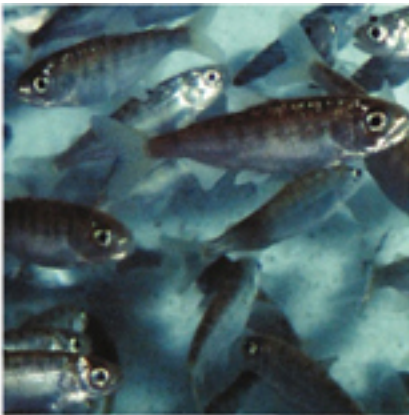


White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam

Annual Report 2004 - 2005

March 2006

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

ANNUAL PROGRESS REPORT

APRIL 2004 - MARCH 2005

Edited by:

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Oregon Department of Fish and Wildlife

In Cooperation With:

Washington Department of Fish and Wildlife
U.S. Geological Survey Biological Resources Division
Columbia River Inter-Tribal Fish Commission
U.S. Fish and Wildlife Service
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EXECUTIVE SUMMARY

We report on our progress from April 2004 through March 2005 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; Report C), Columbia River Inter-Tribal Fish Commission (CRITFC; Report D), and Oregon State University (OSU; Report E).

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

- From December 2003 through August 2004, combined effort by CRITFC, ODFW, and WDFW resulted in applying PIT-tags to 4,713 white sturgeon in John Day Reservoir.
- ODFW, WDFW, and CRITFC crews set 568 baited setlines in John Day Reservoir between 27 June through 19 August 2004, and captured 3,490 white sturgeon, for a CPUE of 6.14.
- Recaptured fish were caught an average of 0.6 km upstream from the location of first-capture.
- There were no significant differences in relative weights of fish >70 cm FL among the three sampling periods when baited setlines were used. Relative weights for fish >70 cm FL were significantly higher in 2004 (mean 102.9) than they were in 2001 (mean 95.0).
- Using multiple mark-recapture estimates, we estimated the total population in John Day Reservoir in 2004 to be 43,500 white sturgeon >54 cm FL. We estimated abundance of fish 70-109 cm FL to be 28,794 fish; abundance of fish 110-166 cm FL was estimated to be 1,279 fish; and abundance of fish > 166 cm FL was estimated to be 457 fish.
- Transplant supplementation (Trawl and Haul) continued in 2004. Only 300 juvenile white sturgeon were captured by trawl net and transplanted, with all released in John Day Reservoir. Trawl catches were exceptionally poor this year. The trawler caught fewer fish on average than in past years, and spent more time trawling to do so.
- We continued sampling with small-mesh gillnets to index recruitment of young-of-year white sturgeon in three Columbia River and two Snake River reservoirs. We captured only two YOY white sturgeon, both from The Dalles Reservoir.

Report B

- The 2004 white sturgeon harvest (recreational, commercial, and subsistence) in Management Zone 6 was 3,628 fish. This is the lowest total harvest since 1996, and is reflective of the 59% reduction of the recreational guideline and 67% reduction of the commercial guideline in Bonneville Reservoir.
- The 2004 Treaty commercial seasons closed March 10 in Bonneville and The Dalles reservoirs, and March 21 in John Day Reservoir. Sport retention seasons were closed on June

26 in Bonneville Reservoir, June 28 in The Dalles Reservoir, and July 12 in John Day Reservoir.

- Compliance with the Sturgeon Management Task Force (SMTF) annual harvest guidelines has been addressed through in-season management actions. Harvest in Bonneville Reservoir during the past three seasons (2002-2004) has averaged 105% of the recreational guideline and 61% of the commercial guideline. Harvest in The Dalles Reservoir for the same period averaged 123% of the recreational guideline and 103% of the commercial guideline. Harvest in John Day Reservoir averaged 117% of the recreational guideline and 90% of the commercial guideline. The trend toward exceeding guidelines reflects the difficulty for the fisheries to adjust to the recent drastic reduction in the guidelines during this period: 71% overall guideline reduction in John Day Reservoir in 2002; 28% overall guideline reduction in The Dalles Reservoir in 2003; and, a 62% overall guideline reduction in Bonneville Reservoir in 2004.
- Harvest per angler trip (bank and boat anglers combined) in Bonneville Reservoir in 2004 was the lowest since the short winter/spring retention seasons began in 1995. Harvest per angler trip in The Dalles Reservoir decreased each of the last three years to a level half that of the 2001 peak. Harvest per angler trip in John Day Reservoir improved over the 2001-2003 seasons, but only to a level about half of the 1997 peak HPUE. Combined Harvest per angler trip (HPUE) in the Bonneville, The Dalles, and John Day recreational fisheries were 0.083, 0.072, and 0.024 respectively.
- The handle of oversize white sturgeon in the John Day recreational fishery has increased since 1995, comprising 11% of white sturgeon handled during 2002-2004. The handle of oversize white sturgeon in the John Day Reservoir recreational fishery is nearly four times greater than that for Bonneville and The Dalles reservoirs during this period.

Report C

- River discharge and water temperatures that occurred during April through July 2004 provided conditions suitable for spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams. Optimal spawning temperatures in the four tailraces occurred for 3-4 weeks and they coincided with the peak of the river hydrograph. However, the peak of the hydrograph was relatively low compared to past years, which is reflected in the relatively low monthly and annual indices of suitable spawning habitat.
- Bottom-trawl sampling in the Bonneville Reservoir revealed the presence of young-of-the-year white sturgeon.

Report D

- During 15 December 2003 through 18 February 2004 Tribal fishers set 1,408 overnight gillnet sets and caught 2,848 white sturgeon (2.02 per set). Only 62% of the sets (872 sets) captured one or more white sturgeon.
- White sturgeon captured in these efforts were 37 - 262 cm FL (mean 87.2 cm).
- Tribal fishers marked all 2,848 white sturgeon John Day Reservoir by removing the 11th right lateral scute. They applied PIT tags to 1,742 white sturgeon.

