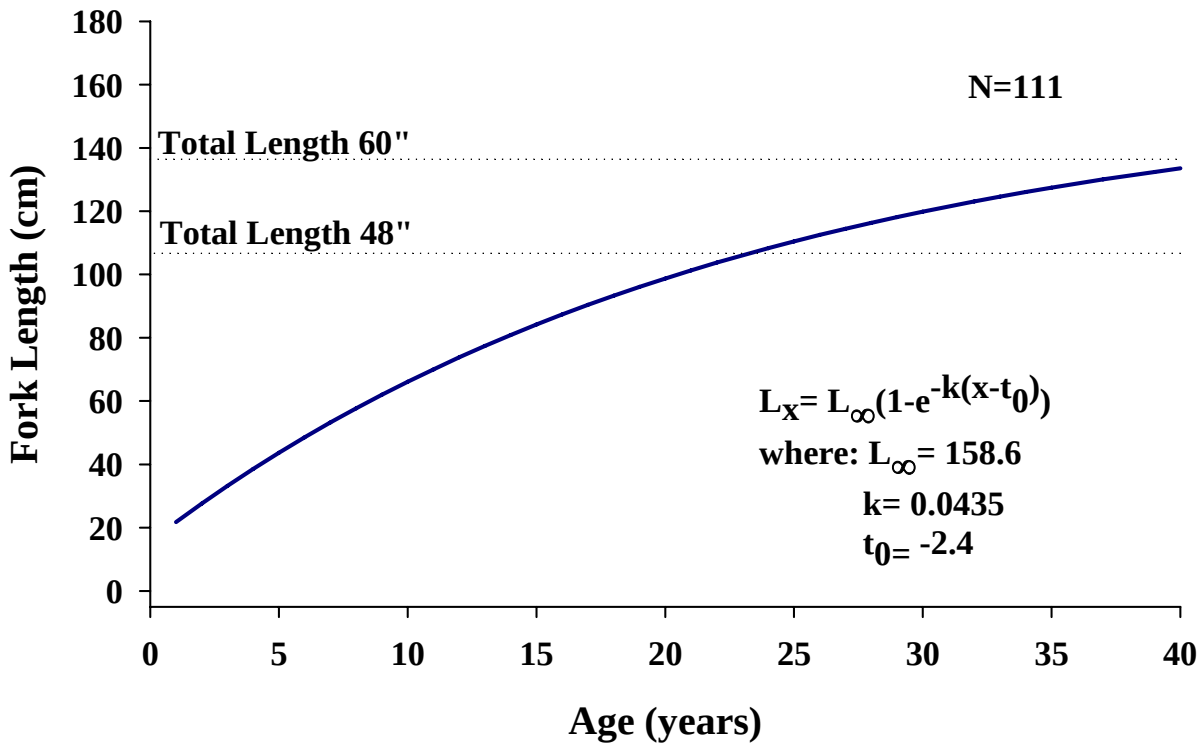

Figure A-6. von Bertalanffy growth function for white sturgeon collected from Bonneville Reservoir during stock assessments.

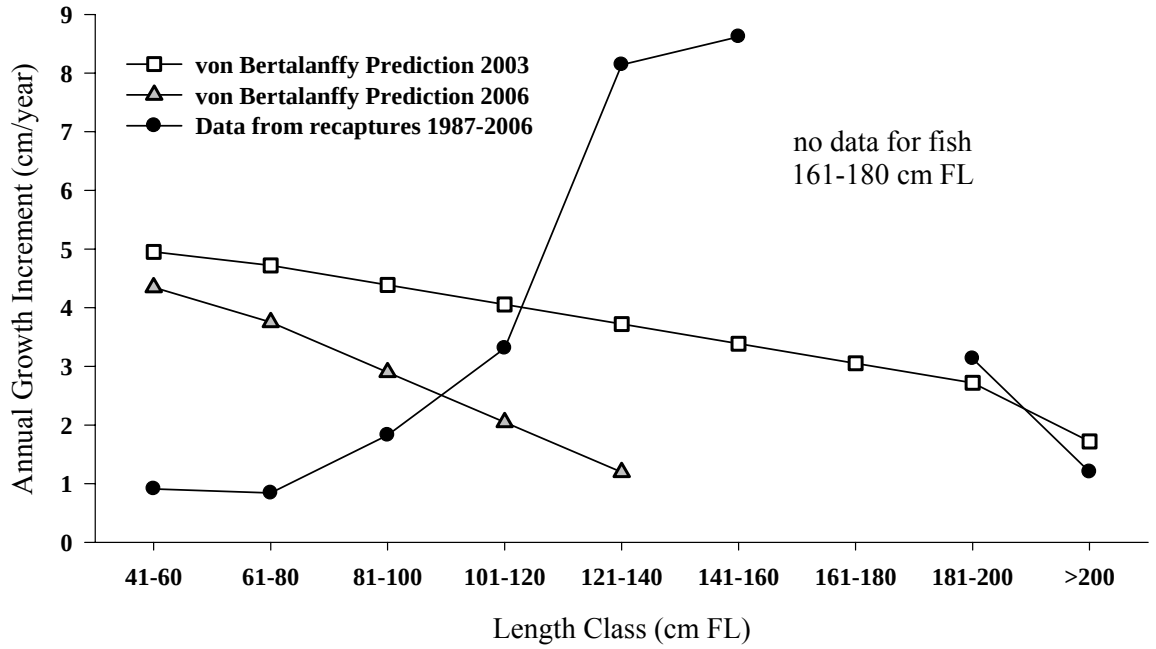

Figure A-7. Mean AGIs by length class predicted by the 2003 and 2006 von Bertalanffy growth functions, and mean AGIs calculated from recaptures of tagged fish from Bonneville Reservoir.

Abundance

The abundance of white sturgeon <70 cm FL was estimated to be 119,021 (95% CI: 84,176-167,657; Table A-6). The abundance of white sturgeon 70-109 cm FL was estimated to be 112,316 (95% CI: 83,311-151,109; Table A-7). The abundance of white sturgeon 110-166 cm FL and those >166 cm FL were estimated to be 947 and 243 respectively (Table A-8). The abundance of legally harvestable fish was estimated to be 6,240 in the sport fishery (96-137 cm FL) and 2,575 in the commercial fishery (103-137 cm FL). The total population of white sturgeon (≥54 cm FL) in Bonneville Reservoir in 2006 was estimated to be 205,392 (Table A-8; Figure A-8).

Table A-6. Mark/recapture data and Schnabel abundance estimate of white sturgeon <70 cm fork length in Bonneville Reservoir, 2006.

Period (t)	Catch (C)	Marks (M)	Recaps (R)	Mortalities/Harvest Unmarked	Mortalities/Harvest Marked	Marks at Large (Mt)	Estimate SUM(M_t*C)/(R+1)
1	1,580	8	[a]	0	0	0	
2	1,006	1,004	0	0	0	8	8,048
3	1,315	1,295	18	0	0	1,012	70,041
4	1,019	990	12	0	0	2,307	180,833
Sum	4,920	3,297	30			Estimate	**119,021**
						95% CI (lower)	84,176
						95% CI (upper)	167,657

[a] White sturgeon recaptured during period 1 are not included in the Schnabel estimate.

Table A-7. Mark/recapture data and Schnabel abundance estimate of white sturgeon 70-109 cm fork length in Bonneville Reservoir, 2006.

Period (t)	Catch (C)	Marks (M)	Recaps (R)	Mortalities/Harvest Unmarked	Mortalities/Harvest Marked	Marks at Large (Mt)	Estimate SUM(M_t*C)/(R+1)
1	2,222	2,108	[a]	261	19	0	
2	511	500	11	250	9	2,089	88,957
3	590	572	17	65	0	2,580	84,567
4	675	644	13	0	0	3,152	151,971
Sum	3,998	3,824	41			Estimate	**112,316**
						95% CI (lower)	83,311
						95% CI (upper)	151,109

[a] White sturgeon recaptured during period 1 were not included in the Schnabel estimate.

Table A-8. Estimated abundances of white sturgeon in Bonneville Reservoir from the 2006 stock assessment. Confidence intervals are given for the size group for which a Schnabel estimate was calculated, and not for size groups for which abundance was estimated by expansion from the length-frequency of the setline catch.

Size Range cm FL		2006 Estimate	Relative Abundance
<70	(≤30” TL)	119,021 (84,176-167,657)	0.447
70-109	(31”-48” TL)	112,316 (83,311-151,109)	0.547
110-166	(48”-72” TL)	947	0.005
167+	(72”+ TL)	243	0.001
54+	(>24” TL)	205,392	--
96-137	(42”-60” TL)[a]	6,240	0.030
103-137	(45”-60” TL)[b]	2,575	0.013

[a] Size range of legally harvestable fish in the sport fishery.
[b] Size range of legally harvestable fish in the commercial fishery.

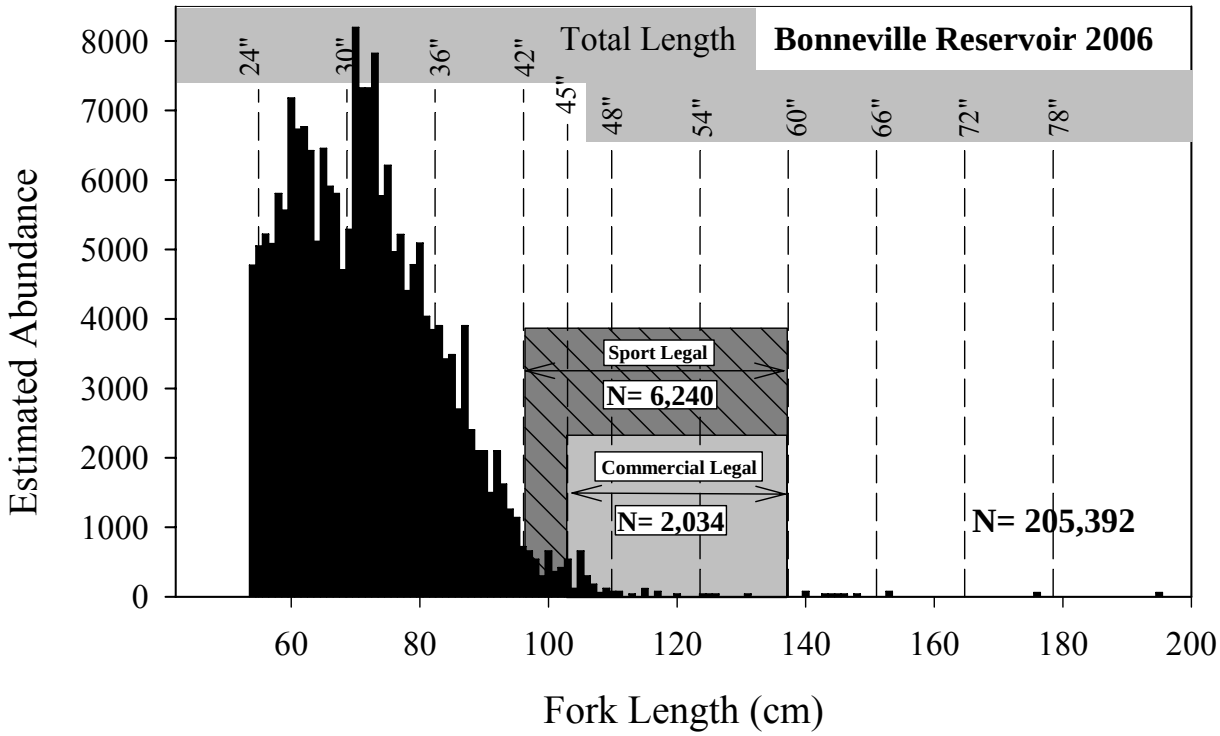

Figure A-8. Length-frequency distribution of white sturgeon (≥ 54 cm FL) in Bonneville Reservoir based on the 2006 stock assessment.

Age-0 Indexing

During age-0 indexing, in all reservoirs combined, 679 white sturgeon were captured in 151 individual net sets. Nets were fished for a combined time of 3,431 hours, with an average time of 22.7 hours per set. Of the 679 white sturgeon captured, 277 (41%) were classified as age-0. Age-0 white sturgeon were captured in all reservoirs sampled in 2006. Captured white sturgeon ranged in length from 16.5 to 92.7 cm FL (Figure A-9), and most (97%) age-0 white sturgeon aged were ≤ 30.0 cm FL. Incidental catch of other fish species during age-0 sampling is presented in appendix Table A-15.

McNary Reservoir

A total of five white sturgeon were captured in 36 individual net sets. Nets were fished for a total of 800 hours, with an average of 22.2 hours per set. Of the five white sturgeon captured, four (80%) were classified as age-0. White sturgeon of all ages were captured in 8% of the sets, while age-0 white sturgeon were captured in 6% of the sets. The CPUE was 0.14 for all white sturgeon and 0.11 for age-0 white sturgeon (Table A-9).

John Day Reservoir

A total of 20 white sturgeon were captured in 40 individual net sets. Nets were fished for a total of 890 hours, with an average of 22.2 hours per set. Of the 20 white sturgeon captured, four (20%) were classified as age-0. White sturgeon of all ages were captured in 20% of the sets, while age-0 white sturgeon were captured in 10% of the sets. The CPUE was 0.50 for all white sturgeon, and 0.10 for age-0 white sturgeon (Table A-9).

The Dalles Reservoir

A total of 130 white sturgeon were captured in 36 individual net sets. Nets were fished for a total of 844 hours, with an average of 23.4 hours per set. Of the 130 white sturgeon captured, 99 (76%) were classified as age-0. White sturgeon of all ages were captured in 69% of the sets, while age-0 white sturgeon were captured in 47% of the sets. The CPUE was 3.61 for all white sturgeon and 2.75 for age-0 white sturgeon (Table A-9).

Bonneville Reservoir

A total of 524 white sturgeon were captured in 39 individual net sets. Nets were fished for a total of 897 hours, with an average of 23.0 hours per set. Of the 524 white sturgeon captured, 170 (32%) were classified as age-0. White sturgeon of all ages were captured in 97% of the sets, while age-0 white sturgeon were captured in 69% of the sets. The CPUE was 13.4 for all white sturgeon and 4.4 for age-0 white sturgeon (Table A-9).

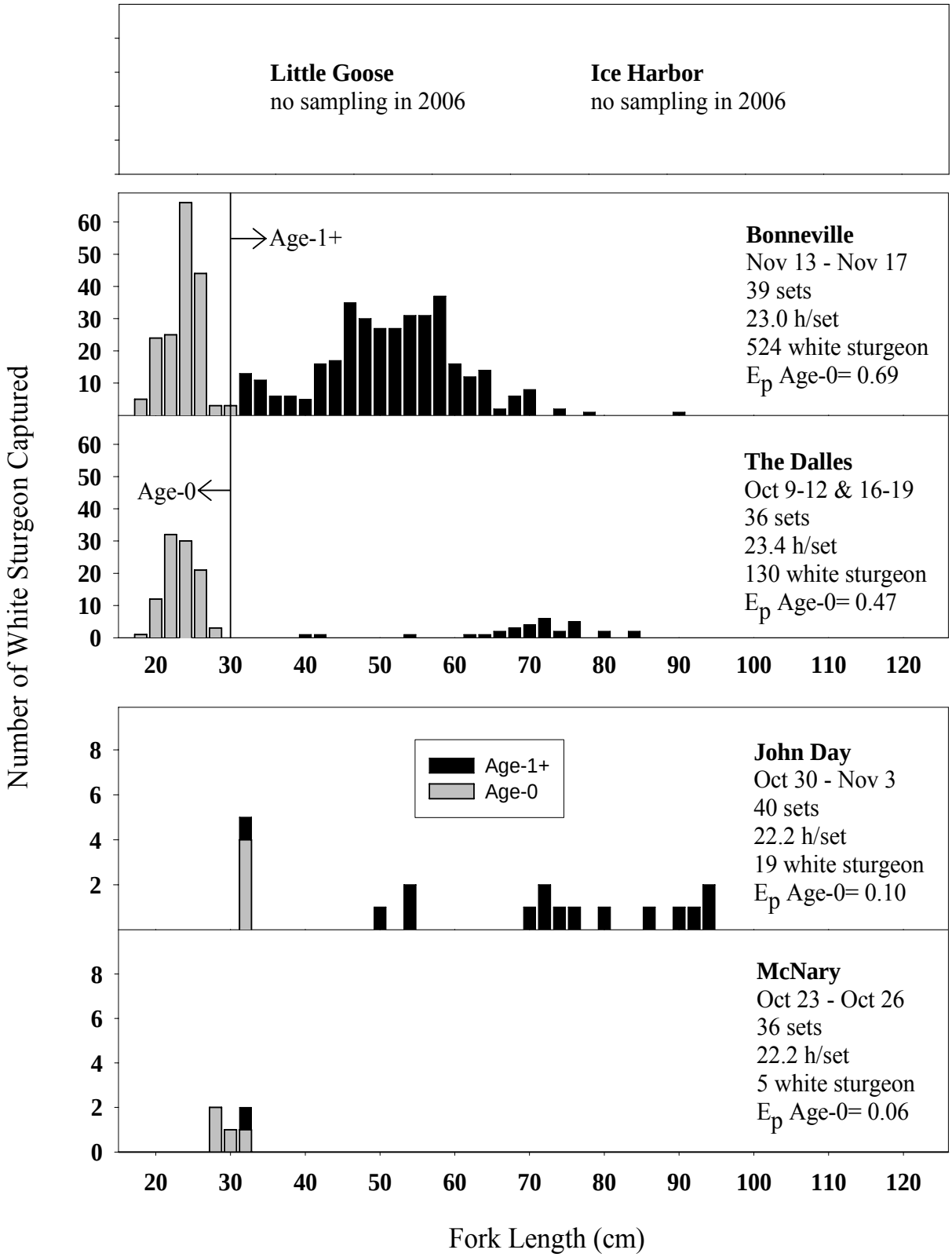

Figure A-9. Length-frequency distributions and catch data for white sturgeon captured during age-0 indexing, October – November 2006.

Table A-9. Effort and catch of white sturgeon in Columbia River reservoirs during age-0 sampling, October and November 2006.

River Reach	Reservoir Quarter [a]				
Parameter	1	2	3	4	All
Bonneville					
Gill Net Sets	6	15	12	6	39
Total Hours	136	342	278	142	897
White Sturgeon Catch (all sizes)	15	248	167	97	524
White Sturgeon Catch (Age-0)	4	129	36	1	170
White Sturgeon / Set	2.50	16.53	13.92	16.17	13.44
White Sturgeon (Age-0)/Set	0.67	8.60	3.00	0.17	4.36
Sets with >0 white sturgeon (all sizes)	83%	100%	100%	100%	97%
Sets with >0 white sturgeon (Age-0)	50%	93%	75%	17%	69%
The Dalles					
Gill Net Sets	9	6	15	6	36
Total Hours	210	142	355	137	844
White Sturgeon Catch (all sizes)	33	79	12	6	130
White Sturgeon Catch (Age-0)	28	67	4	0	99
White Sturgeon / Set	3.67	13.17	0.80	1.00	3.61
White Sturgeon (Age-0)/Set	3.11	11.17	0.27	0.00	2.75
Sets with >0 white sturgeon (all sizes)	89%	100%	47%	67%	69%
Sets with >0 white sturgeon (Age-0)	89%	100%	20%	0%	47%
John Day					
Gill Net Sets	9	9	12	10	40
Total Hours	211	198	267	215	890
White Sturgeon Catch (all sizes)	0	1	6	13	20
White Sturgeon Catch (Age-0)	0	0	2	2	4
White Sturgeon / Set	0.00	0.11	0.50	1.30	0.50
White Sturgeon (Age-0)/Set	0.00	0.00	0.17	0.20	0.10
Sets with >0 white sturgeon (all sizes)	0%	11%	25%	40%	20%
Sets with >0 white sturgeon (Age-0)	0%	0%	17%	20%	10%
McNary					
Gill Net Sets	27	9			36
Total Hours	601	199			800
White Sturgeon Catch (all sizes)	5	0			5
White Sturgeon Catch (Age-0)	4	0			4
White Sturgeon / Set	0.19	0.00			0.14
White Sturgeon (Age-0)/Set	0.15	0.00			0.11
Sets with >0 white sturgeon (all sizes)	11%	0%			8%
Sets with >0 white sturgeon (Age-0)	7%	0%			6%

[a] Reservoir quarters are assigned by dividing the reservoir lengthwise into four sections of equal length starting at the downstream dam (quarter 1) and ending at the upstream dam (quarter 4).

DISCUSSION

Stock Assessment

The estimated total abundance of white sturgeon (≥54 cm FL) in Bonneville Reservoir in 2006 (205,391 fish) was 71% higher than in 2003 (119,909 fish); (Table A-10). However, the 2006 stock assessment indicated a reduction in the legal and over-legal size classes (Table A-11, Figure A-10). There was a 9% reduction in the sport-legal size class, a 1% reduction in the commercial-legal size class, and a 33% reduction in the over-legal size class from 2003 levels. A decrease in these groups from 2003 to 2006 was expected from the modeling done following the 2003 stock assessment. Offsetting the declines was a substantial increase in the 54-69 and 70-109 cm FL size classes, which increased in abundance by 76% and 71% respectively (Table A-10). The abundance of smaller fish is important, as eventually they should contribute to harvest and to spawner abundance. However, due to the relatively slow growth of white sturgeon, these fish may not attain a harvestable size (96-137 cm FL) for several years. Abundance estimates from 1987-2006 for Zone 6 reservoirs and the Hanford reach of McNary Reservoir are presented in Appendix Table A-16.