- In the future CRITFC will continue to coordinate population surveys with ODFW and WDFW; participate in YOY surveys; monitor catch in the Tribal commercial fishery; and complete a survey of Rock Island and Wanapum reservoirs for hatchery-reared sturgeon released in 2003.

Report E

- OSU collected paired blood and gonad samples from 72 white sturgeon in the Columbia River between February 2004 and March 2005.
- White sturgeon showed sex- and maturity-specific levels of plasma steroids and fork length.
- Discriminant function analysis revealed that plasma testosterone, 11-ketotestosterone, and estradiol, as well as fork length led to the correct classification of 63, 52, 97, and 87% of the non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively.
- Discriminant function analysis revealed that plasma T, KT, E2, and FL led to the correct classification of 53% of the pre-vitellogenic females, 86% of the vitellogenic females, 91% of the post-vitellogenic females, 73% of the post-ovulatory females, 14% of the atretic females, 46% of the pre-meiotic males, 88% of the meiotic males, 69% of the spermiating males, and 100% of the post-spermiating males.
- Preliminary evidence suggests that the gametogenic cycle may be a 2 to 4+ year cycle in males and a 2 to 5+ year cycle in females, with the majority of females displaying a 3 to 5+ year cycle.

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

ANNUAL PROGRESS REPORT

APRIL 2004 - MARCH 2005

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: An update of abundance, life history parameters, and population dynamics of white sturgeon in John Day Reservoir, results of transplant supplementation in The Dalles and John Day reservoirs, and a summary of gill-net effort and catch targeting young-of-year white sturgeon in Columbia and Snake River reservoirs.

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October 2005

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ABSTRACT

This report summarizes data collected from April 2004 through March 2005 to: 1) update life history parameters and population dynamics of white sturgeon *Acipenser transmontanus* in John Day Reservoir; 2) examine young-of-year recruitment of white sturgeon in three Columbia River and two Snake River reservoirs; and 3) continue transplant supplementation of juvenile white sturgeon from the Columbia River below Bonneville Dam to The Dalles and John Day reservoirs.

We coordinated sampling to estimate white sturgeon abundance in John Day Reservoir with staff from the Columbia River Inter-Tribal Fish Commission (CRITFC) and the Washington Department of fish and Wildlife (WDFW). From 15 December 2003 through 19 February 2004, CRITFC staff contracted with commercial fishers who set 1,410 nets and captured 2,848 white sturgeon. Staff from Oregon Department of Fish and Wildlife (ODFW), WDFW, and CRITFC set 568 setlines from 7 June through 19 August 2004, and captured 3,490 white sturgeon. White sturgeon were distributed throughout John Day Reservoir with the highest catch rates occurring in the upriver portions of the reservoir. Recaptured fish were most often caught near the site of first capture. However, recaptured fish had moved an average of 0.37 km upstream between marking and subsequent recapture. Combined effort of both winter and summer sampling resulted in the marking of 4,713 white sturgeon with passive integrated transponder (PIT) tags between December 2003 and August 2004. Using multiple mark-recapture estimates, we estimated the total population of white sturgeon over 54 cm fork length in John Day Reservoir in 2004 to be 43,500 fish.

Transplant supplementation efforts (i.e. Trawl-and-Haul) continued in 2004 with transplant of juvenile white sturgeon from below Bonneville Dam to John Day Reservoir. Using trawl gear, 321 juvenile white sturgeon were captured below Bonneville Dam by a private commercial trawler. We transplanted 293 of these fish into John Day Reservoir. All transplanted fish were marked by removal of two lateral scutes; one to identify them as Trawl-and-Haul fish, and one to identify the year of their capture. None of these fish were PIT-tagged.

We assessed recruitment of young-of-year (YOY) white sturgeon using standardized gill nets and fishing locations in The Dalles, John Day, McNary, Ice Harbor, and Little Goose reservoirs. Two YOY sturgeon were captured in The Dalles Reservoir. No YOY sturgeon were captured in any of the remaining reservoirs.

INTRODUCTION

This report summarizes work performed by the Oregon Department of Fish and Wildlife (ODFW) from April 2004 through March 2005 in accordance with tasks outlined in Bonneville Power Administration funded Project 198605000 Performance Work Statement. During this period, we participated in three distinct efforts to assess or restore productivity of white sturgeon *Acipenser transmontanus* in the Columbia River upstream from Bonneville Dam: 1) From June through August 2004 we assessed abundance and productivity measures of white sturgeon in John Day Reservoir; 2) During October and November 2004, we coordinated the transplantation of juvenile white sturgeon from the lower Columbia River (i.e. downstream of Bonneville Dam) to both The Dalles and John Day reservoirs; 3) During October and November 2004, we participated in assessing recruitment of young-of-year white sturgeon (YOY) in The Dalles, John Day, and McNary reservoirs in the Columbia River, and Ice Harbor and Little Goose reservoirs in the Snake River.

These activities are conducted on either an annual or semi-annual basis. Since 2001, stock assessment surveys have been conducted once every three years for each of the three reservoirs in Zone 6 (Bonneville, The Dalles, and John Day). Prior to 2001, stock assessment surveys in these reservoirs were conducted on a five-year rotation. A stock assessment survey was last conducted in John Day in 2001. Trawl-and-Haul supplementation and young-of-year indexing are annual activities.

METHODS

Stock Assessment

We sampled for white sturgeon in John Day Reservoir from June through mid-August of 2004 to estimate population characteristics and abundance. The reservoir was divided into 10 sections. Each section is 11-12 km long, except section 1, which was 14.5 km long. (Figure 1). Setline sampling effort was distributed equally among and within these sections to obtain a representative sample of the population. Additional factors in selecting sampling sites included achieving an even distribution of samples per section, and crew knowledge of previous catches in specific locations. Crews from CRITFC, working with tribal commercial fishers, captured fish during December and January, the first of three sampling periods for the stock assessment survey. The subsequent summer sampling was divided into two five-week periods, referred to as periods two and three. We sampled all sections during each period (Table 1). In previous years, stock assessment surveys have been conducted with a minimum of four sampling periods to maintain satisfactory confidence intervals. However, budget restrictions forced a reduction to only three periods during this year.

Setlines were chosen as the preferred sampling gear because they are less size selective and less damaging to white sturgeon than other sampling gears, and provide suitable catch rates for our objectives (Elliot and Beamesderfer 1990). Setlines measured 600 feet in length and 40 gangions were attached every 15 feet. Gangions were equipped with 12/0, 14/0, and 16/0 hooks, 13 hooks each of two sizes and 14 hooks of the remaining size, which was chosen randomly for each line. Setlines were fished overnight for an average of 22.4 h, and all lines were baited with pickled squid *Loligo* spp.

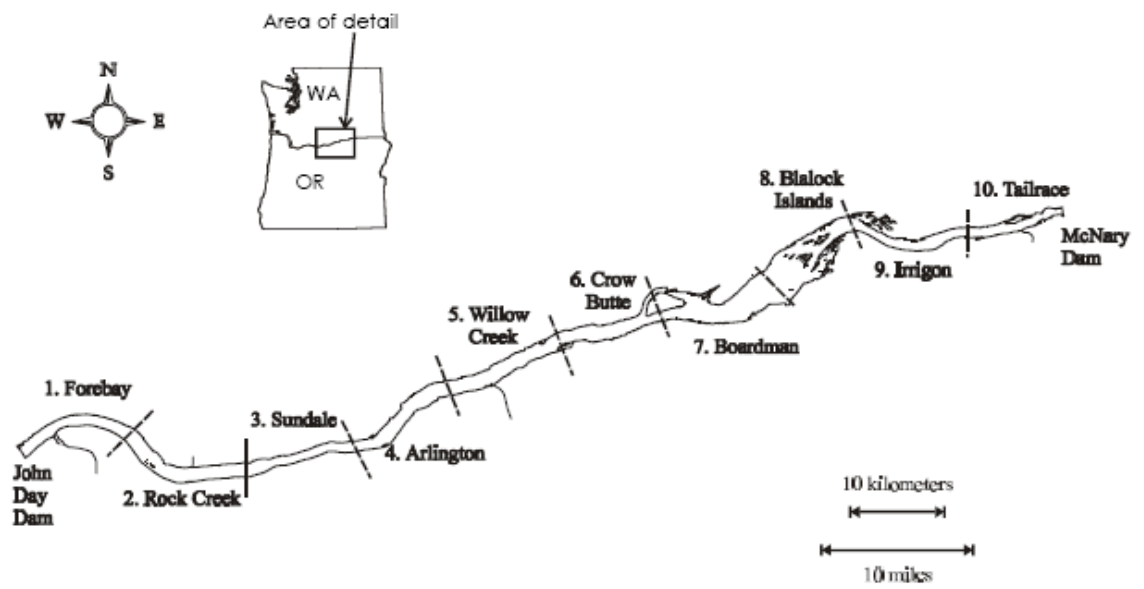


Figure 1. John Day Reservoir and stock assessment sampling sections, 2004.

Table 1. Sampling effort (number of setline sets) for white sturgeon in John Day Reservoir by week and sampling section, June through August 2004.

	Week	Sampling Section										Total
		1	2	3	4	5	6	7	8	9	10	
Period 2	24							29	21			50
	25									25	25	50
	26	29	30									59
	27			31	21							52
	29				1	26	24					51
Period 3	30							30	30			60
	31									30	30	60
	32	29	27	3								59
	33			35	27							62
	34				3	38	24					65
	Total	58	57	69	52	64	48	59	51	55	55	568

All fish were measured to the nearest 1.0 cm fork length. Length measurements are reported here as fork length (FL) unless otherwise indicated. All captured fish were examined for external tags, lost tag scars, fin scars (from aging samples), and scute marks. We subsampled up to 30 fish per 20-cm length interval for weights and aging structures. Total weight was measured to the nearest 1.0 kg and a pectoral fin spine section was removed for subsequent aging. We weighed all recaptured fish. During period one (December and January), most white sturgeon ≥ 70 cm were tagged with a 134.2-MHz ISO passive integrated transponder (PIT) tag. During periods two and three, all white sturgeon were PIT tagged regardless of size. The second left lateral scute was then removed to identify a PIT-tagged fish (Rien et al. 1994). The eleventh right lateral scute was removed to indicate the fish was captured in 2004. We no longer mark white sturgeon with external tags, therefore any external tags found on recaptured fish were removed.

Recoveries of tags applied during previous years were used to describe movement patterns among reservoirs. Recaptured fish with known mark histories were grouped according to the year and reservoir in which they were originally marked. Recoveries of tags applied during the 2004 survey were used to describe movement of fish within John Day Reservoir during the sampling period.

We estimated ages of white sturgeon using thin cross-sections of pectoral fin spine sections following procedures outlined in Beamesderfer et al. 1989. Up to 20 fish for each 20-cm length interval were aged. Each fin-spine section was aged twice by two experienced readers. A third reader, who conducted the majority of aging prior to 2001, aged a 20% subsample of sampled aged by the other two readers to assess differences in application of aging

criteria by less experienced readers. A length-at-age distribution was developed from these age assignments and added to a database of existing information. We derived von Bertalanffy age and growth parameters using length-at-age data and SAS (PROC GLM; SAS 1988) two-way analysis-of-variance (ANOVA).