Table A-10. Summary of white sturgeon abundance by size class, Bonneville Reservoir 1999, 2003 and 2006. Highlighted rows were derived from the Schnabel estimate, non-highlighted rows were based on expansions.

Size Range cm FL	1999	2003	2006 (95% CI)	Difference from 2006	% Difference from 2006
54-69 (24”-30” TL)		52,196	91,885	39,689	76%
70-109 (31”-47” TL)		**65,796**	**112,316 (83,311-151,109)**	**46,521**	**71%**
110-166 (48”-72” TL)		1,171	947	-224	-19%
167+ (72”+ TL)		746	243	-503	-67%
All Sizes (>24” TL)	128,316	119,909	205,391	85,483	71%
96-137 (42”-60” TL)[a]	14,735	6,880	6,240	-640	-9%
103-137(45”-60” TL)[b]		2,597	2,575	-22	-1%

a Size range of legally harvestable fish (sport fishery).
b Size range of legally harvestable fish (commercial fishery).

Table A-11. Summary of abundance estimates by harvest category, Bonneville Reservoir 1999, 2003 & 2006.

Size Range	1999 Estimate	2003 Estimate	2006 Estimate	Difference from 2003	% Difference from 2003
Sub-legal (24”-41” TL)		112,132	198,553	86,421	77%
Sport-legal (42”-60” TL)		6,880	6,240	-640	-9%
Commercial-legal (45”-60” TL)		2,597	2,575	-22	-1%
Over-legal (>60” TL)	580	896	598	-298	-33%

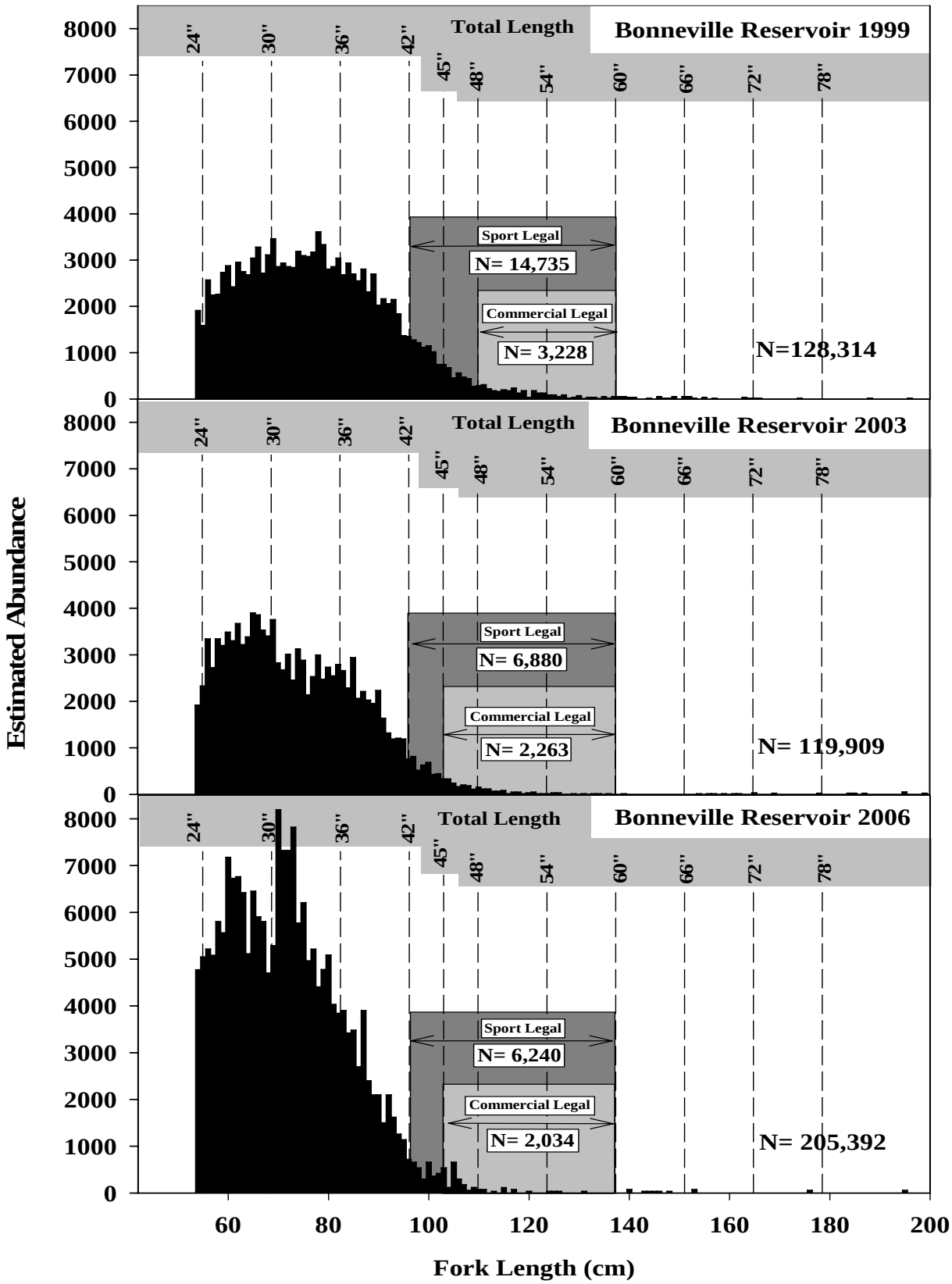

Figure A-10. Abundance by 1-cm fork length intervals for the 1999, 2003, and 2006 Bonneville Reservoir stock assessments.

Condition factors, such as relative weight, can provide an indirect means of evaluating ecological relations and the effects of various management strategies, especially when making size-specific comparisons within or among populations. The overall mean relative weight of white sturgeon in Bonneville Reservoir has been increasing slightly over the past three stock assessments. Mean relative weight in 1999, 2003, and 2006, was 87.61, 92.12, and 94.1 respectively (Table A-12). This is encouraging as in 1999 we reported concern about the decrease in relative weights (from 106.0 to 88.0) and discussed the possibility of a density dependent function on the population that could be inhibiting production within the reservoir (Kern et al., 2001). The increase in overall relative weights is not consistent over all size classes. In the 138-159 and 160+ cm FL size classes, the mean relative weights fluctuate up and down. This is likely due to the small number of samples in those categories (e.g., we caught no fish over 160 cm FL in 2006). Reason(s) for the observed increase in overall relative weights are unknown. Further studies examining size-specific diet and food web dynamics may provide some insight.

Table A-12. Condition of white sturgeon caught using setlines during stock assessments in Bonneville Reservoir, 1999, 2003, and 2006.

	Mean Relative Weight (cm FL, in TL)				
Year	70-95 (31"-42")	96-137 (42"-60")	138-159 (60"-72")	160+ (72"+)	All
1999	86.44	87.73	105.89	93.96	87.61
2003	92.58	91.02	67.70	97.51	92.12
2006	93.16	98.71	102.53	--	94.10

White sturgeon captured and aged during the 2006 stock assessment were estimated to be older than white sturgeon (of similar sizes) captured and aged during previous stock assessments. This trend in age estimations can be seen by examining the von Bertalanffy growth functions from 2006, 2003, and 87-2002 (Figure A-11). Based on the age estimates and the subsequent von Bertalanffy growth functions, a legal size white sturgeon measuring 110 cm FL (48 inches total length) would be approximately 18 years old prior to 2003, 20 years old in 2003, and 25 years old in 2006. This represents an 11% change in 2003 from previous years, a 25% change in 2006 from 2003, and a 38% change in 2006 from 1987-2002. This discrepancy is even more pronounced as the size of the fish increases.

The assigning of older ages in recent years was also observed in The Dalles and John Day Reservoirs (Chapman and Hughes, 2007; Hughes et al., 2006). One explanation may be an unintentional bias towards older age estimates due to our awareness that past readings tended to underestimate the age of individual fish, consequently predicting faster growth (Rien and Beamesderfer, 1994; Kern et al., 2003).

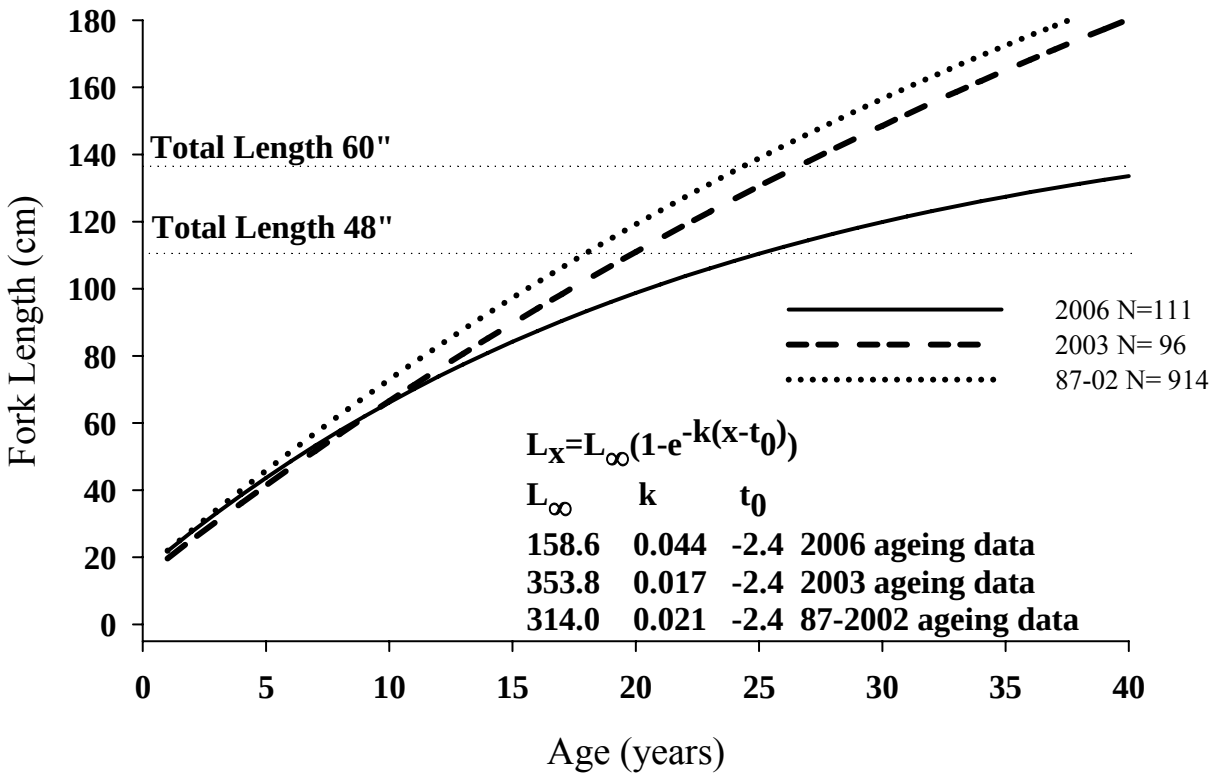

Figure A-11. Comparison of von Bertalanffy growth functions for white sturgeon collected from Bonneville Reservoir during 2006, 2003, and 1987-2002.

Data collected from marked and recaptured fish in Bonneville Reservoir revealed a different pattern of growth than was predicted from the 2003 and 2006 age estimates and the subsequent von Bertalanffy growth functions (Figure A-7). Smaller fish (41-80 cm FL) appear to grow at less than a quarter of the rate predicted from the von Bertalanffy growth function. Additionally, beginning at approximately 80 cm FL, white sturgeon in Bonneville Reservoir appear to experience an increase in annual growth rate, which is not apparent from the AGIs predicted from aging. Growth rate continues to increase until approximately 160 cm FL, at which size annual growth rate begins to decrease again. The von Bertalanffy growth function (and therefore the AGIs predicted from the von Bertalanffy growth function) assumes a linearly decreasing growth rate as fish grow older. Recapture data suggest that white sturgeon in Bonneville Reservoir do not exhibit this pattern. These findings are consistent with what we found in The Dalles Reservoir in 2002 and 2005 and in John Day Reservoir in 2001 and 2004 (Chapman and Hughes Weaver, 2007; Hughes et al., 2006).

Difficulties in obtaining accurate and consistent age data for white sturgeon, coupled with the discrepancies found when comparing predicted and actual growth rates, highlight the need to identify and develop more objective means for quantifying age and growth. Inaccurate growth data can have significant management implications, as current management decisions in Bonneville Reservoir are based on the abundance and growth of white sturgeon below, within, and above the legal size slots of 96-137 cm FL (48”-60” TL) for sport and 103-137 cm FL (45” - 60” TL) for commercial fisheries.

Age-0 Indexing

Recruitment of age-0 white sturgeon was detectable in all reservoirs sampled during 2006. This level of recruitment has not been seen since 1999; however, this was the first year that ODFW conducted age-0 sampling in Bonneville Reservoir using gill nets (Table A-13). Prior to 2006, white sturgeon recruitment in Bonneville Reservoir was sampled with trawls. From 2000-2005, age-0 white sturgeon were captured in The Dalles Reservoir and in McNary Reservoir (Table A-13), but were absent in all other reservoirs sampled. Due to budget cuts we were unable to conduct age-0 sampling in Ice Harbor and Little Goose Reservoirs in 2006.

Table A-13. Proportion of positive sets (E_P) for age-0 (≤ 30 cm FL) white sturgeon in upper Columbia and Snake river reservoirs 1997-2006.

Year	Bonneville	The Dalles	John Day	McNary	Ice Harbor	Little Goose
1997	--[a]	0.74	0.53	--	**0.00**	--
1998	--	0.65	0.08	--	--	0.32
1999	--	0.67	0.22	0.08	0.03	0.08
2000	--	0.14	**0.00**	**0.00**	**0.00**	**0.00**
2001	--	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
2002	--	0.17	**0.00**	0.06	**0.00**	**0.00**
2003	--	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
2004	--	0.06	**0.00**	**0.00**	**0.00**	**0.00**
2005	--	0.03	**0.00**	0.03	**0.00**	**0.00**
2006	0.69	0.47	0.01	0.06	--	--

[a] Prior to 2006, USGS conducted age-0 trawl surveys in Bonneville Reservoir.

In the lower Columbia River basin, water velocity (which, in the reservoir environment, is heavily influenced by dam discharge) appears to play an important role in white sturgeon spawning and recruitment (Parsley 1993; Parsley et al., 1993; Parsley and Beckman, 1994). Data from age-0 indexing, when combined with dam discharge data, suggest that higher discharge rates result in higher levels of recruitment of age-0 white sturgeon (Figure A-12). When the average daily discharge rate at McNary Dam during April-July (the spawning time of white sturgeon in the lower Columbia River) approaches or exceeds 250 kcfs, there was a detectible level of recruitment in all reservoirs sampled. In 10 years of age-0 sampling, the only exception to this was in 2002, when average discharge rates were greater than 250 kcfs and recruitment was detected in only The Dalles Reservoir.

These data support past findings that discharge rates of approximately 250 kcfs or greater during the spawning period create conditions which increase the likelihood of successful recruitment of age-0 white sturgeon in the reservoir environments between McNary and Bonneville dams (Parsley 1993).

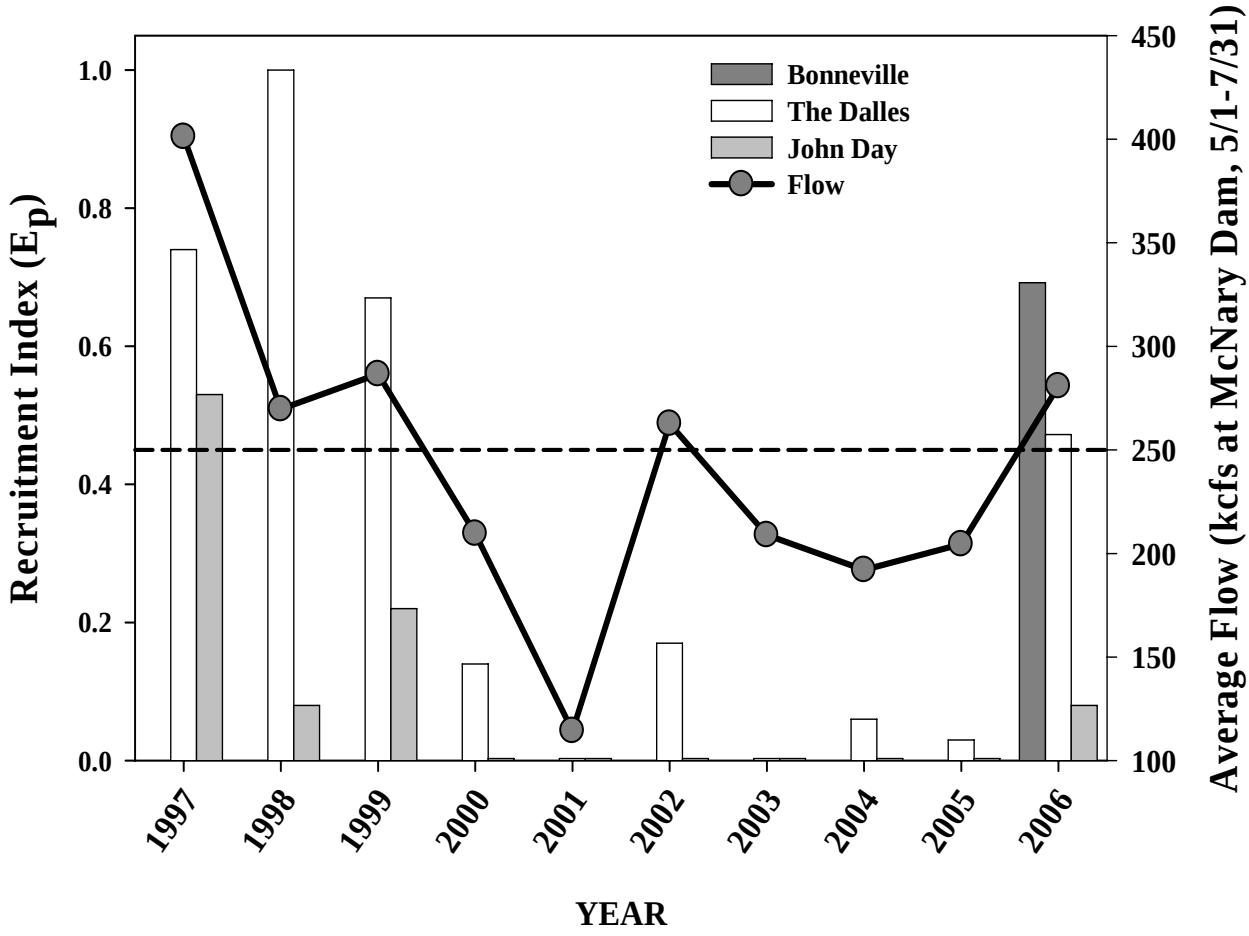

Figure A-12. Recruitment index (E_p; proportion of sets capturing one or more age-0 fish) for white sturgeon in Bonneville, The Dalles, and John Day reservoirs, and average daily flow at McNary Dam (May-July). Index values in The Dalles and John Day reservoirs are based on data from standardized gill net efforts initiated in 1997. Gill net efforts to assess recruitment in Bonneville Reservoir began in 2006. The dashed horizontal line indicates the recommended minimum flow to provide adequate spawning habitat in all three reservoirs.

PLANS FOR NEXT YEAR

A stock assessment survey will be conducted in John Day Reservoir in 2007 (Table A-14). We will assess the age and length structure of the white sturgeon population in John Day Reservoir as well as estimate the abundance of white sturgeon ≥54 cm FL. We will continue to refine existing methods for describing growth of white sturgeon in Zone 6 reservoirs using information obtained from PIT-tag recoveries during stock assessment surveys.

Due to limited funding in 2007, we will only assess age-0 white sturgeon recruitment in Bonneville, The Dalles, John Day, and McNary reservoirs (Table A-14). Surveys will not be conducted in Ice Harbor and Little Goose reservoirs.

Creel surveys will continue in 2007 (Table A-14). We will assist WDFW with creel sampling in Bonneville and John Day Reservoirs to assess recreational fishery harvest rates of white sturgeon.

Table A-14. Approximate timing of major tasks for the 2007-2008 project year.

	2007									2008		
Task	A	M	J	J	A	S	O	N	D	J	F	M
Stock Assessment (John Day Reservoir)			X	X	X							
Age-0 Indexing (Bonneville, The Dalles, John Day, and McNary Reservoirs)							X	X				
Creel (Bonneville and The Dalles Reservoirs)	X	X	X	X	X					X	X	X

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APPENDIX

Table A-15. Species composition by reservoir from Young-of-Year index sampling, October – November 2006. Disposition: 1=alive and released, 2=sacrificed, 3=dead or dying at capture.