We described the relationship between fork length and weight using linear regression of transformed data (PROC GLM; SAS 1988). Relative weights (W_r) were calculated to assess the relative condition of white sturgeon larger than 70 cm (Beamesderfer et al. 1995). We used ANOVA and a Tukey's studentized range test (SAS 1988) to test for significant differences in relative weights of fish between 2001 and 2004, and among 2004 sampling periods two and three (white sturgeon are not weighed during period one).

To estimate overall population abundance, a Schnabel multiple mark-recapture estimate (based on PIT-tags applied and recaptured) was used to first estimate the abundance of the 70-109 cm and 110-166 cm size classes (the two mark groups with the largest sample sizes). Abundance estimates for these two size classes were then expanded to estimate abundance of the remaining size groups (<70 cm and >166 cm). Expansion was based on the relative frequency of the size class in the total setline catch and differences in gear vulnerability (Beamesderfer et al. 1995).

Trawl and Haul Supplementation

From 18 October to 8 November 2004, juvenile white sturgeon captured in the Columbia River downstream from Bonneville Dam were transplanted into John Day Reservoir to supplement the existing population. Trawling was conducted primarily in the navigation channel, between river kilometers (RKm) 209 and 212. This area has been used each year of this study and was originally selected because the bottom type is suitable for trawling, and catch rates of subadult white sturgeon were relatively high in previous years (McCabe and Hinton 1994). The number and duration of daily tows varied with catch rates and transport goals. Tows were made in both upstream and downstream directions.

We used a 7.9-m (headrope length) semi-balloon shrimp trawl, with 38-mm stretched mesh and a 10.0-mm cod end liner to collect juvenile white sturgeon. Since 2000, we have contracted with private commercial trawlers, so trawl vessels vary from year-to-year. The net was emptied after completion of each tow. All fish were removed from the net and placed into 520-L plastic totes with circulating river water at ambient temperature and dissolved oxygen (DO) concentration.

Fish were processed by ODFW staff onboard the contracted trawl vessel. Bycatch was identified, counted, and returned to the river. We measured a subsample of up to 100 white sturgeon each day. All white sturgeon between 30 and 90 cm were transported. All transported fish had their eleventh right lateral scute removed to signify capture in 2004, and the third right scute removed to signify Trawl-and-Haul handling. None of these fish were PIT tagged. At the end of each day, fish were transferred into a 13,000 L or a 5,300 L ODFW liberation truck. In 2004, all fish were released in John Day Reservoir on the Oregon shore of the river at Arlington Boat Ramp (RKm 390), Boardman Boat Ramp (RKm 434), Irrigon Boat Ramp (RKm 455), or Umatilla Boat Ramp (RKm 468).

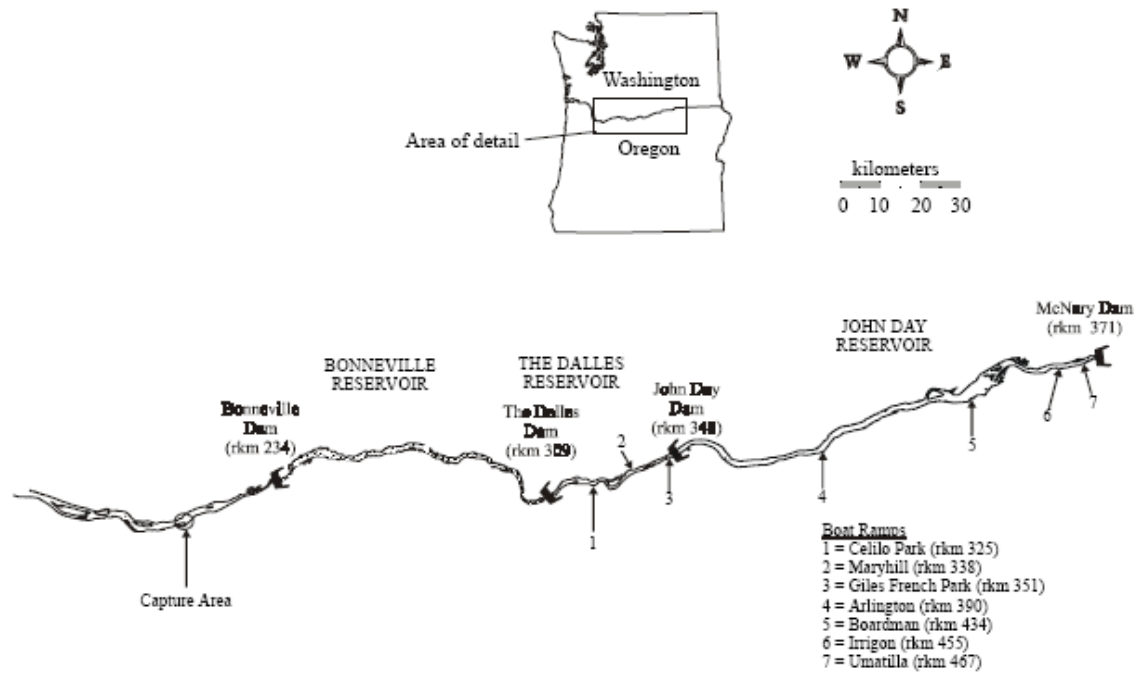


Figure 2. Zone 6, Columbia River, and release sites in The Dalles and John Day reservoirs.