	Bonneville				**The Dalles**			**John Day**			**McNary**			
	Disposition				Disposition			Disposition			Disposition			
Species	1	2	3	All	1	3	All	1	3	All	1	3	All	Total
American Shad *Alosa sapidissima*			4	4				5	53	58				62
Bridgelip Sucker *Catostomus columbianus*					1	2	3	2	3	5	9	9	18	26
Carp *Cyprinus carpio*								2		2				2
Channel Catfish *Ictalurus punctatus*					3		3	68	7	75	572	41	613	691
Chiselmouth *Acrocheilus alutaceus*											27	74	101	101
Coho *Oncorhynchus kisutch*	1			1	1	1	2	1		1				4
Crayfish *(Genus: Pacifastacus)*											1	1	2	2
Largemouth Bass *Micropterus salmoides*								1		1				1
Largescale Sucker *Catostomus macrocheilus*	3		5	8	2	3	5	3	1	4	2	6	8	25
Mountain Whitefish *Prosopium williamsoni*												1	1	1
Northern Pikeminnow *Ptychocheilus oregonensis*	7		49	56	36	32	68	7	14	21	14	45	59	204
Peamouth Chub *Mylocheilus caurinus*	57		176	233	25	32	57				7	17	24	314
Sculpin *(Genus: Cottus)*	2		2	4		1	1		1	1	1	1	2	8
Smallmouth Bass *Micropterus dolomieu*					1	2	3		2	2	3	5	8	13
Walleye *Sander vitreus*						2	2	1	10	11	1	4	5	18
White Sturgeon *Acipenser transmontanus*	507	6	11	524	120	10	130	20		20	5		5	679
Yellow Perch *Perca flavescens*	2			2				52	262	314	129	551	680	996
Total	579	6	247	832	189	85	274	162	353	515	771	755	1,526	3,147

Table A-16. Abundance estimates for Zone 6 reservoirs and the Hanford Reach of McNary Reservoir, 1987 – 2006.

Year	30-72 inch total length N (95% CI)	Number of fish by total length interval (inches) 24-36	36-48	48-60	60-72	72+	Sum	Number/ Acre[a]	Pounds/ Acre[a]
				Hanford Reach and McNary Reservoir					
1995	5,234 (3,782-9,086)	900	2,700	3,400		1,250	8,250	0.2	8
				Bonneville Reservoir					
1989	35,400 (27,500-45,400)	32,900	16,700	1,000	200	600	51,400	2.5	27
1994	35,200 (24,800-66,000)	31,300	18,300	1,300	200	900	52,000	2.5	--
1999	85,400[b]	82,400	41,800	3,200	600	400	128,400	6.2	59
2003	74,000[b]	84,500	33,000	1,100	120	780	119,500	5.7	46
2006	113,300	159,000	45,200	590	350	240	205,400	9.9	67
				The Dalles Reservoir					
1987	23,600 (15,700-33,600)	7,800	11,000	6,100	1,800	1,000	27,700	2.5	73
1988	9,000 (7,300-11,000)	4,200	4,300	1,500	500	800	11,300	1.0	32
1994	9,700 (7,500-14,000)	5,800	5,700	800	<50	300	12,600	1.1	--
2002	33,000 (26,200-42,000)	82,900	13,500	5,900	1,200	800	104,300	9.4	87
2005	45,700 (37,000-56,300)	90,600	10,200	1,100	500	400	102,800	9.3	69
				John Day Reservoir					
1990	3,900 (2,300-6,100)	16,600	1,700	400	100	500	19,300	0.4	3
1996	27,100 (23,800-30,800)	5,800	19,700	4,050	350	700	30,600	0.6	11
2001	19,600[b]	14,900	12,800	1,100	300	900	30,000	0.6	9
2004	30,000[b]	30,200	11,500	1,100	170	470	43,500	0.8	9

[a] Hanford Reach and McNary Reservoir = 45,500 acres; Bonneville Reservoir = 20,800 acres; The Dalles Reservoir = 11,100 acres; John Day Reservoir = 51,900 acres.

[b] Confidence intervals for these estimates are not provided because they are derived from expansion, not directly calculated from mark-recapture data.

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 2006 – MARCH 2007

Report B

Evaluate the success of developing and implementing a management plan to enhance production of white sturgeon in reservoirs between Bonneville and McNary dams

This report includes: Progress on implementing the fisheries management component of the white sturgeon management plan for the Columbia River between Bonneville and McNary dams including results of surveying 2005 sport and commercial white sturgeon fisheries.

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ABSTRACT

The Washington and Oregon Departments of Fish and Wildlife conducted a survey of the 2006 sport fishery on the Columbia River from Bonneville Dam upstream to McNary Dam (Zone 6 management unit) to estimate white sturgeon *Acipenser transmontanus* harvest. The sport fishery was closed to the retention of white sturgeon during 24 July – 31 December in Bonneville Reservoir, with an estimated harvest of 727 fish (104% of the 2006 guideline). The fishery in The Dalles Reservoir was closed to the retention of white sturgeon during 8 April – 31 December, with an estimated harvest of 93 fish (93% of guideline). The John Day Reservoir was closed to retention during 1 July – 31 December, with an estimate harvest of 142 fish (86% of guideline).

Treaty Indian commercial fishers landed 153 white sturgeon from Bonneville Reservoir (38% of the 2006 guideline), 397 from The Dalles Reservoir (72% of guideline), and 312 from John Day Reservoir (85% of guideline), during gill net and setline fisheries. The Columbia River Inter-Tribal Fish Commission and the Yakama Indian Nation estimated an additional 201 fish were harvested from the three reservoirs (28 from Bonneville Reservoir, 115 from The Dalles Reservoir, and 58 from John Day Reservoir), during the 2006 subsistence fisheries.

The harvest guidelines for 2006 were 700 sport and 400 commercial in Bonneville Reservoir, 100 sport and 550 commercial in The Dalles Reservoir, and 165 sport and 335 commercial in John Day Reservoir. These guidelines were established in 2004 in Bonneville Reservoir, 2006 in The Dalles Reservoir, and 2002 in John Day Reservoir.

A targeted catch and release oversize sturgeon fishery began developing in the late 1990s, especially in John Day Reservoir. In 2006, spawning sanctuaries were established below McNary and John Day dams from 1 May – 31 July to protect white sturgeon broodstock from the growing oversize target fishery. Additional monitoring of anglers, especially during non-retention seasons, and particularly in the upper John Day Reservoir where an oversize catch and release target fishery is already established, would aid managers in estimating angler effort and handle of oversize white sturgeon.

INTRODUCTION

This annual report describes progress made by the Washington Department of Fish and Wildlife (WDFW) toward completing tasks outlined in the Statement of Work for Bonneville Power Administration Project 198605000, White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam. The reporting period is from 1 April 2006 through 31 March 2007, but focuses on work conducted from 1 January 2006 through 31 December 2006.

To address tasks related to two of the three FY 2006 multi-agency project objectives, WDFW worked closely with staff from the Oregon Department of Fish and Wildlife (ODFW), the Columbia River Inter-Tribal Fisheries Commission (CRITFC), and Montana State University (MSU). Specific objectives were to:

Objective 1) Implement actions annually that do not involve changes to hydropower system operation and configuration to mitigate for lost white sturgeon productivity.

Objective 2) Monitor and evaluate actions to mitigate for lost white sturgeon production due to development, operation, and configuration of the hydropower system.

The WDFW was contracted to work on Tasks 1.2, 2.1, 2.2, 2.3, and 2.4 (described below) during the performance period.

Task 1.2. Annually set harvest objectives and assess recreational and commercial fishing effort, harvest rate, and harvest in Bonneville, The Dalles and John Day (Zone 6) Reservoirs. The WDFW supplied effort and harvest data to the Sturgeon Management Task Force of the Columbia Basin Fish and Wildlife Authority for review and use in developing the annual white sturgeon fisheries management plans for Zone 6 reservoirs. The task also required WDFW to conduct annual sampling of the Zone 6 recreational and commercial fisheries, and to provide technical input to the in-season management of those fisheries.

Task 2.1. Monitor the status of populations in the three Zone 6 reservoirs. A multiple pass mark-recapture study of the Bonneville Reservoir white sturgeon population was conducted jointly by WDFW and ODFW staff (see Report A in this annual report).

Task 2.2. Determine sex, maturational status, and reproductive potential of white sturgeon in impounded and unimpounded reaches. We worked with MSU staff below Bonneville Dam to capture adult white sturgeon of breeding age and surgically examine them to collect paired gonad tissue and blood samples. Staff at MSU are using those samples to develop methods to determine sex and stage of maturity for white sturgeon (see Report G in this annual report).

Task 2.3. Index annual white sturgeon recruitment in impoundments. We worked with staff from ODFW and the Yakama Nation (YN; contractor to CRITFC) to sample Bonneville, The Dalles, John Day, and McNary Reservoirs to index relative abundance of Age-0 white sturgeon (see Report A and Report D in this annual report).

Task 2.4. Describe distribution and size of white sturgeon previously released into Rock Island Reservoir. We worked with CRITFC and ODFW to sample Rock Island and Wanapum reservoirs for white sturgeon released into Rock Island Reservoir in 2004.

METHODS

Sport Fishery Survey

The 2006 sport fishery survey was conducted in Bonneville and The Dalles reservoirs, and that portion of the John Day Reservoir between Crow Butte Park at river kilometer (rkm) 423 (Figure B-1) and McNary Dam at rkm 470, where fishing is concentrated. Methods were similar to those used annually since 1995 (James et al., 1996) and relied on angling effort distribution data collected during surveys of Bonneville Reservoir from 1988 to 1990, The Dalles Reservoir from 1987 to 1989, and John Day Reservoir from 1989 to 1991 (Hale and James 1993). Sampling (effort accounting and angler interviews) was conducted by WDFW and ODFW (WDFW having lead responsibility for this task).

The survey was limited to legal angling hours for white sturgeon (one hour before sunrise to one hour after sunset). Estimates in this report of angling effort and harvest for steelhead *Oncorhynchus mykiss*, walleye *Sander vitreus*, smallmouth bass *Micropterus dolomieu,* largemouth bass *M. salmoides*, and northern pikeminnow *Ptychocheilus oregonensis*, are considered conservative estimates, because these species can also be harvested at night (steelhead in Washington only).

Angling effort (angler hours) was estimated by counting anglers within representative index areas and expanding those counts to the entire reservoir using an established relationship derived from the 1987 to 1991 aerial counts of anglers within and outside of established index areas (Hale and James, 1993). Thirty-nine indices of angler effort (17 in Bonneville Reservoir, 10 in The Dalles Reservoir, and 12 in John Day Reservoir) were established at popular fishing locations and vantage points in each reservoir, and have remained essentially the same since 1995. In Bonneville Reservoir, one index area (rkm 163) was moved upriver, and shared by two adjacent locations (rkm 168 and rkm 169) in 2000 to account for a shift in Oregon bank angler effort (James et al., 2001). One Washington bank index area (rkm 168) was dropped in 2005 due to lack of angler use. Counts were made of all bank anglers and sport fishing boats within each index area. Average numbers of anglers per boat were determined from angler interviews. Angling effort within index areas was counted once a day between 1000 and 1300 hours. The proportion of the day's total angling effort was calculated from average daily angling effort distributions derived from prior years' data when systematic counts were made throughout the day.

Harvest estimates for boat anglers were calculated by multiplying the observed catch per hour for boat anglers within a reservoir subsection by the total estimated effort (hours) for boat anglers for that subsection. The one fish daily bag limit (enacted in 1991 for The Dalles and John Day reservoirs and in April 1996 for Bonneville Reservoir) makes it likely that some successful bank anglers leave the river before we can interview them, thus biasing our estimate of harvest

per hour of bank angling effort. Boat angler catch per hour of effort is not biased by the one fish daily bag limit since we only interview boat anglers after they complete their trip. To arrive at unbiased estimates of white sturgeon harvest by bank anglers, we calculated reservoir specific ratios of boat angler harvest per unit effort (HPUE) vs. bank angler HPUE for years prior to one fish bag limits (1993-95 for Bonneville Reservoir, 1988-89 for The Dalles Reservoir, and 1989-90 for John Day Reservoir). The boat angler HPUE for 2006 was used to adjust the 2006 bank angling HPUE such that boat HPUE versus bank HPUE matched the pre-one fish daily limit ratio. Harvest estimates were derived for each angling method (bank/boat), reservoir subsection, and weekend/weekday type to account for differential catch and sampling rates. Harvest and angling effort estimates were derived for each week.

Treaty Indian Commercial and Subsistence Harvest

Numbers of white sturgeon harvested in Zone 6 treaty Indian commercial fisheries were estimated from poundage reported on fish receiving tickets for each gear type and catch area. Poundage of white sturgeon was converted to numbers of fish by dividing the total poundage by an average fish weight obtained during random biological sampling of treaty Indian commercial landings. This approach to derive numbers landed is considered more accurate than just taking numbers from the commercial landing tickets (sales are in pounds and therefore carefully recorded, whereas numbers on the tickets are often just estimated during large deliveries). Landings by reservoir were estimated from the catch area reported on fish receiving tickets. The legal size slot for treaty Indian commercial fisheries was 114-152 cm (45-60 in) total length (TL) in Bonneville Reservoir, and 122-152 cm (48-60 in) TL in The Dalles and John Day reservoirs. Yakama Nation technical staff conducted unstructured interviews of treaty Indian fishers to estimate subsistence harvest of white sturgeon in each reservoir.

RESULTS

Sport Fishery Survey

Bonneville Reservoir

We began our survey of the 2006 sport fishery on 2 January and continued sampling through 23 July. State fishery managers closed the fishery to retention of white sturgeon on 24 July based on our in-season projection that harvest would reach the guideline by that date.

Anglers fished an estimated 102,666 hours (18,309 trips) in Bonneville Reservoir during the retention season (Table B-1). Angling effort for white sturgeon comprised 54% (9,958 trips) of the total estimated effort. The estimated number of angler trips for other target species were as follows: 940 (5%) for anadromous salmonids, 1,148 (6%) for American shad *Alosa sapidissima*, 553 (3%) for walleye, 2,107 (12%) for smallmouth and largemouth bass, 3,291 (18%) for northern pikeminnow, 210 (1%) for other resident fish, and 102 (1%) for anglers participating in tournaments.

Angler trips for white sturgeon during the 2006 retention season increased 26% from the 2005 retention period effort. The 26,609 white sturgeon caught (kept and released; Table B-2) during the 2006 retention season are 47% more than the 2005 retention period catch. Sub-legal catch increased by 70% and oversize catch increased by 15% over corresponding 2005 catches. The fishery for white sturgeon encompassed the entire reservoir although most of the harvest occurred downstream of Hood River, Oregon (rkm 271). Monthly combined boat and bank harvest per angler trip (HPUE) peaked in June at 0.13 fish per trip. Season HPUE averaged 0.03 fish per trip for bank anglers and 0.11 fish per trip for boat anglers targeting white sturgeon (Table B-3). The 2,266 white sturgeon anglers interviewed accounted for 16% of the estimated bank effort (angler hours) and 15% of the estimated boat effort for white sturgeon (Tables B-1 and B-4).

Anglers released 18% of the legal size catch during the retention period, due in part to the daily bag limit regulation, which allowed retention of only one fish per day. The percentage of sub-legal (<107 cm TL; <42 in TL), legal (107-152 cm TL; 42-60 in TL; both kept and released), and oversize (>152 cm TL; >60 in TL) white sturgeon in the reported catch was 93%, 4%, and 3%, respectively (Table B-4). This distribution of catch by size is similar to the distribution in 2005, with a slight gain in the oversize category and a corresponding decrease in the sub-legal category. The length distribution of the sampled harvest ranged from 91-137 cm fork length (FL), with 75% of the harvest occurring in the bottom 15 cm of the legal size range (<112 cm FL; 107-121 cm TL; Table B-5). Boat anglers' HPUE of 96-137 cm FL (approximately equivalent to 42-60 in TL) fish increased from 2005, tying 2004 for the second lowest HPUE since the creel survey began in 1987. Bank anglers' HPUE continued a 4-year slide to slightly more than half the 2005 value and a new record low. Combined boat and bank HPUE set new record lows in each of the last 3 years (Table B-6). The estimated sport harvest (727) was 104% of the 700 white sturgeon guideline (Table B-7). Sport harvest averaged 97% of the guideline from 1997-2006.

Oversize catch in Bonneville Reservoir since 1995 has ranged from 0.1% to 5.7% of total catch. The 937 oversize fish caught in 2006 represent 3.5% of total catch in 2006, and the third highest catch on record since 1995 (Table B-8; Figure B-2).

The Dalles Reservoir

We began our survey of the 2006 sport fishery on 2 January and continued sampling through 7 April. State fishery managers closed the fishery to retention of white sturgeon on 8 April. Based on the 2005 stock assessment, the guidelines were reduced in 2006 from 400 recreational and 900 commercial to 100 recreational and 550 commercial.

Anglers fished an estimated 26,740 hours (4,426 trips) in The Dalles Reservoir during the retention season (Table B-1). Angling effort for white sturgeon comprised 55% (2,450 trips) of the total estimated trips. The estimated number of angler trips for other target species were as follows: 660 (15%) for anadromous salmonids, 0 (0%) for American shad, 1,248 (28%) for walleye, 29 (1%) for smallmouth and largemouth bass, 0 (0%) for northern pikeminnow, 39 (1%) for other resident fish, and 0 (0%) for anglers participating in tournaments.

Angler trips for white sturgeon during the 2006 retention period were down 66% from the 2005 retention period effort. The 1,587 white sturgeon caught (kept and released; Table B-2) during the 2006 retention season are 87% less than the 2005 retention period catch. The sport fishery effort for white sturgeon was focused primarily from the John Day Dam tailrace

downstream to Miller Island (rkm 327). Monthly combined boat and bank HPUE peaked in March at 0.07 fish per trip. Season HPUE averaged 0.01 for bank anglers and 0.08 for boat anglers targeting white sturgeon (Table B-3). The 764 white sturgeon anglers interviewed accounted for 19% of the estimated bank effort (angler hours) and 20% of the estimated boat effort for white sturgeon (Tables B-1 and B-4).

Anglers released 5% of the legal size catch during the retention period. The percentage of sub-legal (<122 cm TL; <48 in TL), legal (122-152 cm TL; 48-60 in TL), and oversize (>152 cm TL; >60 in TL) white sturgeon in the sampled catch was 91%, 6%, and 3%, respectively (Table B-4). This distribution of catch by size is similar to the distribution in 2005, with a slight gain in the legal size category and a decrease in the oversize and sub-legal categories. The length distribution of the sampled harvest ranged from 110-144 cm FL, with 71% of the harvest occurring in the bottom 15 cm range of the legal size slot (<126 cm FL; 122-137 cm TL; Table B-5). Boat anglers' HPUE of 110-137 cm FL (approximately equivalent to 48-60 in TL) fish increased 1% from 2005, but was the second lowest since 1997. Bank anglers' HPUE dropped for the second year in a row to the lowest level since 1987. Combined boat and bank HPUE was the lowest since 1995 (Table B-6). The estimated harvest (93) was 93% of the 100 white sturgeon guideline (Table B-7). Sport harvest averaged 104% of the guideline from 1997-2006.

Oversize catch in The Dalles Reservoir since 1995 has ranged from 0.5% to 4.5% of total catch. The 40 oversize fish caught in 2006 represent 2.5% of total catch, and a 93% drop from the 2005 oversize catch (Table B-8, Figure B-2).

John Day Reservoir

We began our survey of the 2006 sport fishery in John Day Reservoir on 2 January and continued sampling through 30 June. The fishery was closed to retention of white sturgeon on 1 July 2006.

Anglers fished an estimated 88,002 hours (16,263 trips) in John Day Reservoir during the retention season (Table B-1). Angling effort for white sturgeon comprised 29% (4,753 trips) of the total estimated trips. The estimated number of angler trips for other target species were as follows: 2,162 (13%) for anadromous salmonids, 1,313 (8%) for American shad, 4,760 (29%) for walleye, 2,589 (16%) for smallmouth and largemouth bass, 46 (<1%) for northern pikeminnow, 286 (2%) for other resident fish, and 354 (2%) for tournament anglers.

Angler trips for white sturgeon during the 2006 retention season were down 48% from the 2005 retention period effort. The 4,729 white sturgeon caught (kept and released; Table B-2) during the 2006 retention season was 25% less than the 2005 retention period catch. Anglers concentrated their effort for white sturgeon from McNary Dam downstream past Irrigon, Oregon to rkm 449. Monthly combined boat and bank HPUE peaked in June at 0.04 fish per trip. Season HPUE averaged 0.02 for bank anglers and 0.03 for boat anglers targeting white sturgeon (Table B-3). The 1,209 white sturgeon anglers interviewed accounted for 16% of the estimated bank effort (angler hours) and 22% of the estimated boat effort for white sturgeon (Tables B-1 and B-4).

Anglers released 15% of the legal size catch during the retention period (Table B-4). The percentage of sub-legal (<122 cm TL; <48 in TL), legal (122-152 cm TL, 48-60 in TL), and oversize (>152 cm TL, >60 in TL) white sturgeon in the reported catch was 94%, 3%, and 3%,

respectively (Table B-4). This length distribution is similar to the distribution in 2005, with a slight gain in the oversize category and a decrease in the sub-legal category. The length distribution of the sampled harvest ranged from 109-135 cm fork length, with 88% of the harvest occurring in the bottom 15 cm range of the legal size slot (<126 cm FL; 122-137 cm TL; Table B-5). Boat anglers' HPUE of 110-137 110-138 cm FL (approximately equivalent to 48-60 in TL) fish doubled from 2005. Bank anglers' HPUE was more than ten times the 2005 value, and the third highest on record. Combined boat and bank HPUE was also the third highest on record (Table B-6). The estimated harvest (142) was 86% of the 165 white sturgeon guideline (Table B-7). Sport harvest averaged 92% of the guideline from 1997-2006.