Young-of-Year Indexing

During October and November of 2004, we sampled The Dalles, John Day, and McNary reservoirs in the Columbia River, and Little Goose and Ice Harbor reservoirs in the Snake River (Figure 2), to examine white sturgeon YOY recruitment levels relative to previous years sampled. We used gill nets to collect YOY white sturgeon, and sampling methodology was similar to past years (Burner et al. 1999). Nets measured 91.4 m long and 3.7 m deep (for a total area of 338.2 m²) and were constructed of 5.1-cm stretched measure multifilament nylon webbing. Nets were set in standardized locations (Parsley et al. 1999) to allow comparisons of catch with previous years. Nets were fished on the river bottom overnight for an average of 22.0 h. Because nets are deployed during daylight hours and most white sturgeon captures are believed to occur during darkness, all nets set overnight are considered to have been sampling for equal amounts of “effective fishing time”. Therefore, each overnight set was considered a single effort. We classified white sturgeon as YOY or as age 1 or older based on length-frequency distribution verified by aging of pectoral fin spines collected from all sturgeon. We calculated mean catch per unit effort (CPUE) and proportion of positive efforts (E_p). The CPUE was expressed as the number of fish caught per overnight set; the E_p was the proportion of overnight sets that captured at least one white sturgeon (Counihan et al. 1999). We calculated CPUE and E_p for YOY white sturgeon and for white sturgeon of all sizes.

RESULTS

Stock Assessment

Catch

We caught 3,490 white sturgeon during sampling activities in John Day Reservoir from 7 June through 19 August 2004 (Table 2). Size distribution of setline catch was: 93.7% <110 cm FL, 4.8% 110-137 cm FL, and 1.5% >137 cm FL. At the time of this stock assessment, regulations allowed sport and commercial fishers to harvest fish from 110-137 cm FL (48"-60" TL).

Distribution and Movement

We captured white sturgeon throughout the reservoir, with higher catch rates occurring in the upriver half of the reservoir. Catch rates averaged 6.14 fish per setline, with section eight exhibiting the highest catch rate (12.27 fish per setline) and section two exhibiting the lowest catch rate (0.68 fish per set) (Table 3).

We recaptured 390 PIT-tagged fish that were tagged during the 2004 season. Most recaptured fish were recaptured in the same section they were marked in, with 58% recovered within 10 Rkm of the original marking location (Table 4). The average movement of recaptured fish was 0.59 Rkm upstream from where they were originally marked. The furthest upstream movement observed was 90 Rkm, and the furthest downstream movement observed was 70 Rkm. We recaptured two PIT-tagged fish from previous stock assessment efforts that had moved downstream from McNary Reservoir, where they were originally marked (Appendix Tables A-4 and A-5).

Table 2. Catches of white sturgeon with setlines in John Day Reservoir by week and sampling section, June through August 2004.

	Week	Sampling Section										Total	
		1	2	3	4	5	6	7	8	9	10		
Period 2	24							277	215				492
	25									229	113		342
	26	41	35										76
	27			115	152								267
	29				0	232	227						459
Period 3	30							311	411				722
	31									284	260		544
	32	37	4	0									41
	33			64	139								203
	34				8	144	192						344
	Total	78	39	179	299	376	419	588	626	513	373		3,490

Table 3. Catch per unit effort of white sturgeon with setlines in John Day Reservoir by week and sampling section, June through August 2004.

	Week	Sampling Section										Total	
		1	2	3	4	5	6	7	8	9	10		
Period 2	24							9.55	10.24				9.84
	25									9.16	4.52		6.84
	26	1.41	1.17										1.29
	27			3.71	7.24								5.13
	29				0.00	8.92	9.46						9.00
Period 3	30							10.37	13.70				12.03
	31									9.47	8.67		9.07
	32	1.28	0.15	0.00									0.69
	33			1.83	5.15								3.27
	34				2.67	3.79	8.00						5.29
	Total	1.34	0.68	2.59	5.75	5.88	8.73	9.97	12.27	9.33	6.78		6.14

Table 4. Frequency of movement of fish between marking and recapture events. Negative numbers indicate downstream movement and positive numbers indicate upstream movement. Multiple recaptures of individual fish are included.

Number of River KM Moved	Frequency of Recaptures	% Frequency of Recaptures
-70	1	0.26%
-65	0	0.00%
-60	0	0.00%
-55	2	0.51%
-50	1	0.26%
-45	6	1.54%
-40	8	2.05%
-35	4	1.03%
-30	9	2.31%
-25	1	0.26%
-20	8	2.05%
-15	14	3.59%
-10	23	5.90%
-5	130	33.33%
5	95	24.36%
10	29	7.44%
15	12	3.08%
20	14	3.59%
25	10	2.56%
30	6	1.54%
35	4	1.03%
40	1	0.26%
45	3	0.77%
50	3	0.77%
55	2	0.51%
60	0	0.00%
65	0	0.00%
70	1	0.26%
75	2	0.51%
80	0	0.00%
85	0	0.00%
90	1	0.26%
Total	390	

Age and Growth

We assigned ages to 183 white sturgeon captured from John Day Reservoir in 2004. Ages ranged from 0-57 years old and variation between ages assigned by primary readers was high (Table 5). There was 14% agreement in the final ages assigned by the primary readers. Reader one assigned older ages than Reader two in 81% of the samples. Due to the magnitude of the discrepancy between Reader one and two, final ages were assigned only by Reader one, using assigned ages by all readers, and past experience as guides.

We compared differences in the assigned ages of a subsample of 48 fish aged by three different readers. Reader two, who was a relatively new reader, assigned younger ages than Readers one and three (Figure 3). Reader one tended to assign ages similar to Reader three. The difference between readers is similar to past years (Kern et al. 2003).

Age assignments from this year were combined with age assignments in previously years (Table 6), to estimate parameters of a von Bertalanffy growth equation (Figure 4). The von Bertalanffy length-at-age prediction was then plotted with the mean length of assigned ages to visually compare how well the prediction matches the assigned ages (Figure 5). Two-way ANOVA (type III sum of squares) showed that ages assigned to length classes varied significantly between fish captured in 2004 and fish captured in previous years in John Day Reservoir ($p < 0.0001$, $df=8$, $F=9.08$, $r^2=0.801$).