Oversize catch in John Day Reservoir since 1995 has ranged from 1.3% to 12.8% of total catch. The 99 oversize fish caught in 2006 represent 2.1% of total catch, and a 74% drop from the 2005 oversize catch (Table B-8; Figure B-2).

Treaty Indian Commercial and Subsistence Harvest

The 2006 treaty Indian commercial harvest estimates for Zone 6 were 153 white sturgeon from Bonneville Reservoir, 397 white sturgeon from The Dalles Reservoir, and 312 white sturgeon from John Day Reservoir (Table B-7). The entire commercial harvest for 2006 in John Day Reservoir was landed during the winter gill net fishery (1 February – 21 March). The harvest in John Day Reservoir was slightly below its 335-fish guideline (93%). In addition to the winter gill net fishery, a summer setline fishery (31 July – 15 August) for Bonneville and The Dalles reservoirs also occurred in 2006. Total harvest estimates for Bonneville and The Dalles reservoirs were 38% and 72% of guideline, respectively. The treaty Indian Zone 6 subsistence white sturgeon harvest estimated by CRITFC and YN was 201 fish (Table B-7): 28 from Bonneville Reservoir; 115 from The Dalles Reservoir; and, 58 from John Day Reservoir. Twenty-seven percent (55 fish) of the subsistence harvest occurred during the winter gillnet fishery, with 34% (68) and 39% (78)n the summer and fall setline fisheries, respectively (Roger Dick, Jr., CRITFC, personal communication). The fall fishery was for subsistence only.

DISCUSSION

Zone 6 White Sturgeon Harvest Management

Bonneville Reservoir

Since the 1,520 fish recreational guideline began in 1997, HPUE for both boat and bank anglers has declined, while their relative effort has fluctuated. From 1988-2002 bank effort generally exceeded boat effort. Beginning in 2003 the majority of effort shifted to boat angling. Combined sport and commercial harvest as compared to the guideline trended downward from 1997 through 2003, stabilized for two years when the guidelines were lowered in 2004, then dropped again in 2006. Also, in spite of a one month longer season, the combined boat and bank white sturgeon sport effort increased by only 5%, and boat HPUE dropped by 12% from 2004.

In the sport fishery, the portion of fish harvested within the smallest 15 cm of the legal size slot (107 - 122 cm TL) dropped from 92% in the 2005 season (Langness et al., in press) to 75% during the 2006 season. The combination of that drop, the low commercial harvest, the downward trend in both boat and bank HPUE, and the longer season, with the increases in sub-legal and oversize recreational catch may indicate that removal from the legal size class currently exceeds recruitment from the sub-legal size class. The jump in oversize catch may reflect a shift in effort from upriver areas, partly due to the spawning sanctuary closures from May through July in The Dalles and John Day reservoirs.

The Dalles Reservoir

Abundance estimates from the 1997 stock assessment in The Dalles Reservoir (North et al., 1999), supported an increase of the recreational harvest guideline from 200 to 700 fish in 1998. Season lengths between 1998 and 2002 showed a slight increasing trend. Effort fluctuated from 1998 through 2002; however, the HPUE trended down for combined boat and bank angler fisheries. The legal sized population estimate in the reservoir declined from 8,300 fish in 1997 (North et al., 1999) to 5,900 fish in 2002 (Kern et al., 2003). Subsequently there was a 43% guideline decrease in 2003. From 2003 through 2005, combined boat and bank angler effort increased slightly, while HPUE continued to trend downward. Those trends, combined with drop in abundance estimates and a shift toward the lower end of the frequency distribution, indicated a need to reduce the guidelines in 2006, resulting in a shorter season and lower total catch. In 2006, 71% of the proportion of sport harvested white sturgeon in the smallest 15 cm of the legal size range (122-137 cm TL) dropped from 75% in 2005 to 71% in 2006. Tribal fisheries failed to reach their white sturgeon guideline in 2003 and 2005, and despite a guideline reduction, they failed again in 2006. As in Bonneville Reservoir, the trends may indicate that removal from the legal size class exceeds recruitment from the sub-legal size class. The 93% drop in oversize catch from the 2005 level was due, at least in part, to the implementation of the May-July spawning sanctuary in 2006.

John Day Reservoir

Recreational effort initially rose following the adoption of the 560 fish guideline in 1997, with the highest HPUE and the second highest harvest since 1989. Harvest peaked in 1998, and effort peaked in 1999. Effort, harvest, and HPUE declined substantially after their peak, and the recreational guideline was reduced to 165 in 2002. Since then the season length has steadily decreased as HPUE has trended upward. The proportion of effort attributed to boat and bank anglers has remained relatively stable since 1989 (generally favoring boat anglers). Size composition of the recreational harvest in 2006 (88% of the 2006 harvested fish were in the smallest 15 cm of the legal size range (122-137 cm TL) was in the middle of the range for the prior four years, perhaps indicating some stabilizing of the population.

The 2001 (Kern et al., 2003) and 2004 (Hughes et al., 2006) stock assessments estimated an increase in the sub-legal population size from 25,500 in 1996 (North et al., 1998) to 27,667 in 2001 and 41,762 in 2004, and a sharp decline in the legal sized population from 4,040 in 1996 to 1,077 in 2001 and 1,094 in 2004. The 2007 stock assessment should show whether recruitment to the legal size slot is increasing.

The recreational and commercial harvest guidelines were not met in most years from 1997-2001. This inability to meet harvest guidelines, combined with a lower legal sized

population abundance estimate and indications of poor recruitment into the fishery, resulted in lowering both the recreational and commercial guidelines in 2002 to 165 fish and 335 fish, respectively. The recreational season ended by late August in 2002, by late July in 2003, by mid July in 2004 and 2005, and by the end of June in 2006. The commercial harvest guideline was exceeded in 2005, and except for 2003 was nearly reached each year since 2001.

The oversize target fishery in John Day Reservoir has increased tremendously since 1995 (Figure B-2). Catch has ranged from a low of 16 in 1996 to a high of 1,037 in 2004 (Table B-8). The oversize percentage of total catch has averaged 3.4 times higher for John Day than for the other two reservoirs, and has ranged as high as 12.8%. Beginning in 2006, a May-July spawning sanctuary was implemented for 1.5 miles downstream of McNary Dam. While it is too early to be certain of its effect, the oversize handle in 2006 dropped to the second lowest since 1995.

PLANS FOR NEXT YEAR

WDFW will monitor Zone 6 sport and treaty Indian commercial fisheries in 2006. We will work with ODFW and CRITFC during the summer of 2007 to assess the status of the white sturgeon population in the John Day Reservoir. We will obtain breeding adult white sturgeon, from which we can collect paired gonad-tissue and blood samples, to help MSU determine sex and stage of maturity. During the fall of 2007, we will work with ODFW and CRITFC in white sturgeon recruitment indexing in McNary, John Day, The Dalles, and Bonneville reservoirs on the Columbia River. These activities will be reported in next year's annual progress report.

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APPENDIX

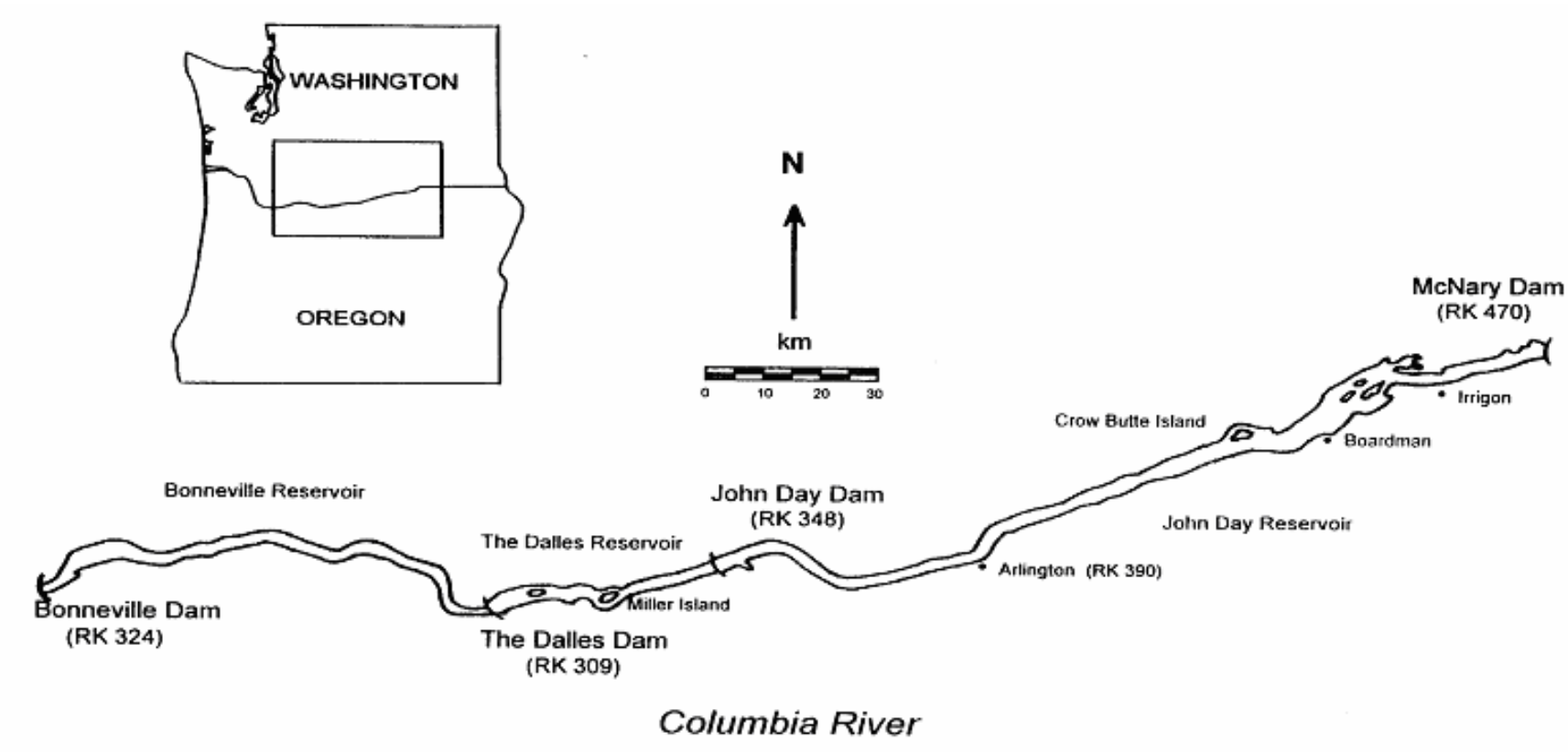

Figure B-1. Location of the recreational fishery survey on the Columbia River. Bonneville and The Dalles Reservoirs, and from Crow Butte upstream to McNary Dam on John Day Reservoir.

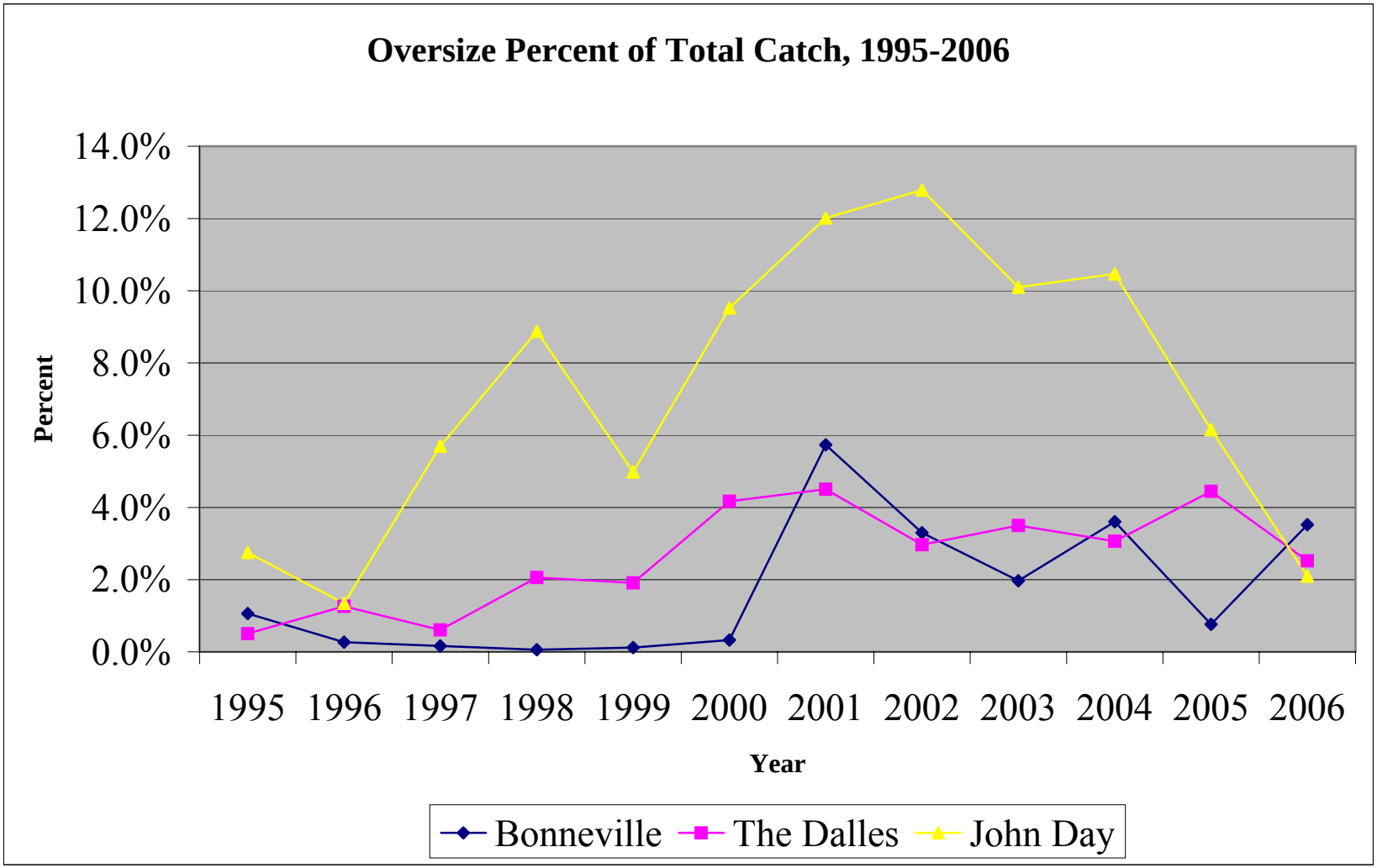

Figure B-2. Percent of total catch represented by oversize sturgeon in Zone 6 reservoirs, 1995-2005.

Table B-1. Combined Washington and Oregon recreational fishery angling effort estimates for Bonneville Reservoir, 1 January through 23 July 2006; The Dalles Reservoir, 1 January through 7 April 2006; and John Day Reservoir, 1 January through 30 June 2006.

Species	Bonneville		The Dalles		John Day	
Method	Hours	Trips	Hours	Trips	Hours	Trips
White Sturgeon						
Bank	23,063	4,396	9,844	1,411	10,749	2,094
Boat	31,829	5,562	5,672	1,039	14,006	2,659
Total	54,892	9,958	15,516	2,450	24,755	4,753
Salmonids[a]						
Bank	7,039	765	1,160	148	4,769	1,073
Boat	666	175	2,601	512	5,558	1,089
Total	7,705	940	3,761	660	10,327	2,162
American Shad						
Bank	4,314	1,074	0	0	101	36
Boat	191	74	0	0	5,433	1,277
Total	4,505	1,148	0	0	5,534	1,313
Walleye						
Bank	43	10	193	77	12	4
Boat	2,472	543	6,903	1,171	26,386	4,756
Total	2,515	553	7,096	1,248	26,398	4,760
Basses[b]						
Bank	684	265	165	29	1,211	368
Boat	8,267	1,842	0	0	13,024	2,221
Total	8,951	2,107	165	29	14,235	2,589
Northern Pikeminnow						
Bank	10,307	1,460	0	0	62	27
Boat	11,991	1,831	0	0	133	19
Total	22,298	3,291	0	0	195	46
Other						
Bank	598	165	101	23	468	155
Boat	330	45	101	16	549	131
Total	928	210	202	39	1,017	286
Tournament						
Bank	0	0	0	0	0	0
Boat	872	102	0	0	5,541	354
Total	872	102	0	0	5,541	354
Combined Total						
Bank	46,048	8,135	11,463	1,688	17,372	3,757
Boat	56,618	10,174	15,277	2,738	70,630	12,506
Total	102,666	18,309	26,740	4,426	88,002	16,263

[a] *Includes Chinook, coho, and steelhead*
[b] *Includes largemouth and smallmouth bass.*

Table B-2. Combined Washington and Oregon recreational fishery harvest, and catch and release estimates for Bonneville Reservoir, 1 January through 23 July 2006; The Dalles Reservoir, 1 January through 7 April 2006; and John Day Reservoir, 1 January through 30 June 2006.

Species	Bonneville	The Dalles	John Day
White sturgeon [a]			
Legals kept	727	93	142
Sub-legals released	24,783	1,449	4,465
Legals released	162	5	23
Oversize released	937	40	99
Total released	25,882	1,494	4,587
Chinook salmon [b]			
Adults kept	48	0	290
Jacks kept	16	0	32
Total kept	64	0	322
Released	19	0	46
Coho salmon [c]			
Adults kept	0	0	0
Jacks kept	20	0	0
Total kept	20	0	0
Steelhead [d]			
Kept	26	199	138
Released	9	51	76
American shad			
Kept	5,684	0	2,719
Released	6,221	0	6,239
Walleye			
Kept	335	821	2,262
Released	76	138	765
Basses [e]			
Kept	587	6	1,479
Released	6,895	30	9,853
Northern pikeminnow kept	7,832	11	162
Other resident fish kept	69	19	879

[a] *White sturgeon seasons were closed to retention 24 July – 31 December in Bonneville Reservoir, 8 April to 31 December in The Dalles Reservoir, and 1 July – 31 December in John Day Reservoir.*
[b] *Chinook seasons were closed to retention 1 January – 15 March, 1 May – 12 May, and16 September – 29 September in all three reservoirs.*
[c] *Coho seasons were closed to retention 1 January - 31 July.*
[d] *Steelhead seasons were closed to retention 1 April – 15 June.*
[e] *Includes largemouth and smallmouth bass.*

Table B-3. Estimates of recreational fishery angler trips for white sturgeon, white sturgeon harvest, and harvest per angler trip (HPUE) for Bonneville Reservoir, 1 January through 23 July 2006; The Dalles Reservoir, 1 January through 7 April 2006; and John Day Reservoir, 1 January through 30 June 2006.

Month	Bonneville			The Dalles			John Day		
Method	Trips	HPUE	Harvest	Trips	HPUE	Harvest	Trips	HPUE	Harvest
January									
Bank	637	0.00	0	539	0.01	8	0	0.00	2 [a]
Boat	616	0.07	45	408	0.06	23	0	0.00	0 [a]
Total	1,253	0.04	45	947	0.03	31	0	0.00	2 [a]
February									
Bank	472	0.02	11	277	0.00	0	192	0.01	2
Boat	521	0.06	29	186	0.02	3	66	0.06	4
Total	993	0.04	40	436	0.01	3	258	0.02	6
March									
Bank	679	0.04	26	490	0.01	5	425	0.02	8
Boat	640	0.05	30	411	0.13	54	882	0.02	22
Total	1,319	0.04	56	901	0.07	59	1,307	0.02	30
April									
Bank	852	0.02	17	105	0.00 [b]	0	491	0.02	11
Boat	691	0.04	27	34	0.00 [b]	0	492	0.02	12
Total	1,543	0.03	44	139	0.00 [b]	0	983	0.02	23
May									
Bank	590	0.03	19	0	0.00	0	388	0.03	12
Boat	570	0.04	21	0	0.00	0	354	0.03	9
Total	1,160	0.03	40	0	0.00	0	742	0.03	21
June									
Bank	509	0.05	23	0	0.00	0	598	0.02 [b]	14
Boat	1,717	0.16	277	0	0.00	0	865	0.05 [b]	46
Total	2,226	0.13	300	0	0.00	0	1,463	0.04 [b]	60
July									
Bank	657	0.04 [b]	24	0	0.00	0	0	0.00	0
Boat	807	0.22 [b]	0	0	0.00	0	0	0.00	0
Total	1464	0.14[b]	0	0	0.00	0	0	0.00	0
Combined									
Bank	4,396	0.03	120	1,411	0.01 [b]	13	2,094	0.02 [b]	49
Boat	5,562	0.11	607	1,039	0.08 [b]	80	2,659	0.03 [b]	93
Total	9,958	0.07	727	2,450	0.04 [b]	93	4,753	0.03 [b]	142

[a] *No creel sampling was conducted in January. Estimates are based on historical averages.*

[b] *Harvest per angler trip calculated for the period when retention was allowed.*

Table B-4. Numbers of white sturgeon anglers interviewed and numbers of white sturgeon kept and released reported during sampling of recreational fisheries in Bonneville Reservoir, 1 January through 23 July 2006; The Dalles Reservoir, 1 January through 7 April 2006; and John Day Reservoir, 1 January through 30 June 2006.