Data from fish that were recaptured this year were combined with data from previous years to estimate the average annual growth increment (AGI) for fish of various size classes. The mean AGI determined from the von Bertalanffy length at age prediction was plotted with the mean AGI determined from recaptured fish (Figure 7).

There were no significant differences ($p=0.37$, $df=1$, $F=0.80$, $r^2=0.001$) in relative weights (Figure 7) between sampling periods. The mean relative weight for period two was 102.4 and for period three was 103.2. Fish were not weighed during period one. Fish captured in 2004 had a mean relative weight of 102.9, significantly higher than fish captured in 2001 and 1996 with mean relative weights of 95.0 and 98.5 ($p < 0.0001$, $df=2$, $F=45.01$, $r^2=0.05$).

Table 5. Differences in assigned age between two primary readers and final assigned age of white sturgeon pectoral fin spine sections collected in John Day Reservoir, 2004. An age difference of zero means the two readers agreed on the final assigned age.

Age Difference	Final Assigned Age																%	Total	
	3	4	5	6	7	8	9	10	11	12-14	15-17	18-20	21-23	24-26	27-29	>29			
-3	1	1	.	.	.	1.1	2
-2	1	.	.	.	0.5	1
-1	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	1	.	2.2	4
0	1	4	2	.	3	3	1	1	.	1	2	1	5	.	1	.	13.7	25	
1	.	.	1	1	5	10	4	1	3	1	1	3	3	5	.	.	.	20.8	38
2	2	2	2	1	3	3	2	8	3	1	.	.	.	14.8	27
3	1	2	1	1	2	1	1	7	7	1	.	.	.	13.1	24
4	2	1	1	.	5	4	3	1	1	.	9.8	18
5	1	.	5	3	2	.	.	6	11
6	2	5	2	.	.	4.9	9
7	1	1	1	.	.	1.6	3
8	1	.	1	3	.	2.7	5
9	1	2	.	1.6	3
10	1	.	2	.	1.6	3
11	1	.	0.5	1
12	3	.	1.6	3
13	1	.	0.5	1
15	1	.	0.5	1
26	1	.	0.5	1
All	1	4	3	2	11	19	8	6	9	8	7	25	33	22	10	15	100	183	

Table 6. Age and length-frequency distribution of white sturgeon collected in John day Reservoir, 1988-2004.

Age	Fork Length										Mean FL	Std	N
	20- 39	40- 59	60- 79	80- 99	100- 119	120- 139	140- 159	160- 179	180- 199	>199			
0	11	.	.	.	.	.	.	.	.	.	26.9	2.4	11
1	10	9	.	.	.	.	.	.	.	.	38.7	6.2	19
2	13	17	.	.	.	.	.	.	.	.	40.5	7.2	30
3	8	22	.	.	.	.	.	.	.	.	45.3	7.7	30
4	8	24	2	.	.	.	.	.	.	.	49	9.8	34
5	6	23	8	.	.	.	.	.	.	.	51.6	9.1	37
6	3	22	18	1	.	.	.	.	.	.	58.4	11.2	44
7	.	28	23	7	.	.	.	.	.	.	64.4	12.2	58
8	.	19	30	4	4	.	.	.	.	.	68.6	13.6	57
9	.	15	28	15	3	1	.	.	.	.	71.2	15.7	62
10	.	6	27	13	3	1	.	.	.	.	76.5	15.7	50
11	.	3	16	8	11	.	.	.	.	.	83.7	18.6	38
12	.	2	14	23	12	1	.	.	.	.	88.4	15.9	52
13	.	3	5	10	25	9	.	.	.	.	101.4	19.2	52
14	.	.	3	9	19	10	3	.	.	.	110.1	19.1	44
15	.	.	1	14	15	19	3	.	.	.	112.2	18.7	52
16	.	.	1	9	13	10	4	.	.	.	113.5	19.3	37
17	.	.	.	12	17	15	3	1	.	1	115.2	22.5	49
18	.	.	.	8	16	23	7	2	.	.	121.4	18.4	56
19	.	.	.	11	11	13	9	.	.	.	119	22.2	44
20	.	.	.	10	11	14	6	1	2	.	120.7	24.8	44
21	.	.	.	6	10	14	16	5	.	.	129.4	23.8	51
22	.	.	.	3	9	12	6	3	2	1	132.4	30.5	36
23	.	.	.	3	3	5	3	1	2	.	131.1	31.7	17
24	.	.	2	.	6	6	8	2	1	.	131.8	27.6	25
25	.	.	.	2	3	5	3	3	3	.	140.8	32	19
26	.	.	.	2	1	3	2	2	4	2	157.4	38	16
27	.	.	.	1	1	1	3	2	1	.	145.2	33.7	9
28	.	.	.	1	1	.	1	.	1	1	154.4	50.4	5
29	.	.	.	.	1	1	1	.	2	3	173.3	43.6	8
>29	.	.	.	.	.	3	4	4	11	24	195.3	29	46
All	59	193	178	172	195	166	82	26	29	32	98.1	42.5	1132