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal Released	Legal kept	Oversize released
Bonneville						
Bank						
January	158	378	62	0	0	0
February	205	418	44	0	2	0
March	290	771	134	1	6	1
April	350	847	180	0	3	1
May	162	505	195	0	3	0
June	133	423	421	2	9	3
July	106	360	179	1	2	1
Bank Total	1,404	3,702	1,215	4	25	6
Boat						
January	97	538	705	1	14	1
February	96	467	175	2	5	1
March	97	474	235	0	4	1
April	96	511	163	1	3	0
May	67	415	152	5	3	19
June	246	1,386	777	5	36	80
July	163	1,062	540	8	32	39
Boat Total	862	4,853	2,747	22	97	141
Combined Total	2,266	8,555	3,962	26	122	147
The Dalles						
Bank						
January	205	779	43	0	3	3
February	96	267	3	0	0	1
March	208	699	22	0	1	1
April	30	115	4	0	0	0
Bank Total	539	1,860	72	0	4	5
Boat						
January	82	374	86	1	4	0
February	47	247	21	0	1	2
March	90	480	122	0	11	2
April	6	45	3	0	0	0
Boat Total	225	1,146	232	1	16	4
Combined Total	764	3,006	304	1	20	9

continued

Table B-4 continued.

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal Released	Legal kept	Oversize released
John Day						
Bank						
January	0	0	0	0	0	0
February	31	50	8	0	0	1
March	199	496	25	0	1	1
April	230	698	50	2	2	2
May	63	176	11	0	1	0
June	82	253	29	0	1	0
Bank Total	605	1,673	123	2	5	4
Boat						
January	0	0	0	0	0	0
February	20	121	24	0	0	1
March	150	731	201	2	5	4
April	234	1,235	160	0	4	10
May	56	269	68	0	2	1
June	144	771	155	0	6	1
Boat Total	604	3,127	608	2	17	17
Combined Total	1,209	4,800	731	4	22	21

Table B-5. Length frequencies of harvested white sturgeon measured during sampling of recreational fisheries in Bonneville Reservoir, 1 January through 23 July 2006; The Dalles Reservoir, 1 January through 7 April 2006; and John Day Reservoir, 1 January through 30 June 30 2006. Shaded areas indicate average fork length equivalents to the bottom 15 cm (total length) of the legal size slot.

Fork Length (cm)	Bonneville	The Dalles	John Day	Fork Length (cm)	Bonneville	The Dalles	John Day
90				130	2		
91	1[a]			131			
92				132		2	1
93				133			
94				134	1		
95	5[a]			135			1
96	10[a]			136			
97	3			137	1		
98	10			138			
99	7			139			
100	3			140			
101	4			141			
102	5			142			
103	4			143			
104	5			144		1	
105	4			145			
106	6			146			
107	3			147			
108	3			148			
109	1		2[a]	149			
110	3	3[a]	3[a]	150			
111	3	1	2	151			
112	2		2	152			
113				153			
114		2	3	154			
115	2		2	155			
116	2			156			
117	2	2	1	157			
118	2	1	1	158			
119				159			
120		1	3	160			
121		2		161			
122	1		1	162			
123	5			163			
124				164			
125	2		1	165			
126	1		1	166			
127	1	1		167			
128		1					
129	2			**Total**	**106**	**17**	**24**

[a] *These were legal fish based on their total lengths. They are included with the bottom 15 cm of the legal size slot.*

Table B-6. Estimated angling effort, harvest, and harvest per angler trip (HPUE) of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1987 through 2006

Reservoir		Bank anglers			Boat anglers			Combined
Year	Period	Trips	Harvest	HPUE	Trips	Harvest	HPUE	HPUE
Bonneville (95-138 cm fork length interval) [a]								
1987	-- [b]							
1988	Mar-Oct	5,653	532	0.094	4,776	688	0.144	0.117
1989	Mar-Oct	8,028	1,316	0.164	5,792	1,099	0.190	0.125
1990	Mar-Oct	7,213	719	0.100	7,349	1,055	0.144	0.122
1991	-- [b]							
1992	-- [b]							
1993	Mar-Oct	7,599	678	0.089	6,747	736	0.109	0.099
1994	Mar-Oct	7,821	1,024	0.131	5,329	1,089	0.204	0.161
1995	Feb-Apr	2,541	456	0.180	1,750	857	0.490	0.306
1996	Jan-Mar	3,341	823	0.246	1,735	463	0.267	0.253
1997	Jan- 4 Apr	5,093	808	0.159	2,535	632	0.249	0.189
1998	Jan- 19 Apr	4,913	358	0.073	4,990	1,214	0.243	0.159
1999	Jan- 16 Apr	4,724	374	0.079	3,884	789	0.203	0.135
2000	Jan- 7 Apr	3,724	425	0.114	3,187	779	0.245	0.174
2001	Jan- 12 Aug	6,867	459	0.067	5,328	852	0.160	0.107
2002	Jan- 4 Aug; 28 Sep - Dec	7,838	644	0.082	6,423	867	0.135	0.106
2003	Jan- 6 July	4,092	247	0.060	5,733	1,186	0.207	0.146
2004	Jan- 25 June	4,195	212	0.051	5,327	574	0.108	0.083
2005	Jan- 10 June	3,820	196	0.051	4,102	386	0.094	0.073
2006	Jan- 23 July	4,396	119	0.027	5,562	601	0.108	0.072
The Dalles (110-138 cm fork length interval) [a]								
1987	Jun-Oct	5,019	465	0.093	3,618	339	0.094	0.093
1988	Mar-Oct	5,043	257	0.051	2,566	170	0.066	0.056
1989	Mar-Oct	3,659	119	0.033	1,760	99	0.056	0.040
1990	-- [b]							
1991	-- [b]							
1992	-- [b]							
1993	Mar-Oct	2,058	46	0.023	1,902	61	0.032	0.027
1994	Mar-Oct	3,124	75	0.024	1,863	68	0.037	0.029
1995	Mar-May	957	28	0.029	510	18	0.035	0.031
1996	Mar-Apr	655	21	0.031	251	29	0.115	0.055
1997	Jan- 4 May	2,278	119	0.052	538	16	0.030	0.048
1998	Jan- 7 June	4,102	455	0.111	1,319	296	0.225	0.139
1999	Jan- 11 June	5,396	411	0.076	1,804	207	0.115	0.086
2000	Jan- 18 June	4,202	260	0.062	2,953	472	0.160	0.102
2001	Jan- 8 Apr	2,124	100	0.047	1,858	456	0.245	0.140
2002	Jan- 12 July	3,879	260	0.067	4,140	556	0.134	0.102
2003	Jan- 20 June	3,797	93	0.025	2,721	312	0.115	0.062
2004	Jan-27 June	3,259	169	0.052	3,074	284	0.092	0.072
2005	Jan- 24 June	3,531	66	0.019	3,715	263	0.071	0.045
2006	Jan-8 April	1,411	12	0.009	1,039	75	0.072	0.036

continued

Table B-6 continued

Reservoir		Bank anglers			Boat anglers			Combined
Year	Period	Trips	Harvest	HPUE	Trips	Harvest	HPUE	HPUE
John Day (110-138 cm fork length interval) [a]								
1987	-- [b]							
1988	-- [b]							
1989	May-Jul	3,572	22	0.006	3,401	34	0.010	0.008
1990	Mar-Dec	3,806	33	0.009	3,063	82	0.027	0.017
1991	Apr-Sep	1,977	36	0.018	2,463	73	0.030	0.024
1992	-- [b]							
1993	Mar-Oct	3,208	56	0.018	4,466	111	0.025	0.022
1994	Mar-Oct	3,221	42	0.013	6,860	164	0.024	0.020
1995	Mar-May	1,891	12	0.006	2,407	30	0.013	0.010
1996	Mar-Apr	1,524	17	0.011	1,396	27	0.020	0.015
1997	Feb-Aug	4,780	166	0.035	5,968	287	0.048	0.042
1998	Jan-Oct	5,531	161	0.029	8,540	371	0.043	0.038
1999	Jan-Dec	6,542	99	0.015	10,110	278	0.028	0.023
2000	Jan-Dec	5,204	44	0.008	9,230	280	0.030	0.022
2001	Jan-Dec	5,939	109	0.018	8,941	160	0.018	0.018
2002	Jan- 23 Aug	2,794	45	0.016	5,877	111	0.019	0.018
2003	Jan-27 July	3,212	35	0.011	5,465	128	0.023	0.019
2004	Jan-11 July	3,203	45	0.014	4,756	149	0.031	0.024
2005	Jan-10 July	4,113	8	0.002	5,025	81	0.016	0.010
2006	Jan-30 June	2,094	45	0.021	2,659	85	0.032	0.027

[a] *Harvest estimates exclude legally kept fish with fork lengths outside the given ranges for each reservoir. Legal size is based on total length.*
[b] *Minimal or no sampling.*

Table B-7. Sturgeon Management Task Force harvest guidelines and estimated harvest of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1992 through 2006.

Fishery	Bonneville		The Dalles		John Day		Unspecified	
Year	Guideline	Harvest	Guideline	Harvest	Guideline	Harvest	Harvest	Total
Recreational								
1992	1,350	1,717	100	139	100	147	0	2,003
1993	1,350	2,307	100	158	100	144	0	2,609
1994	1,350	2,223	100	154	100	234	0	2,611
1995	1,350	1,370	100	50	100	53	0	1,473
1996	1,350	1,353	100	80	100	62	0	1,495
1997	1,520	1,463	200	178	560	464	0	2,105
1998	1,520	1,626	600-800	857	560	593	0	3,076
1999	1,520	1,235	600-800	695	560	422	0	2,352
2000	1,520	1,262	600-800	809	560	434	0	2,505
2001	1,520	1,426	700	677	560	299	0	2,402
2002	1,520	1,560	700	878	165	187	0	2,625
2003	1,700	1,542	400	447	165	186	0	2,175
2004	700	852	400	530	165	229	0	1,611
2005	700	596	400	382	165	128	0	1,106
2006	700	727	100	93	165	142	0	962
Indian Commercial								
1992	1,250	1,446	300	431	100	23	0	1,600
1993	1,250	1,415	300	579	100	12	0	2,006
1994	1,250	1,176	300	309	100	117	0	1,602
1995	1,250	1,421	300	312	100	308	0	2,041
1996	1,250	1,005	300	230	100	360	0	1,595
1997	1,300	1,852	400	498	1,160	1,260	0	3,610
1998	1,300	1,462	1,000-1,200	1,108	1,160	1,100	0	3,670
1999	1,300	1,280	1,000-1,200	1,051	1,160	760	0	3,091
2000	1,300	1,165	1,000-1,200	1,342	1,160	788	0	3,295
2001	1,300	1,287	1,100	1,215	1,160	755	0	3,257
2002	1,300	472	1,100	1,152	335	326	0	1,950
2003	1,200	379	900	811	335	251	0	1,441
2004	400	464	900	975	335	309	0	1,748
2005	400	550	900	831	335	360	0	1,741
2006	400	153	550	397	335	312	0	862
Combined recreational and commercial fisheries								
1992	2,600	2,863	400	570	200	170	0	3,603
1993	2,600	3,722	400	737	200	156	0	4,615
1994	2,600	3,399	400	463	200	351	0	4,213
1995	2,600	2,791	400	362	200	361	0	3,514
1996	2,600	2,358	400	310	200	422	0	3,090
1997	2,820	3,315	600	676	1,720	1,724	0	5,715
1998	2,820	3,088	1,800	1,965	1,720	1,693	0	6,746
1999	2,820	2,515	1,800	1,746	1,720	1,182	0	5,443
2000	2,820	2,427	1,800	2,151	1,720	1,222	0	5,800
2001	2,820	2,713	1,800	1,892	1,720	1,054	0	5,659
2002	2,820	2,032	1,800	2,030	500	513	0	4,575
2003	2,900	1,921	1,300	1,258	500	437	0	3,616
2004	1,100	1,136	1,300	1,505	500	538	0	3,359
2005	1,100	1,146	1,300	1,213	500	488	0	2,869
2006	1,100	880	650	490	500	454	0	1,824

continued

Table B-7 continued

Fishery	Bonneville		The Dalles		John Day		Unspecified	
Year	Guideline	Harvest	Guideline	Harvest	Guideline	Harvest	Harvest	Total
Indian subsistence [a]								
1992		89		--[b]		--[b]	119	208
1993		146		31		30	56	263
1994		290		197		163	0	650
1995		566		260		320	0	1,146
1996		256		116		110	0	482
1997		130		40		63	0	233
1998		109		86		45	0	240
1999		90		116		28	0	234
2000		191		128		24	0	343
2001		174		276		26	0	476
2002		146		197		27	0	370
2003		93		202		30	0	325
2004		60		172		37	0	269
2005		66		196		49	0	311
2006		28		115		58	0	201

[a] *The SMTF did not establish harvest guidelines for the subsistence fishery, however, the expected annual subsistence harvest was 300 white sturgeon for1991 through 2003.*
[b] *Not available.*

Table B-8. Oversize white sturgeon catch and percent of total catch during retention periods in Zone 6 reservoirs, 1995 – 2006[a].

Year	Bonneville[b]			The Dalles[c]			John Day[d]		
	Oversize Catch	Total Catch	% of Total	Oversize Catch	Total Catch	% of Total	Oversize Catch	Total Catch	% of Total
1995	156	14,662	1.1%	11	2,162	0.5%	143	5,192	2.8%
1996	29	10,952	0.3%	30	2,380	1.3%	16	1,187	1.3%
1997	22	13,398	0.2%	15	2,468	0.6%	553	9,715	5.7%
1998	11	18,097	0.1%	157	7,630	2.1%	883	9,944	8.9%
1999	15	12,475	0.1%	170	8,910	1.9%	591	11,857	5.0%
2000	49	14,984	0.3%	404	9,694	4.2%	876	9,196	9.5%
2001	1,378	24,039	5.7%	244	5,417	4.5%	1,034	8,608	12.0%
2002	980	29,698	3.3%	303	10,218	3.0%	977	7,640	12.8%
2003	583	29,573	2.0%	355	10,140	3.5%	852	8,439	10.1%
2004	797	22,083	3.6%	369	12,059	3.1%	1,037	9,907	10.5%
2005	139	18,115	0.8%	556	12,510	4.4%	388	6,304	6.2%
2006[e]	937	26,609	3.5%	40	1587	2.5%	99	4,729	2.1%

[a] *An unknown amount of oversize handling occurs during non-retention periods.*

[b] *Retention closed (and creel survey completed) in April for 1995 - 2000, and in June for 2004 and 2005.*

[c] *Retention closed (and creel survey completed) in April for 2001, in May for 1996 and 1997, and in June for 1995 and 1998-2000 .*

[d] *Retention closed (and creel survey completed) in May for 1996, and in June for 1995..*

[e] *Beginning in 2006, May – July spawning sanctuaries were implemented in The Dalles and John Day Reservoirs*

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 2006 – MARCH 2007

Report C

Describe reproduction and early life history characteristics of white sturgeon populations in the Columbia River between Bonneville and Priest Rapids dams

and

Define habitat requirements for spawning and rearing white sturgeon and quantify the extent of habitat available in the Columbia River between Bonneville and Priest Rapids dams

This report includes: Progress updates on young-of-the-year recruitment in Bonneville Reservoir and indices of white sturgeon spawning habitat for 2006 for McNary, John Day, The Dalles, and Bonneville dam tailrace spawning areas.

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ABSTRACT

River discharge and water temperatures that occurred during April through July 2006 provided conditions suitable for spawning by white sturgeon *Acipenser transmontanus* downstream from Bonneville, The Dalles, John Day, and McNary dams. Annual indices of spawning habitat that allow comparisons of conditions within a spawning area among years revealed that spawning conditions in 2006 were among the best seen over the past 22 years. Bottom-trawl sampling in the Bonneville Reservoir verified successful recruitment of age-0 white sturgeon; the proportion of positive tows for 2006 (0.21) was slightly lower than the median (0.30) of the previous 17 annual values.

INTRODUCTION

This annual report describes progress of the U.S. Geological Survey, Western Fisheries Research Center, Columbia River Research Laboratory, on the Bonneville Power Administration funded Project 198605000 – White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam. The reporting period is 1 April 2006 through 31 March 2007.

The multi-agency project has four common objectives. Those objectives are to:

1) Develop and implement mitigation actions that do not involve changes to hydro system operation and configuration.

2) Mitigate for effects of hydro system operation and configuration by developing and recommending actions that involve changes to hydro system operation and configuration to optimize physical habitat conditions for white sturgeon *Acipenser transmontanus* production.

3) Monitor and evaluate actions to mitigate for lost white sturgeon production due to development, operation, and configuration of the hydro system.

4) Assess losses to white sturgeon production due to development, operation, and configuration of the hydro system.

During this reporting period the U.S. Geological Survey worked on two tasks related to the four objectives stated above. Those tasks and the objective addressed were to:

1) Determine the availability of habitat for spawning by white sturgeon based on river discharges and water temperatures that occurred in 2006 – Objective 1.

2) Use a bottom trawl to determine if recruitment of white sturgeon to young-of-the-year (age-0) occurred in Bonneville Reservoir – Objective 3.

METHODS

Availability of Spawning Habitat

Parsley and Beckman (1994) presented the results of hydraulic simulations of the physical habitat downstream of McNary, John Day, The Dalles, and Bonneville dams in response to river discharges. The methods, models, and results from that paper were used with river discharges and water temperatures that occurred during 2006 as inputs to create a daily index of white sturgeon spawning habitat availability for these four known spawning areas. Mean daily river discharges and water temperatures that occurred at the dams during April through July were obtained from the Data Access in Real Time (DART) web page (http://www.cqs.washington.edu/dart/).

Age-0 Indexing

We sampled for juvenile white sturgeon during September 2006 with a 6.2-m high-rise bottom trawl (Palmer et al., 1988) to determine if recruitment to age-0 occurred in Bonneville Reservoir. The previously designed sampling program calls for conducting a total of 66 tows at 11 sites in Bonneville Reservoir (6 replicates per site). Sample sites were designated with a code indicating statute river mile and relative position across the river channel. The last digit of the site designation represents position in the channel, with 1 through 4 designating ¼ channel width increments from left to right facing upstream. Digits preceding the last number represent river miles to the nearest 0.1-mile from the mouth of the Columbia or Snake rivers. For example, the designation of 34753 indicates that the site is near river mile 347.5 and in the third quadrant of the river from the left bank (looking upstream).

Trawling was conducted in an upstream direction and each tow was 10 minutes in duration. Trawl duration timing began when the net first contacted the riverbed. After 10 minutes, hydraulic winches were engaged to retrieve the trawl. Adjustments to the lengths of the trawl warps were typically made during each tow depending on local site conditions. These adjustments were made to ensure that the gear remained on the riverbed as bottom topography changed. We estimated the distance fished during each tow with a Garmin GPSMAP 2006/2010 Global Positioning System (GPS) receiver using the Differential Global Positioning Service and determined the area fished by multiplying the distance by 4.4 m, the estimated fishing width of our bottom trawl. We also used the GPS unit to navigate the trawling vessel among trawl sites and to maintain a speed-over-ground of approximately 3 km/h during each tow.

All fish captured were enumerated and released. Generally, lengths were obtained from all fish with the exception of American shad *Alosa sapidissima*. When catch of an individual species was high, a subsample of 50 individuals was measured. We measured the total length

(TL) on all fish and fork length (FL) on fish with forked caudal fins to the nearest 1 mm. Only white sturgeon were weighed. Age-0 white sturgeon were weighed to the nearest 1 g and larger juveniles were weighed to the nearest 5 or 10 g with a hanging scale.

Catch-per-unit-effort (CPUE) of white sturgeon was expressed as the number of fish caught per 2,500 m^2. The proportion of positive tows (E*p*) for age-0 white sturgeon was calculated as the ratio of tows where at least one age-0 was captured to the total number of tows conducted.

RESULTS AND DISCUSSION

Availability of Spawning Habitat Downstream from Bonneville, The Dalles, John Day, and McNary Dams

River discharges and water temperatures that occurred during April through July 2006 provided conditions suitable for spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams. The river hydrograph (Figure C-1) shows that daily discharge increased in April and remained relatively high with several peaks before declining in mid June. Water temperature, one factor which determines the time period when spawning will occur, rose to optimal levels (13.3^{o}C) for spawning by white sturgeon between 16-17 May in all areas (Figure C-2). The optimal spawning period was moderately long in the Bonneville, The Dalles, and John Day tailraces with temperatures exceeding optimum levels (15.2^{o}C) 20-21 days later in each tailrace. After reaching optimal levels at McNary Dam, water temperatures declined to less than optimal on 26 May. Temperatures then warmed to optimal levels on 31 May and remained optimal until 9 June.

Optimal spawning temperatures in the four areas coincided with the highest river discharges, resulting in indices of spawning habitat among the highest yet observed for The Dalles, John Day, and McNary Dam spawning areas. The monthly estimates of the index of spawning habitat for The Dalles, John Day, and McNary spawning areas in May were nearly double the average of past years (Figure C-3). The indices were slightly above average levels in June in all areas except the McNary Dam spawning area where it was well above the average.

Annual indices of spawning habitat that allow comparisons of conditions within a spawning area among years revealed that spawning conditions in 2006 were among the best seen over the past 22 years. The annual Weighted Usable Area (WUA) index of spawning habitat for each of the three impounded areas was substantially higher than the median values for prior years (50.4 ha vs. 31.1 ha for The Dalles Dam tailrace spawning area, 89.6 ha vs. 49.6 ha for the John Day Dam tailrace spawning area, and 124.9 ha vs. 59.5 ha for the McNary tailrace spawning area). The Bonneville Dam tailrace spawning area was only slightly higher than the median value (58.1 ha vs. 56.4 ha; Figure C-4). The 2006 index ranked 9th highest for the Bonneville Dam spawning area, 5th for The Dalles and John Day dam spawning areas, and 3rd highest for the McNary Dam spawning area over the past 22 years (Table C-1; Figure C-4).

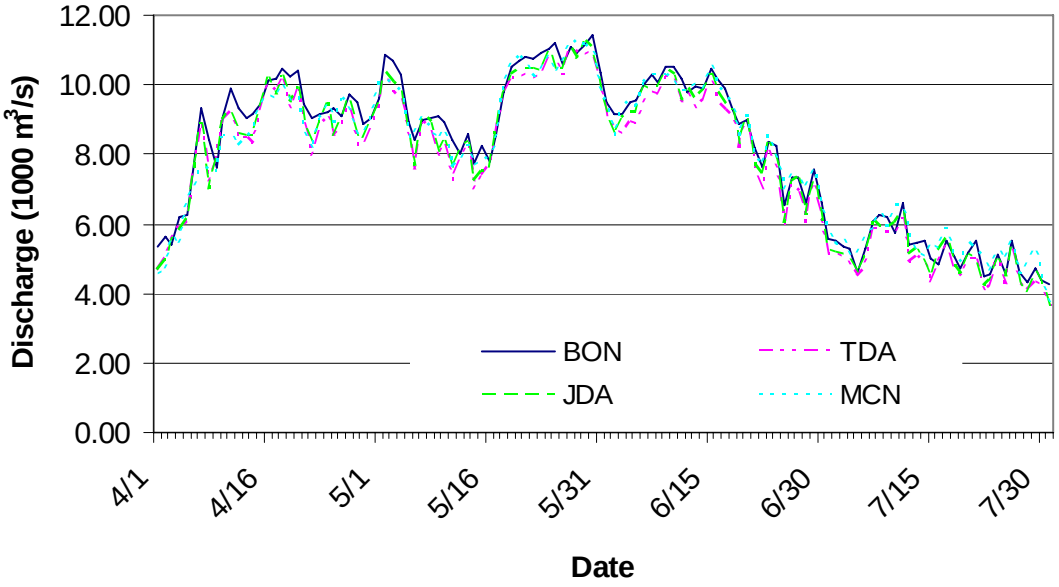

Figure C-1. River discharges at Bonneville (BON), The Dalles (TDA), John Day (JDA), and McNary (MCN) dams during 2006. Data were obtained from the DART website (http:\\www.cqs.washington.edu\dart\).

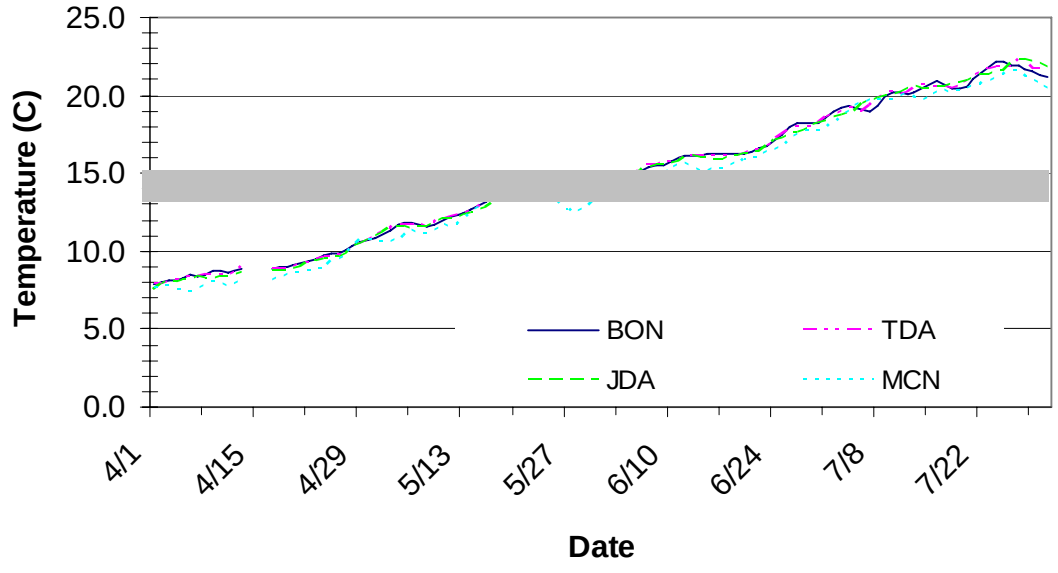

Figure C-2. Water temperatures at Bonneville (BON), The Dalles (TDA), John Day (JDA), and McNary (MCN) dams during 2006. Data were obtained from the DART website (http:\\www.cqs.washington.edu\dart\). Optimal temperatures for spawning by white sturgeon are 13.2 – 15.2° C and are indicated by the horizontal gray band.

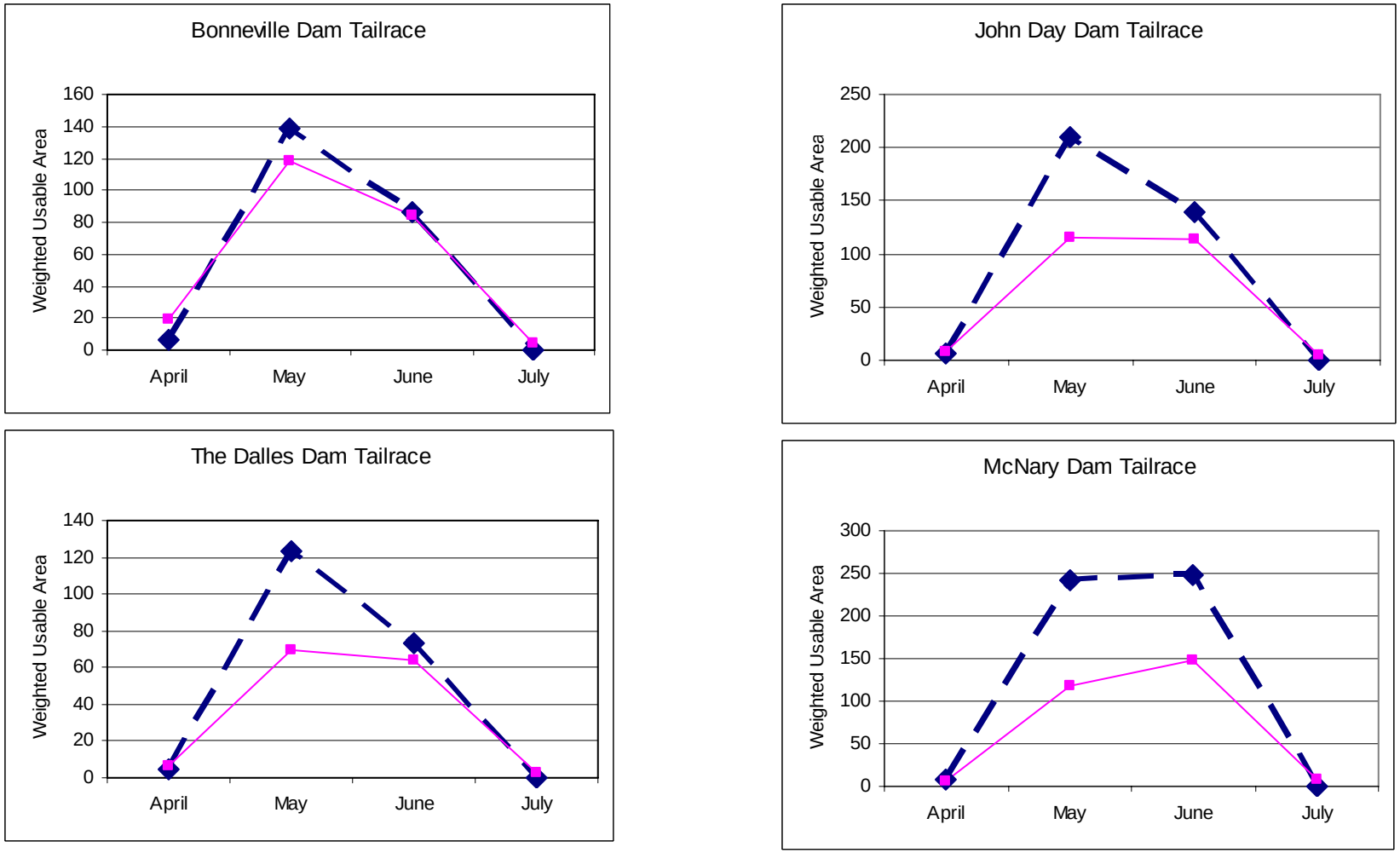

Figure C-3. Dashed lines depict mean monthly indices of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon during 2006. Solid lines depict the average mean monthly index for each month during 1985-2005. The scale differs on the Y-axis among graphs.

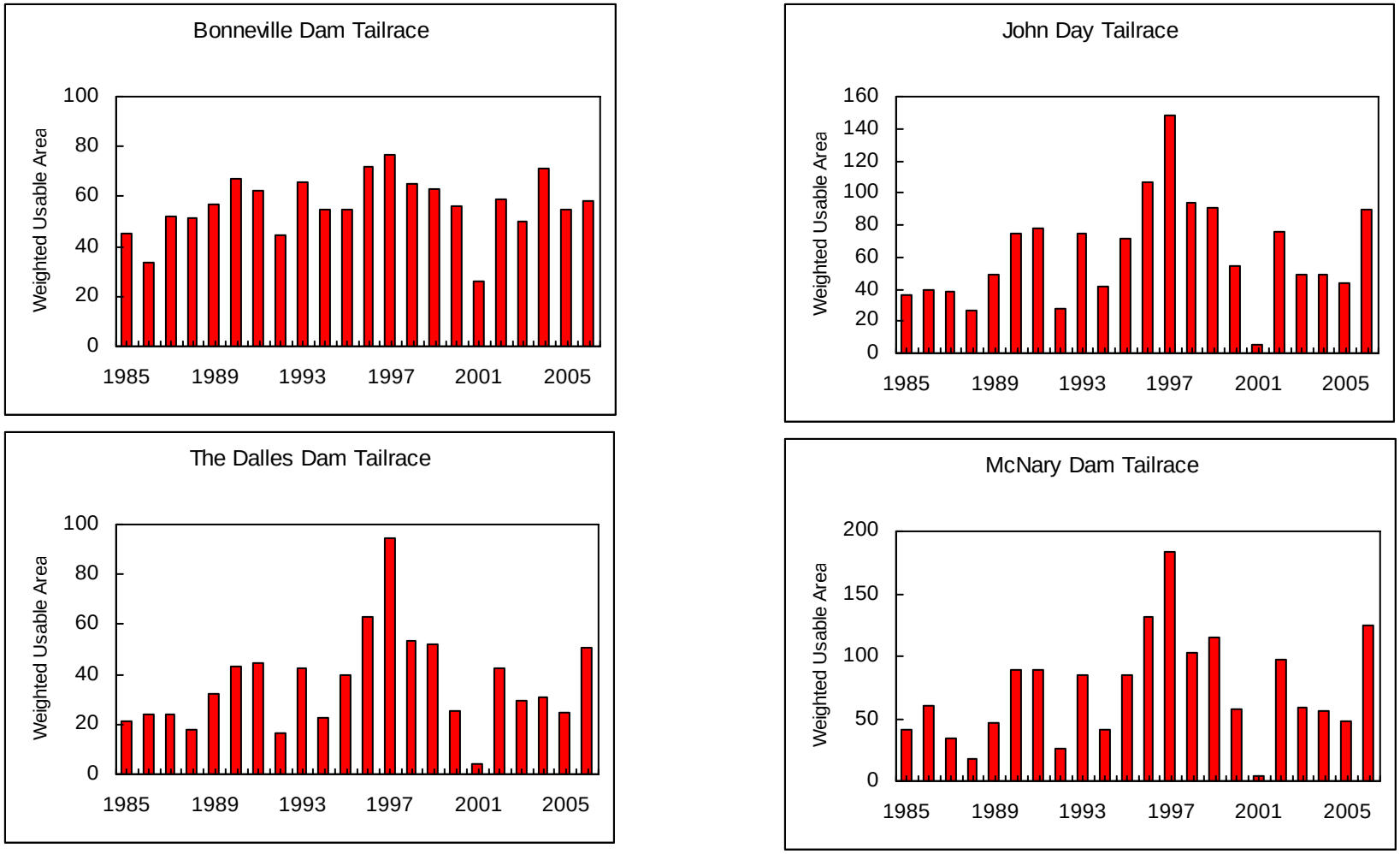

Figure C-4. Annual mean composite indices of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon for each of the four dam tailraces that have been modeled (Parsley and Beckman 1994). The scale differs on the Y-axis among graphs.

Age-0 Indexing in Bonneville Reservoir

The bottom-trawl sampling program was completed as scheduled during 2006. We fished the bottom trawl on 13 days from 11 September to 29 September in Bonneville Reservoir. We had one delay due to adverse weather conditions. As typically happens, several trawl tows were aborted when the gear became snagged on the riverbed or when debris such as trees, rocks, or other items encumbered the trawl during a tow. The sampling protocol calls for clearing the net and resampling the location. Thus, all sites were successfully trawled. No nets were lost while sampling this year, although several nets required extensive work to repair tears and holes.

Recruitment of age-0 white sturgeon occurred in Bonneville Reservoir in 2006 and catches were substantially higher than catches in 2005. We captured 53 juvenile white sturgeon with the trawl during our sampling and 25 (47%) of these were classified as age-0 based on length frequency (Figure C-5). Age-0 white sturgeon were captured at 6 of the 11 sites (Table C-1). They ranged in length from 114 to 249 mm TL and weighed 7 to 62 g. Older juvenile white sturgeon were captured at 9 sites of the 11 sites (Table C-2). They ranged in length from 367 to 1190 mm TL and weighed 200 to 3950 g.

For the 2006 sampling season, the proportion of positive tows for age-0 white sturgeon in Bonneville Reservoir was 0.21. Compared to past years (Table C-2), this indicates a moderate abundance of age-0 white sturgeon in the Bonneville Reservoir in 2006 and is the best index of relative abundance for highly skewed trawl data (Counihan et al., 1999). The CPUE for combined effort at each of the 11 sites sampled with the bottom trawl ranged from 0.0 to 0.72 age-0 white sturgeon per 2,500 m^2 and from 0.0 to 4.05 fish per 2,500m^2 for all white sturgeon caught (Table C-2). The mean CPUE for all sites was 0.41 age-0 white sturgeon per 2,500 m^2 (SE = 0.24) and 0.87 fish per 2,500m^2 (SE = 0.42) for all juvenile white sturgeon.

Trawl catches in Bonneville Reservoir were dominated by juvenile American shad which made up 48.9 % of the total catch, followed by sand rollers *Percopsis transmontana* at 30.7%, and prickly sculpin *Cottus asper* at 10.7% (Table C-3). White sturgeon were the fourth most abundant fish and comprised 5.8% of the catch.

PLANS FOR NEXT YEAR

The USGS will not work on this project in 2007.

ACKNOWLEDGMENTS

We thank Bjorn van der Leeuw, Corey Wright, and Brian Ekstrom for their assistance with the trawling. We appreciate the efforts of Tom Rien and Dave Ward for their work with the Bonneville Power Administration on contracting issues associated with this multi-agency effort. Jonathan McCloud was the technical representative for the Bonneville Power Administration. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the United States Department of Interior or the United States Geologic Survey of any product or service to the exclusion of others that may be suitable.

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APPENDIX

Table C-1. Annual indices of spawning habitat downstream from The Dalles Dam and age-0 white sturgeon relative abundance in Bonneville Reservoir. The spawning habitat index is temperature conditioned weighted usable area and the index of abundance is the proportion of positive tows (E*p*) during bottom trawling efforts. Bottom trawling was not conducted in 1992.

Year	Index of spawning habitat	E*p*
1989	32.25	0.04
1990	43.38	0.41
1991	44.20	0.82
1992	16.33	
1993	42.64	0.50
1994	22.81	0.19
1995	39.59	0.55
1996	63.25	0.89
1997	94.52	0.82
1998	53.61	0.68
1999	51.81	0.60
2000	25.38	0.12
2001	3.90	0.00
2002	42.15	0.17
2003	29.15	0.09
2004	31.09	0.12
2005	24.88	0.06
2006	50.43	0.21

Table C-2. Characteristics of bottom trawling conducted to index recruitment of white sturgeon in Bonneville Reservoir during 11 September to 29 September 2006. Age-0 white sturgeon were differentiated by length frequency analysis.

Site	Number of trawl tows	Total area sampled (ha)	Number of white sturgeon collected		White sturgeon catch/2500 m^2	
			All ages	Age-0	All ages	Age-0
15052	6	1.3753	1	1	0.182	0.182
15734	6	1.3664	1	0	0.183	0.000
15951	6	1.4188	23	15	4.053	2.643
16522	6	1.3742	1	1	0.182	0.182
16851	6	1.3497	1	0	0.185	0.000
17063	6	1.3927	4	4	0.718	0.718
17374	6	1.3888	2	0	0.360	0.000
17652	6	1.3707	0	0	0.000	0.000
17911	6	1.3732	2	1	0.182	0.364
18351	6	1.3940	18	3	3.228	0.538
18523	6	1.3899	0	0	0.000	0.000
Totals	66	15.1937	53	25		

Table C-3. Number and percent of fish caught in bottom trawls in Bonneville Reservoir during fall sampling in 2006.

Common name	Scientific name	Number of fish captured	Percent of catch
White sturgeon	*Acipenser transmontanus*	53	5.8
American shad	*Alosa sapidissima*	445	48.9
Northern pikeminnow	*Ptychocheilus oregonensis*	5	0.6
Peamouth	*Mylocheilus caurinus*	11	1.2
Redside shiner	*Richardsonius balteatus*	3	0.3
Bridgelip sucker	*Catostomus columbianus*	2	0.2
Largescale sucker	*Catostomus macrocheilus*	2	.02
Channel catfish	*Ictalurus punctatus*	4	0.4
Sand roller	*Percopsis transmontana*	280	30.7
Prickly sculpin	*Cottus asper*	97	10.7
Smallmouth bass	*Micropterus dolomieui*	6	0.7
Walleye	*Sander vitreus*	3	0.3

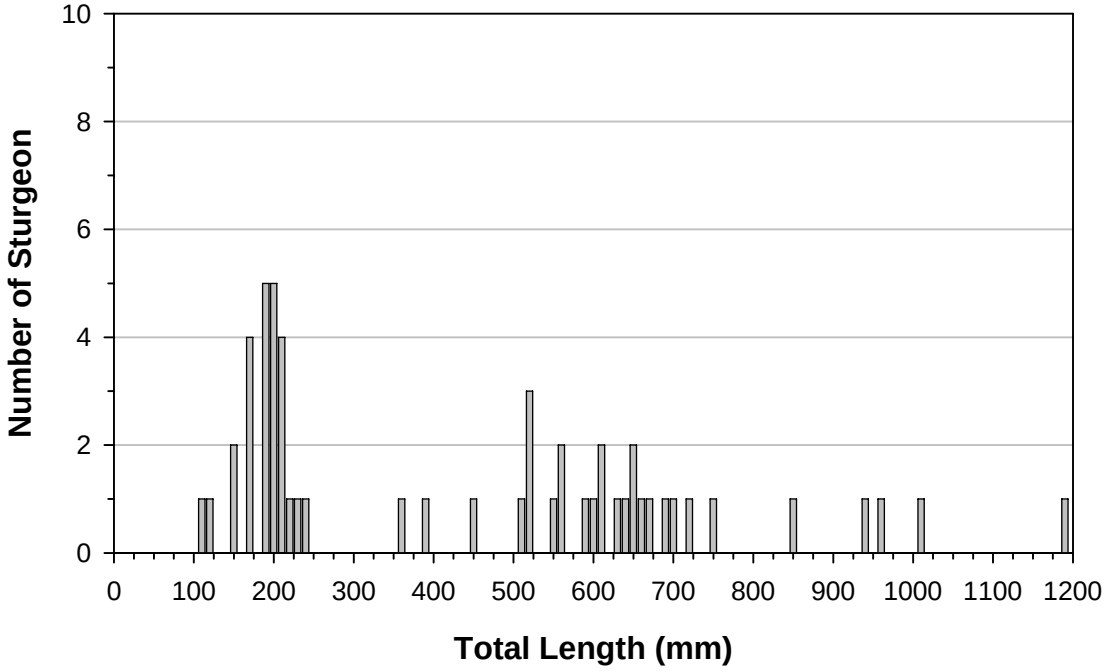

Figure C-5. Length frequency of white sturgeon captured during bottom trawling in Bonneville Reservoir from 11 September to 29 September 2006.

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 2006 – MARCH 2007

Report D

Evaluate the success of developing and implementing a management plan to enhance production of white sturgeon in reservoirs between Bonneville and McNary dams

This report includes: A summary of work for capture and mark efforts on white sturgeon in Bonneville Reservoir for population abundance estimates.