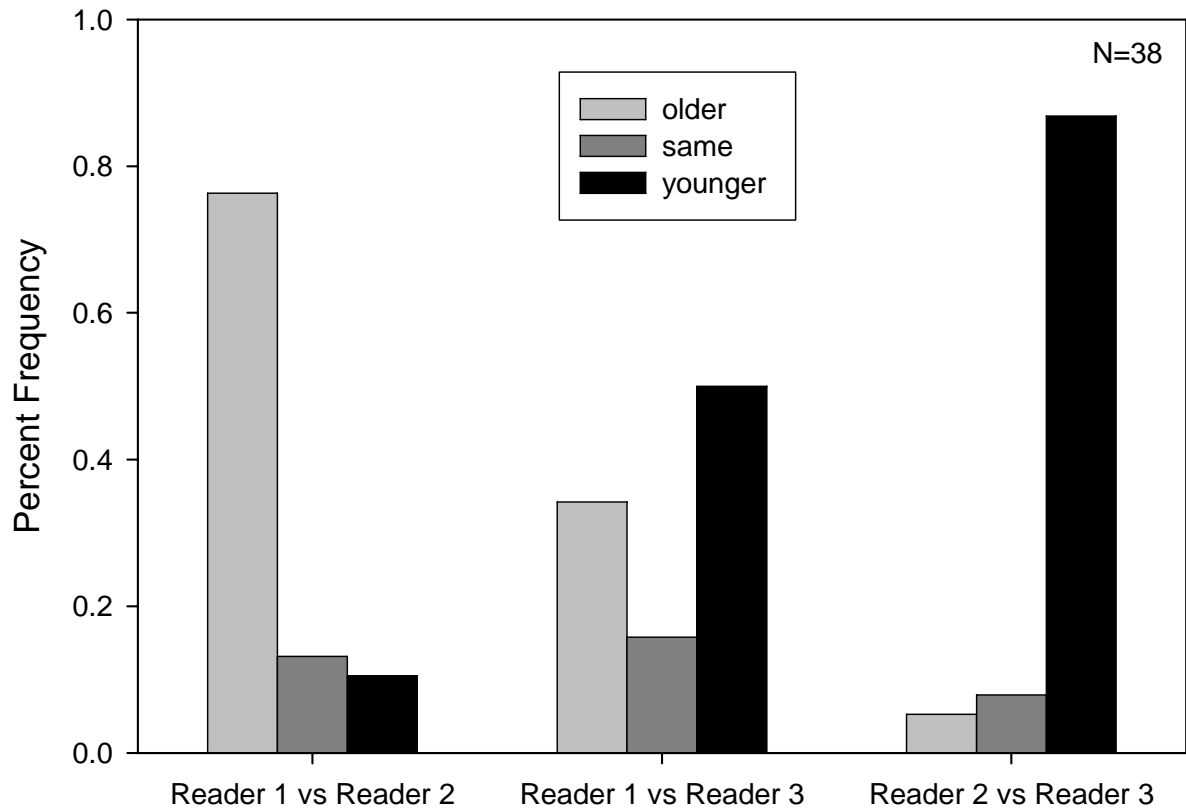


Figure 3. Percent frequency of the differences in age assignments by three readers of a sub-sample of the pectoral spine sections collected from white sturgeon in John Day Reservoir 2004.

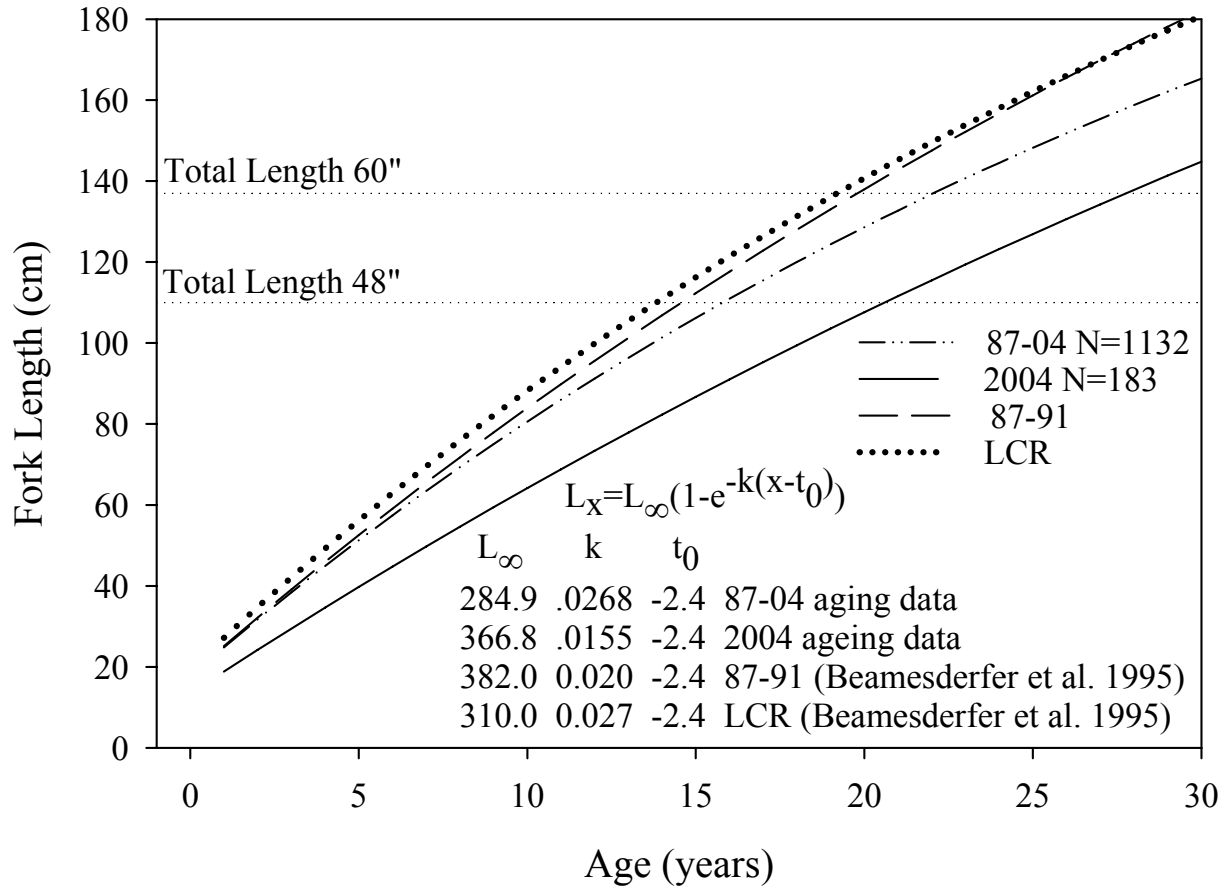


Figure 4. Comparison of von Bertalanffy growth parameters for white sturgeon collected from John Day Reservoir during 1897-1991, 1987-2004, and 2004. Also included are von Bertalanffy growth parameters for white sturgeon collected from the lower Columbia River (LCR).