Prepared By:

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Columbia River Inter-Tribal Fish Commission

Portland, Oregon, USA

January 2008

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ABSTRACT

The Columbia River Inter-Tribal Fish Commission (CRITFC) conducted mark and tagging operations for the Bonneville Reservoir white sturgeon *Acipenser transmontanus* population survey from 5 December through 30 December 2005. During this effort, contract tribal fishers set a total of 433 overnight gillnet sets. The catch-per-unit effort was 8.90 sturgeon per set. A total of 3,853 white sturgeon were captured, including recaptures, and passive integrated transponder (PIT) tags were applied to 1,933 fish. A combined Yakama Nation (YN), Washington Department of Fish and Wildlife (WDFW), and Oregon Department of Fish and Wildlife (ODFW) crew conducted recapture sampling during the summer of 2006.

INTRODUCTION

In this report, we summarize work completed by Columbia River Inter-Tribal Fish Commission (CRITFC), under subcontract from Oregon Department of Fish and Wildlife (ODFW), from 1 April 2006 through 31 March 2007 performed to meet objectives of Bonneville Power Administration (BPA) tasks outlined under project 1986-050-00. Some elements were completed prior to the 1 April 2006 date, but are linked to the primary tasks for the 1 April 2006 through 31 March 2007 reporting period. The primary objectives for CRITFC under this project were to perform management activities that assisted ODFW and Washington Department of Fish and Wildlife (WDFW) with their management specific tasks of assessing population structure of white sturgeon *Acipenser transmontanus* in Bonneville Reservoir and monitoring of the tribal commercial and non-tribal sport fisheries.

Our tasks for this period were to:

1) Capture and mark/tag approximately 3,000 white sturgeon in Bonneville Reservoir as part of a population survey.
2) Assist ODFW and WDFW in conducting the population survey in Bonneville Reservoir during the summer sampling periods.
3) Provide assistance to cooperating agencies in conducting young-of-year (age-0) white sturgeon surveys in selected Columbia River and Snake River reservoirs.
4) Sample Zone 6 tribal commercial and subsistence fishery, and work jointly with ODFW and WDFW to estimate harvest and exploitation and characterize the commercial fishery for white sturgeon between Bonneville and McNary dams (Zone 6).

In accompanying sections, ODFW (Report A) will present information from the population survey in Bonneville Reservoir (Task 2) and age-0 surveys (Task 3), and WDFW (Report B) will present the results of the harvest and exploitation rates (Task 4).

METHODS

To provide data for the assessment of white sturgeon population parameters in Bonneville Reservoir, CRITFC contracted tribal commercial fishers to capture, mark, and tag white sturgeon during the first marking session. Prior to the start of the field season, informational mailings were sent to regional, state and tribal law enforcement agencies. A brief press release was also distributed to area media, primarily newspapers, to inform the public of our impending field efforts. Operations in Bonneville Reservoir began on 5 December 2005 and were completed on 30 December 2005, for a total of four weekly fishing periods. Tribal fishers sampled Bonneville Reservoir from river kilometer (rkm) 243 to rkm 305, although the majority of effort was downstream of rkm 298. The river width narrows considerably upstream of rkm 298 and contains numerous underwater hazards (i.e. sunken barges, cables, automobiles, etc.). These hazards, combined with the close proximity of commercial river traffic, precludes this area from a standard sampling session using all fishers at once, although some minor effort was expended in this area. The reservoir was divided into four consecutive sections ranging in length from 14.4 to 16.1 rkm. Separating the reservoir into discrete reaches and sampling them individually increased the likelihood that effort was consistent throughout the reservoir (Figure D-1). Boat restricted zones and commercial fishing sanctuaries were not sampled during the marking effort. All fishers were assigned to the lowermost section at the beginning of the sampling period and each week they advanced upstream to the next section, sampling the majority of the reservoir during the four week sampling period. During the last few days of sample four period, fishers were allowed to fish at large within the reservoir, excluding boat restricted zones and commercial fishing sanctuaries. The fishing at large accounted for a few sets outside of the four standard sampling sites. Sampling began on Monday of each week and ran through Friday, except when limited by severe weather or mechanical problems. Nets were checked and reset each day.

Three Yakama Nation (YN) fishery technicians and three tribal commercial fishers and their crews performed all sampling operations. Each commercial fisher was required to provide three crewmembers to perform marking, measuring, and tagging of white sturgeon along with any other requested data collections. A CRITFC biologist and YN technicians reviewed the sampling and data collection procedures with the contractors at the start of the sampling season.

Sampling was conducted from tribal commercial fishing vessels with diver gill nets. Vessels consisted of two 8 m long bow pickers and one 5.5 m open hull boat. The length of nets fished ranged from approximately 70 to 120 m. The majority of nets had 20.3 to 24.1 cm stretched mesh, although each fisher generally fished one or two nets with slightly smaller mesh at 19.1 cm stretched mesh. A wide variety of materials were used for anchors and floats, although all nets were marked with compressed Styrofoam crab pot buoys placed on float lines at each end. Paired buoys were labeled with a unique alpha-numeric code and a contact phone number. In addition, fisher's nets were labeled with their tribal enrollment number for identification purposes.

Captured white sturgeon were generally processed as they were brought on board the boat; although occasionally some fish were placed in small water filled totes prior to processing.

All captured white sturgeon were examined for tags, tag scars, missing scutes, and pectoral fin scars. White sturgeon with missing scutes or tag scars were scanned with a passive integrated transponder (PIT) tag detector to examine for previously applied PIT tags. All white sturgeon were measured to the nearest cm fork length (FL) and the twelfth right lateral scute was removed to indicate the year of capture (i.e., 2005-2006). Weights were not recorded during this marking effort. Fish less than 70 cm were not PIT-tagged and were released after being examined for marks, measured and scute-marked for the year of capture. White sturgeon equal to or greater than 70 cm FL, that did not possess a PIT tag (125 or 134 MHz), were injected with a 134 MHz PIT tag, applied into the musculature beneath the bony plates in the dorsal region of the head, near the midline. The second left lateral scute was removed to identify a PIT-tagged fish (Rien et al., 1994). We used general-purpose implanters with standard 12 gauge needles to inject PIT tags. All PIT tag numbers were recorded with corresponding biological information for the tagged fish. Fish were released immediately after data collection. Data were collected on waterproof data sheets that were compiled at the end of each week by CRITFC staff. Copies were made and originals were transferred to ODFW staff for data proofing and entry. PIT tag codes were downloaded weekly from the detectors and e-mailed to ODFW staff for verification against those codes written on data sheets.

Fishers were paid a daily boat lease rate and a set fee for each captured and processed white sturgeon recorded on the data sheets. Since fishers were paid on a per catch basis, they were motivated to search out areas they believed would be productive within the section boundaries. Each boat was typically able to fish 10 – 15 nets per day, depending on catch rates and efficiency of processing. If catch rates increased, but processing efficiency and data quality waned, the numbers of nets deployed were reduced accordingly.

We collected Global Positioning System (GPS) data (i.e., latitude/longitude) in conjunction with regular set information that included the rkm, set and pull times, depth, and temperature. The addition of GPS data provides detail about sampling locations, and distributions of sampling effort and catch rates. We mapped GPS coordinates and sturgeon catch for individual sets using Geographic Information System (GIS). We symbolized set specific catches of white sturgeon with circles sized in proportion to the numbers of sturgeon caught in each set. Circles sized for the catches of 1, 10 and 100 sturgeon were used as benchmarks for this analysis. Plotted locations were superimposed on a to-scale river map based upon a USGS quadrangle topographical map of the region that borders Bonneville reservoir.

RESULTS

A total of 3,853 white sturgeon were captured in 433 gillnet sets. Our sampling efforts were generally distributed evenly throughout Bonneville Reservoir, with the exception of a few locations upstream of Section 4. Analysis of location-specific catch rates showed the largest catches occurred in lower and middle portions of Bonneville reservoir (Figure D-3). Of the 3,853 white sturgeon captured, we applied PIT tags to 1,933 fish. White sturgeon captured ranged from 22 cm to 242 cm FL (Figure D-2), with a mean fork length of 74.0 cm. The total white sturgeon catch without recaptures consisted of 3,797 sub-legal commercial/sport sized fish (98.5%; less than 48 inches total length [TL] or 122-cm TL); 39 commercial/sport legal size (1.1%; between 48 inches TL and 60 inches TL or 122 cm TL and 153 cm TL); and 15 over legal size (0.4%; greater than 60 inches TL or 153 cm TL). The mean white sturgeon catch per set for all sets combined was 8.90 white sturgeon per set. All white sturgeon captured and handled in Bonneville Reservoir were released back into the reservoir. We noted no direct mortalities of white sturgeon during our capture and mark efforts.

Numbers of incidentally caught fish were low (N= 16) when compared to the catch of white sturgeon, the target species. The total number of fish caught, the number released alive, and the number released moribund, respectively, are indicated in parentheses after each species name: coho salmon *Oncorhynchus kisutch* (8-2-6), Chinook salmon *O. tshawytscha* (3-1-2), steelhead trout *O. mykiss* (1-1-0), northern pikeminnow *Ptychocheilus oregonensis* (3-0-3), and walleye *Sander vitreus* (1-0-1).

We recorded 433 unique GPS locations for all sample sets, with most (~ 97%) coordinates for sets containing white sturgeon (N= 381), when plotted, were located within the reservoir boundaries; approximately 3% of positive sets were associated with coordinates on land.

DISCUSSION

Our catch in 2005-06 of 3,853 white sturgeon from a total of 433 overnight sets, represents a substantial increase in both the number and catch per unit when compared to the 2,996 sturgeon captured with 629 sets in 2002-03 (Kappenman and Parker 2005). Catch per unit effort, i.e., sturgeon per overnight set, in 2005-06 of 8.90 sturgeon per net was the highest recorded for Bonneville Reservoir since we started tagging sturgeon using gillnets as a capture gear at 8.90 sturgeon per net, nearly double the 4.77 fish per net in 2002-03, (Kappenman and Parker 2005). The increased catch in 2005-06 resulted largely from an increase in abundance of juvenile sturgeon (Figure D-2). As in previous tagging efforts, fishers were able to exploit white sturgeon concentrated in deep holes and slack water areas; preferred white sturgeon habitat during winter months. Catches of 50 or more fish in a single net is not unusual and in some cases 100 fish or more have been captured in a single set. Plotted positions of individual sets show the variation in location of sites and catches throughout the reservoir, although some

affinity for higher catches appears to be tied to outlets of major tributaries (Figure D-3). While unusual, it is not uncommon for GPS positions to be "off" from the sampled location.

The greater abundance of smaller juveniles was commensurate with a decrease of 14.0 cm from the mean length recorded in the previous survey (Kappenman and Parker, 2005). Although there was a substantial decline in the mean length of fish sampled compared to the previous survey (2003), the proportions of sub-legal, legal and oversize white sturgeon were essentially unchanged from the previous survey (Kappenman and Parker 2005).

The 2005-06 tagging operation performed by CRITFC, ODFW, and WDFW is the third cooperative effort (1999-2000, 2002-03, 2005-06) to update population abundance and structure in Bonneville Reservoir (Kappenman and Parker 2001, Kappenman and Parker 2005). This information, in conjunction with long-term datasets from other Columbia River reservoirs, will be used to assess population dynamics, determine harvest quotas and evaluate the effects of ongoing mitigative activities for white sturgeon between Bonneville and McNary dams. The data presented in this report will provide a link between past and future population assessments in our effort to manage these populations for productivity and stable fisheries.

PLANS FOR THE UPCOMING YEAR

Plans for next year include participating in a white sturgeon population survey of John Day Reservoir, age-0 sampling in selected Columbia River reservoirs. A more detailed analysis of our GPS data will be conducted when a minimum of three sample years per reservoir is obtained. The analysis will use the multiple years of GPS data and associated catch and set data for individual reservoirs during our winter tagging period. The intent is to publish this analysis in a peer-reviewed journal.

ACKNOWLEDGEMENTS

Our sincere appreciation and thanks to Yakama Nation fishery technicians Al McConville, Chuck Gardee, and James Kiona; contract fishermen Robert Brigham, Mathew McConville, James Bronson and their crew members for their diligent efforts, particularly regarding the weeks of inclement weather conditions that occurred during the marking effort. Additional thanks goes to ODFW staff for assistance with data entry and proofing which facilitated the reporting process.

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FIGURES

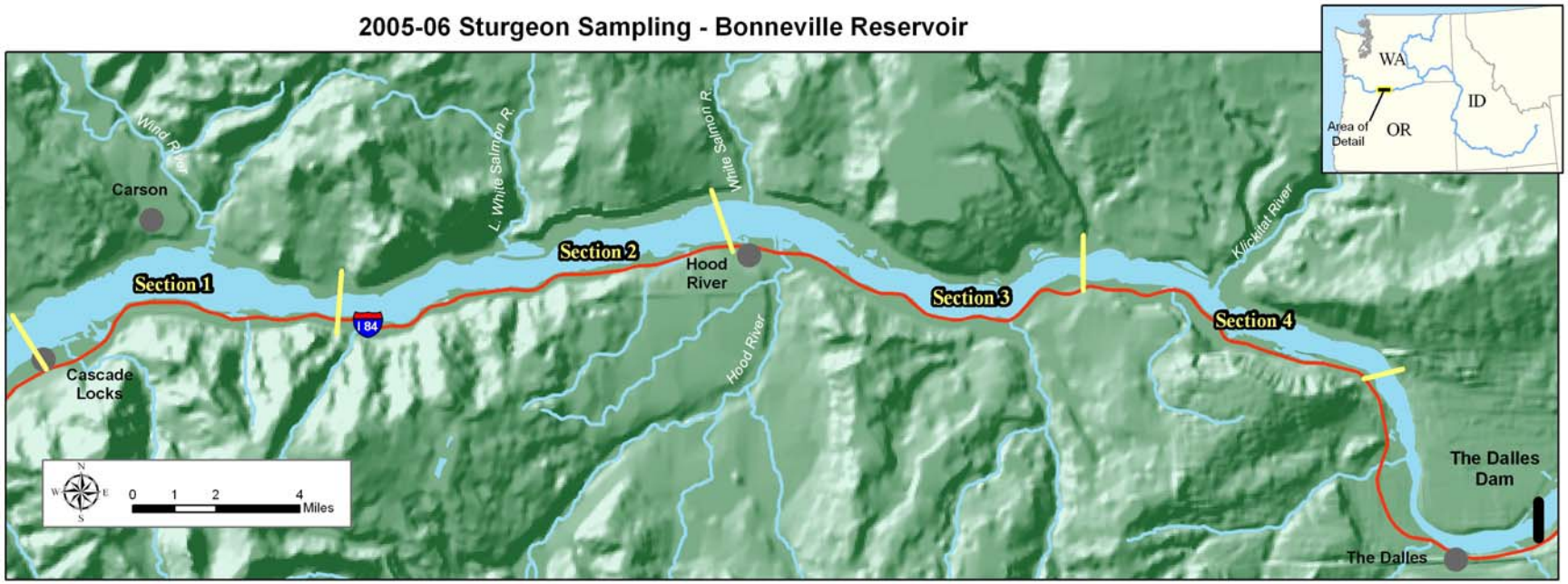

Figure D-1. Map of Columbia River showing a portion of Bonneville Reservoir and the sections where white sturgeon marking and tagging efforts were conducted in 2005-06.

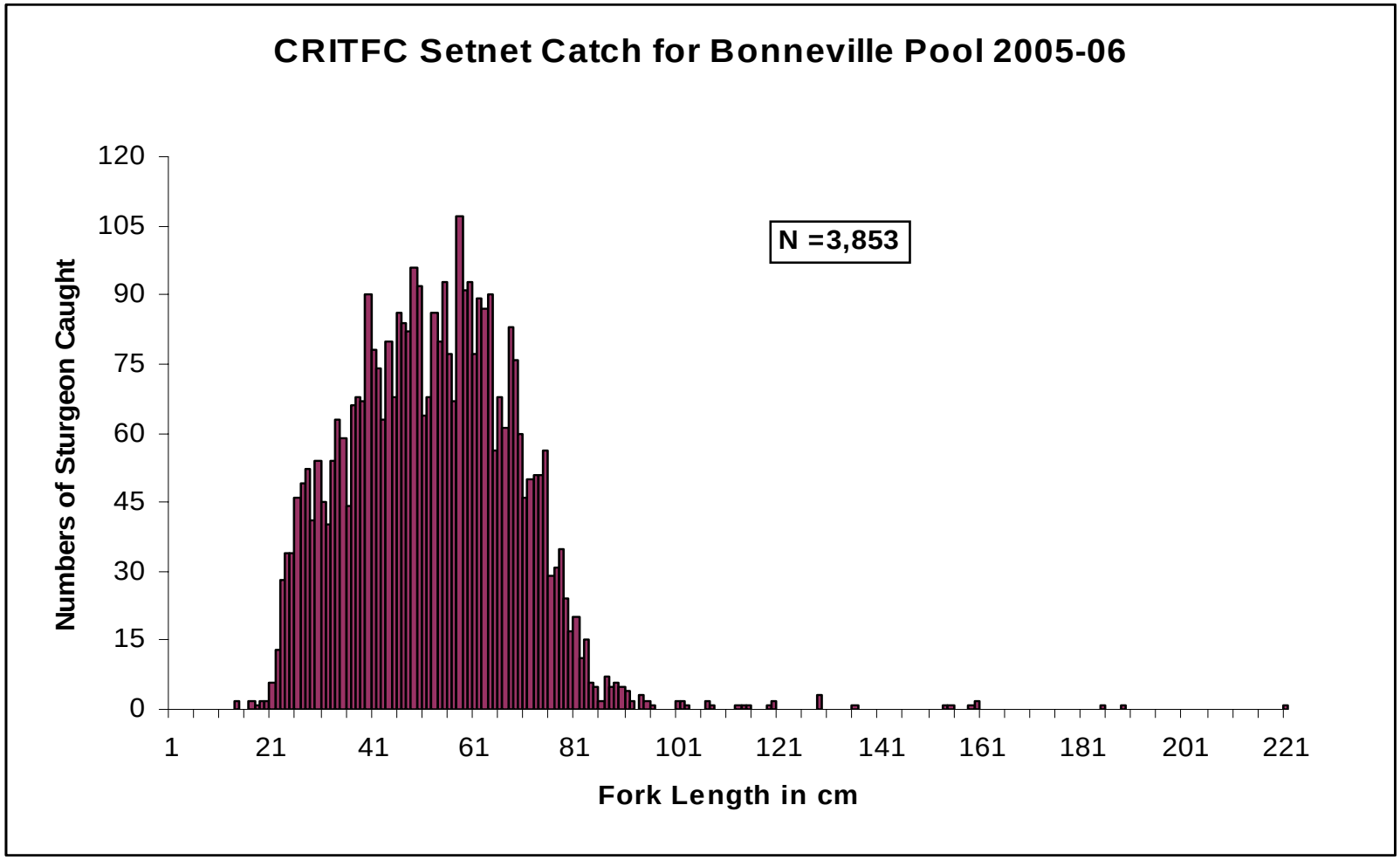

Figure D-2. Length frequency distribution for white sturgeon collected with gill nets in Bonneville Reservoir in 2005-06 by tribal fishers and Yakama Nation fish technicians.

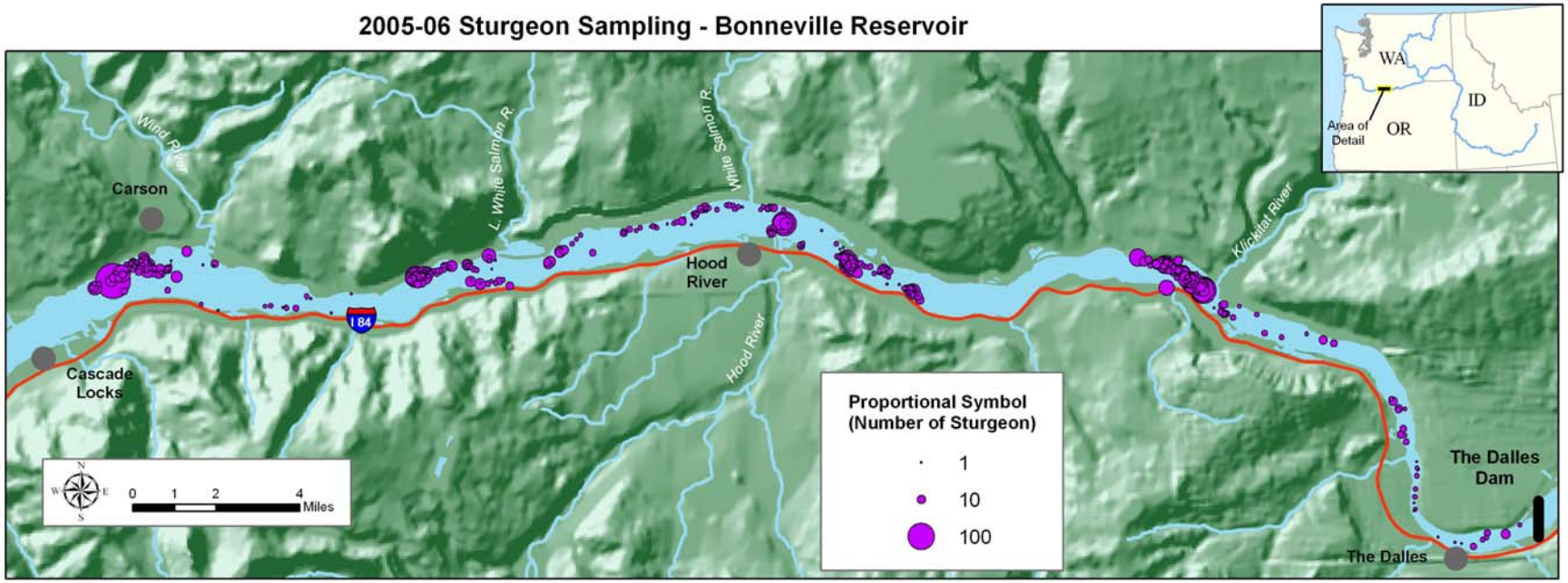

Figure D-3. Paired white sturgeon catch and set coordinate data (latitude/longitude) for Bonneville Reservoir during the winter 2005-06 sampling period. Dot size is proportional to the number of white sturgeon captured in each set. Three representative catch sizes are shown for scale purposes.

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 2006 – MARCH 2007

Report E

Determine spawning interval of white sturgeon in the Columbia River

This report includes: Progress update on the maturation cycle in wild white sturgeon.

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October 2007

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ABSTRACT

During 1 April 2006 through 31 March 2007, Montana State University/U.S. Fish and Wildlife Service researchers collected gonadal biopsies from adult white sturgeon in 1) the cul-de-sac of The Dalles Dam with Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, and Columbia River Inter-Tribal Fish Commission and 2) below Bonneville Dam with Washington Department of Fish and Wildlife. The objective of this research is to describe the maturation cycle in wild white sturgeon. White sturgeon were caught by set-lines. Gonadal tissue was collected by biopsy, and the gonad samples were processed histologically. A total of seven adult white sturgeon were captured in the cul-de-sac of The Dalles Dam over a two-week period. None of these fish had been handled in previous sampling efforts in this area. Five of these fish were females of which two were pre-vitellogenic (Stage 2), two were early vitellogenic (Stage 3), and one was ripe (Stage 5). The remaining two fish were males with pre-meiotic testicular tissue (Stage 2). A total of 602 adult white sturgeon have been marked with spaghetti tags, scute marks, and PIT tags below Bonneville Dam since 2000 (n=183 in 2000, n=90 in 2001, n=67 in 2002, n=101 in 2003, n=57 in 2004, n=37 in 2005, n=67 in 2006). Gonadal biopsies have been collected from 493 of these fish. In 2006, a total of 105 fish were caught, 27 of which were tagged in previous years and 67 of which were "new" fish to the study. Eleven of the 105 handled were recaptured in the same season (2006). A total of 93 gonad samples were collected for histological analysis. One male had such small testicular lobes, a gonadal biopsy was not attempted to determine stage of maturity. Of the 93 gonad samples, 53 were collected from females, 30 were collected from males, and 1 was collected from a hermaphrodite. The reproductive structure of the oversize white sturgeon population below Bonneville Dam was determined using the 2000-2006 data. Of the females (n=319), 58% were pre-vitellogenic (Stages 1 and 2), 28% were vitellogenic (Stages 3 and 4), 4% were post-vitellogenic or ripe (Stage 5), 6% were postovulatory (Stage 7), and 4% were undergoing follicular atretic (Stage 8). Of the males (n=164), 58% were non-reproductive (Stage 2), 17% were mid-spermatogenic (Stage 3 and 4), 20% were spermiating (Stage 5), and 5% were post-spermiation (Stage 6).

INTRODUCTION

This annual report describes progress of Montana State University (MSU) on the Bonneville Power Administration funded Project 198605000 – White Sturgeon Restoration and Enhancement in the Columbia and Snake Rivers Upstream from Bonneville Dam. This report covers the period of 1 April 2006 through 31 March 2007.

During this reporting period, MSU worked on one task related to Objective 4 of the common objectives listed in the multi-agency project. Objective 4 involves assessment of losses to white sturgeon production due to development, operation, and configuration of the hydro system. Specifically, the task was to describe the maturation cycle for white sturgeon.

METHODS

Collection of Fish

Gonad samples were collected from sturgeon over the legal size limit (> 137-cm fork length (FL), herein referred to as adult fish) in 1) the cul-de-sac of The Dalles Dam with the help of Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife, and Columbia River Inter-Tribal Fish Commission and 2) below Bonneville Dam with the help of WDFW in May of 2006. Fish were captured using set-lines. Individual fish were marked with spaghetti tags, scute marks, and passive integrative transponder (PIT) tags as described in Rien et al. (1994). Fork length and total length (TL) were measured for every fish.

Collection of Biological Samples and Gonadal Histology

Gonadal tissue was collected following the protocol of Webb (1999) and stored in phosphate-buffered formalin. Gonadal tissue was embedded in paraffin, sectioned at 5 µm, and stained by Periodic Acid Schiff reagent (Luna 1968). Slides were examined under a compound scope (Leica, 40x-1000x), and the germ cells were scored for stage of maturation according to the modified protocol of Van Eenennaam and Doroshov (1998) for white sturgeon (Table E-1). When assigning the spawning periodicity in recaptured females, it was assumed that the fastest cycle in a pre-vitellogenic Stage 2 female with no evidence of a chorion in the oocytes was likely 3 years.

RESULTS

Maturation Cycle

A total of seven adult white sturgeon were captured in the cul-de-sac of The Dalles Dam over a two-week period in 2006. None of these fish had been handled in previous sampling efforts in this area. Five of these fish were females of which two were pre-vitellogenic (Stage 2), two were early vitellogenic (Stage 3), and one was ripe (Stage 5). The remaining two fish were males with pre-meiotic testicular tissue (Stage 2).

A total of 602 adult white sturgeon have been marked with spaghetti tags, scute marks, and PIT tags below Bonneville Dam (n=183 in 2000, n=90 in 2001, n=67 in 2002, n=101 in 2003, n=57 in 2004, n=37 in 2005, n=67 in 2006). In 2006, a total of 105 fish were handled, 27 of which were tagged in previous years, 67 of which were "new" fish to the study, and 11 of which were handled twice in the season (within season recapture). Of the 94 fish "new" and out-of-season recaptures, 55 were visually identified as females and 39 were visually identified as males.

A total of 93 gonad samples were collected for histological analysis from white sturgeon below Bonneville Dam. Of the 93 gonad samples, 53 were collected from females, 30 were collected from males, and one was collected from a hermaphrodite (Figure E-1). The inter-sex fish had predominately testicular tissue with spermatogonia and residual spermatozoa and primary oocytes interspersed throughout the gonad. Nine of the samples did not contain gonial cells, but all of these fish were identified as males with small testicular lobes in the field. It is often very difficult to collect gonadal tissue from males with small testicular lobes. Histological analysis revealed 26 Stage 2 (pre-vitellogenic), ten Stage 3 (early vitellogenic), nine Stage 4 (mid-vitellogenic), zero Stage 5 (post-vitellogenic or ripe), and eight Stage 7 (post-ovulatory) females. Two females had evidence of follicular atresia during the late phase of oogenesis and appeared to have undergone atresia within the last 2-9 months. These two females were classified as Stage 2 (pre-vitellogenic) as this was the primary stage of development seen in the gonadal sample. Histological analysis revealed 16 Stage 2 (pre-meiotic), six Stage 3 and 4 (mid-spermatogenic), one Stage 5 (spermiating), and two Stage 6 (post-spermiating) males.

No post-vitellogenic or ripe females were captured in 2006. However, the highest number of post-ovulatory females captured within any given year of this study were captured in 2006: A total of 8 Stage 7 (post-ovulatory females) were captured. The post-ovulatory females were captured between 9 June and 7 July at water temperatures of 15-19˚C. The rate of gonadal recrudescence ("gonad clean-up") and the influence of water temperature on this process are unknown in white sturgeon. The spermiating male was captured on 21 July when water temperature was 21˚C, and the post-spermiating males were captured on 6 July and 7 July. The hermaphrodite that had gonadal tissue containing residual spermatozoa (post-spermiation) was captured on 10 July (20˚C).

In 2006, 27 fish were recaptured (29% of the total fish captured in 2006). Of these 27 fish, six were tagged in 2000, two were tagged in 2001, seven were tagged in 2002, two were tagged in 2003, six were tagged in 2004, and four were tagged in 2005 (Table E-2). One fish (688747) was tagged in 2000 and recaptured in 2003 and again in 2006. Sex determined at the time of gonadal biopsy in 2006 revealed 15 females and 12 males. The maturation cycle could not be determined in six fish (four males and two females) due to the absence of gonial cells in the gonad sample at the time of tagging or recapture and the lack of blood plasma for steroid analysis. In 2006, there was good evidence supporting a 2-year reproductive cycle in female white sturgeon below Bonneville Dam, similar to the biennial cycle seen in white sturgeon in captivity. Female 1297250 was post-ovulatory in 2004 and again in 2006 (i.e., this female spawned in 2004 and 2006). Females 8372274 and 9349347 were both vitellogenic in 2004 and in 2006. There was no evidence of follicular atresia remaining in the gonad tissue collected, suggesting both of these females successfully spawned in 2005. These females should have spawned in 2006 given the proper environment (e.g., feed, no stress, proper spawning cues). Three females appeared to have a 2-year or longer cycle, while one female appeared to have a 2- to 4-year cycle and six females appeared to have a 3-year or longer maturation cycle. All males had a maturation cycle of 2 years or longer (Table E-2).

The reproductive structure of the oversize white sturgeon population below Bonneville Dam was determined using the 2000-2006 data. Of the females (n=319), 58% were pre-vitellogenic (Stages 1 and 2), 28% were vitellogenic (Stages 3 and 4), 4% were post-vitellogenic

or ripe (Stage 5), 6% were postovulatory (Stage 7), and 4% were undergoing follicular atretic (Stage 8). Of the males (n=164), 58% were non-reproductive (Stage 2), 17% were mid-spermatogenic (Stage 3 and 4), 20% were spermiating (Stage 5), and 5% were post-spermiation (Stage 6).

DISCUSSION

Of the adult females sampled in 2000-2006, 58% were pre-vitellogenic (Stages 1 and 2), 28% were vitellogenic (Stages 3 and 4), 4% were post-vitellogenic or ripe (Stage 5), 6% were postovulatory (Stage 7), and 4% were undergoing follicular atretic (Stage 8). Welch and Beamesderfer (1995) found 37% of the females > 166 cm FL in Bonneville, The Dalles, and John Day Reservoirs were maturing (equivalent to Stages 3 and 4 in this study), while 10% of the females were mature or spent (equivalent to Stages 5 and 6 in this study). DeVore et al. (1995) found 2% of the females ≥ 110 cm FL below Bonneville Dam were ripe or spent (equivalent to Stages 5 and 6 in this study). Of the oversize males in this study, 58% were non-reproductive (Stage 2), 17% were mid-spermatogenic (Stage 3 and 4), 20% were spermiating (Stage 5), and 5% were post-spermiation (Stage 6). Ten percent of the adult females in this study were capable of or had spawned successfully, while 25% of the adult males were capable of or had spawned successfully.

It is difficult to determine histologically the exact timing of follicular atresia (i.e., this spawning season or last) as the rate of atresia differs greatly among individuals and is influenced by water temperature. As well, follicular atresia can occur during the late phase of vitellogenesis and may not be easily distinguished from atresia that occurs during the spawning season. In culture, white sturgeon females that undergo follicular atresia have been found to have residual pigment in gonadal tissue 1 year after gonadal regression occurred, and these females were capable of reutilizing the yolk and producing ovarian follicles to spawn the following season (pers. obs.). Two of the females had evidence of follicular atresia and appeared to have undergone atresia within the last 2-9 months during 2006. These females had Stage 2 oocytes as well as atretic bodies. The percentage of wild adult females that developed ovarian follicles and failed to complete maturation and/or ovulate may range from 0-4% per season. All of the females classified as atretic in this study underwent follicular atresia during vitellogenesis or post-vitellogenesis.

It is interesting to note that the largest number of post-ovulatory females were captured in 2006 during the course of this study. It is not possible to determine whether this was due to a good water year providing proper spawning cues and habitat, decreased stress associated with the change in fishing regulations, or random chance. It will be possible to compile spill information from Bonneville Dam and compare conditions (temperature and flow) and spawning habitat over the course of this study for a future report. With regard to the impact of changing fishing regulations on the successful spawning of white sturgeon below Bonneville Dam, it would seem that if a positive effect of more protective regulations was to occur, it would be seen two or more

years following the regulation change, as the reproductive cycle of female white sturgeon requires a minimum of 2 years.

Sustainable harvest levels of sturgeon in the Columbia River are based on population models and fecundity estimates (DeVore et al., 1995), of which spawning frequency and an understanding of the maturation cycle are critical elements. Exact knowledge of the maturation cycle in white sturgeon in the Columbia River requires following the stage of development in individual fish over many years. Females in all stages of development were found throughout the winter and spring below Bonneville Dam, which is consistent with a maturation cycle longer than one year, as previously discussed for white sturgeon by DeVore et al. (1995) and Doroshov et al. (1997). The data collected from recaptured oversize fish below Bonneville Dam in 2000-2006 revealed that males of reproductive size are not spawning every year. It appears that the gametogenic cycle in males may be a 2 to 5+ year cycle. Two females recaptured in 2004 were the first females in this study to have evidence of a 2-year gametogenic cycle. In 2006, there was evidence for two females developing gametes on a 2-year cycle, and one female (Female 1297250) spawning on a 2-year cycle. All of the other recaptured females to date have 2 to 5 or more year reproductive cycles. It is essential to continue this work to determine 1) the true maturation cycle in wild white sturgeon and 2) the proportion of fish spawning on 2, 3, 4, 5, 6, etc. year cycles. This information is critical to management of Zone 6 white sturgeon populations as well as the endangered Kootenai River white sturgeon, the upper Columbia River white sturgeon, and the Snake River white sturgeon populations. The maximum fraction of mature wild white sturgeon in the Columbia River is estimated to be 33% based on a 3-year cycle (Welch and Beamesderfer 1995). Given that the preliminary results of this study show a 2 to 5+ year cycle in the majority of females, and that 10% of the adult females in this study were capable of or had spawned successfully, it appears that the estimated maximum fraction of spawning females may be 10-33%, even with consideration of capture gear and location biases.

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APPENDIX

Table E-1. Stages of gonadal development identified from gonadal biopsies of white sturgeon.

Developmental Stage		Description
Females		
Differentiation	1	Clusters of oogonia
Previtellogenic	2	Endogenous growth of oocyte, small translucent oocytes < 0.6 mm
Early vitellogenic	3	Enlarged oocytes with thin vitelline envelope surrounded by granulosa cell layer and yolk globules, cream to grey colored 0.6-2.1 mm
Mid-vitellogenic	4	Fully differentiated follicular layer and yolk platelets, pigmented ovarian follicles 2.2-2.9 mm
Post-vitellogenic	5	Fully grown ovarian follicles with differentiated chorion and germinal vesicle displaced to animal pole, fully pigmented ovarian follicles > 3.0 mm
Oocyte maturation	6	Ovulated oocytes that have undergone germinal vesicle breakdown
Post-ovulatory	7	Ovaries contain numerous postovulatory follicles and the next generation of oocytes similar to Stage 2
Atretic	8	Atretic vitellogenic follicles containing residual yolk, atretic mature follicles containing residual yolk and dark pigment, presence of atretic bodies
Males		
Differentiation	1	Clusters of primary spermatogonia
Pre-Meiotic	2	Spermatogonia undergoing mitosis
Onset of Meiosis	3	Spermatogonia (~50%) and spermatocytes
Meiotic	4	Majority of cysts contain spermatocytes and spermatids, less than 25% of cysts contain spermatogonia
Spermiation	5	Cysts and ducts contain spermatozoa
Post-spermiation	6	Residual spermatozoa in testicular lobules

Table E-2. Oversize white sturgeon recaptured in 2006 below Bonneville Dam. Fish identification is the last seven digits of the PIT tag number. Field sex is based on visual examination of the gonad at the time of biopsy. All field calls were confirmed histologically and were correct. Stage of maturity is based on histological examination of the gonadal tissue when a biopsy was conducted. Stage of maturity in fish that did not have gonadal tissue collected or had no gonial cells present in the histological sample were determined by sex steroid concentrations when available (these fish are denoted by *). Fish 688747** was tagged in 2000, recaptured in 2003 and again in 2006. The data for this female are presented in chronological order. U = unknown due to no gonadal biopsy, no gonial cells present in histological sample, and no plasma sex steroid data available. NA = not available.

Fish ID	Year Tagged	Fork Length (cm) (yr tagged / 2006)	Field Sex	Stage of Maturity (yr tagged / 2006)	Spawning Periodicity
1297250	2004	217 / 218	Female	Stage 7 / Stage 7	2 yr
8372274	2004	240 / 240	Female	Stage 4 / Stage 4	2 yr
9349347	2004	234 / 236	Female	Stage 4 / Stage 4	2 yr
8353057	2002	207 / 204	Female	Stage 2* / Stage 7	2+ yr
8345319	2002	242 / 240	Female	Stage 3 / Stage 3	2+ yr
7560838	2000	224 / 223	Female	Stage 4 / Stage 3	2+ yr
8373012	2002	228 / 221	Female	Stage 2 / Stage 2	2-4+ yr
8344140	2003	209 / 212	Female	Stage 2 / Stage 2	3+ yr
7526227	2002	231 / 235	Female	Stage 2 / Stage 2	3+ yr
8353721	2001	207 / 207	Female	Stage 2 / Stage 3	3+ yr
9702411	2005	240 / 236	Female	Stage 2 / Stage 2	3+ yr
6909641	2000	225 / 230	Female	Stage 2 / Stage 2	3+ yr
9485462	2005	262 / 263	Female	Stage 2 / Stage 4	3+ yr
6802374	2000	194 / 217	Female	U / Stage 3	NA
7526255	2000	231 / 235	Female	U / Stage 2	NA
0517944	2004	215 / 217	Male	Stage 2 / Stage 2	2+ yr
1295541	2004	198 / 200	Male	Stage 4 / Stage 3	2+ yr
6888747**	2000	225 / 222 / 222	Male	U/Stage 2/Stage 2	2+ yr
8352388	2003	207 / 205	Male	Stage 5 / Stage 2	2+ yr
8353011	2001	193 / 201	Male	Stage 2 / Stage 4	2+ yr
8351797	2002	203 / 209	Male	Stage 5 / Stage 3	2+ yr
8373912	2002	211 / 206	Male	Stage 4 / Stage 2	2+ yr
9354394	2005	181 / 183	Male	Stage 2 / Stage 2	3+ yr
1291172	2004	206 / 207	Male	Stage 2* / U	NA
9367764	2005	170 / 173	Male	U / 2	NA
7550249	2000	193 / 204	Male	U / U	NA
7575675	2002	219 / 219	Male	U / Stage 2	NA

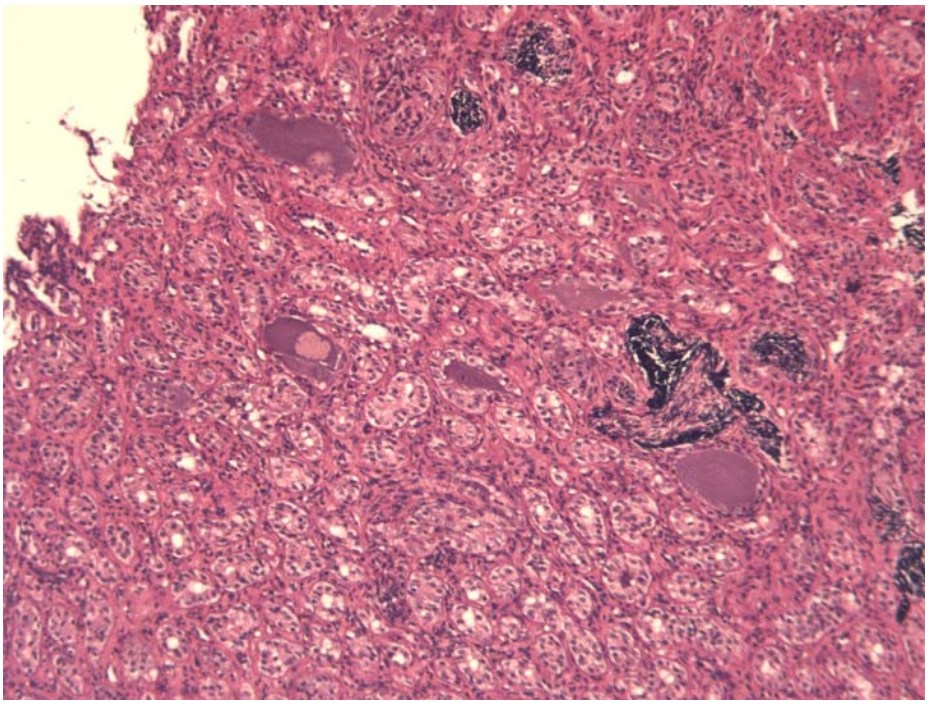

Figure E-1. Microscopic image of gonadal tissue collected from an inter-sex white sturgeon adult below Bonneville Dam in 2006. The gonadal tissue contained predominately spermatogonia with residual spermatozoa and few primary oocytes interspersed throughout the tissue.