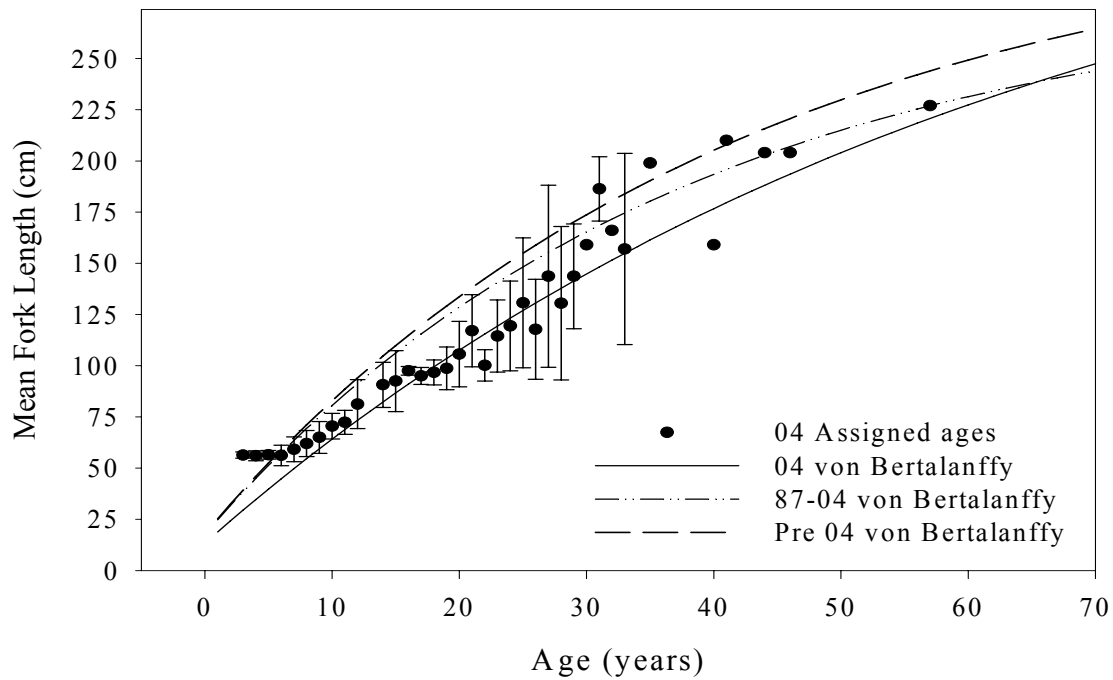


Figure 5. Comparison of ages assigned in 2004 with von Bertalanffy functions for 2004, 1987-2004, and pre-2004, John Day Reservoir white sturgeon. Error bars represent the standard deviation of the fork lengths.

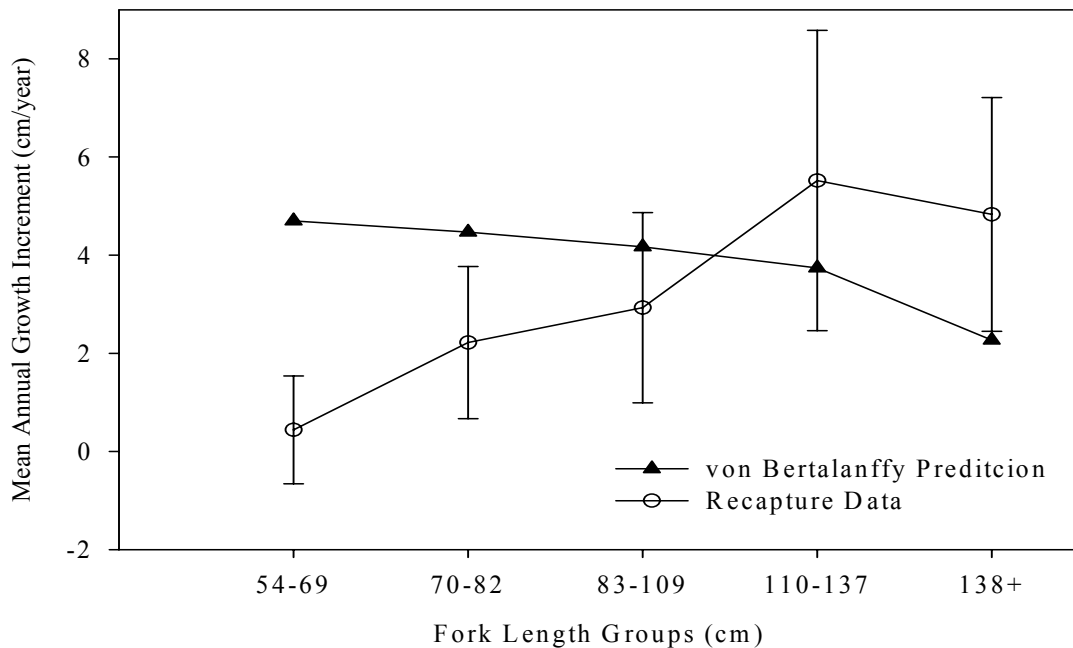


Figure 6. Comparison of mean annual growth increment (AGI) predicted by the von Bertalanffy growth function and AGI calculated from recaptures of tagged fish from John Day Reservoir. Error bars represent the standard deviation of the AGI.

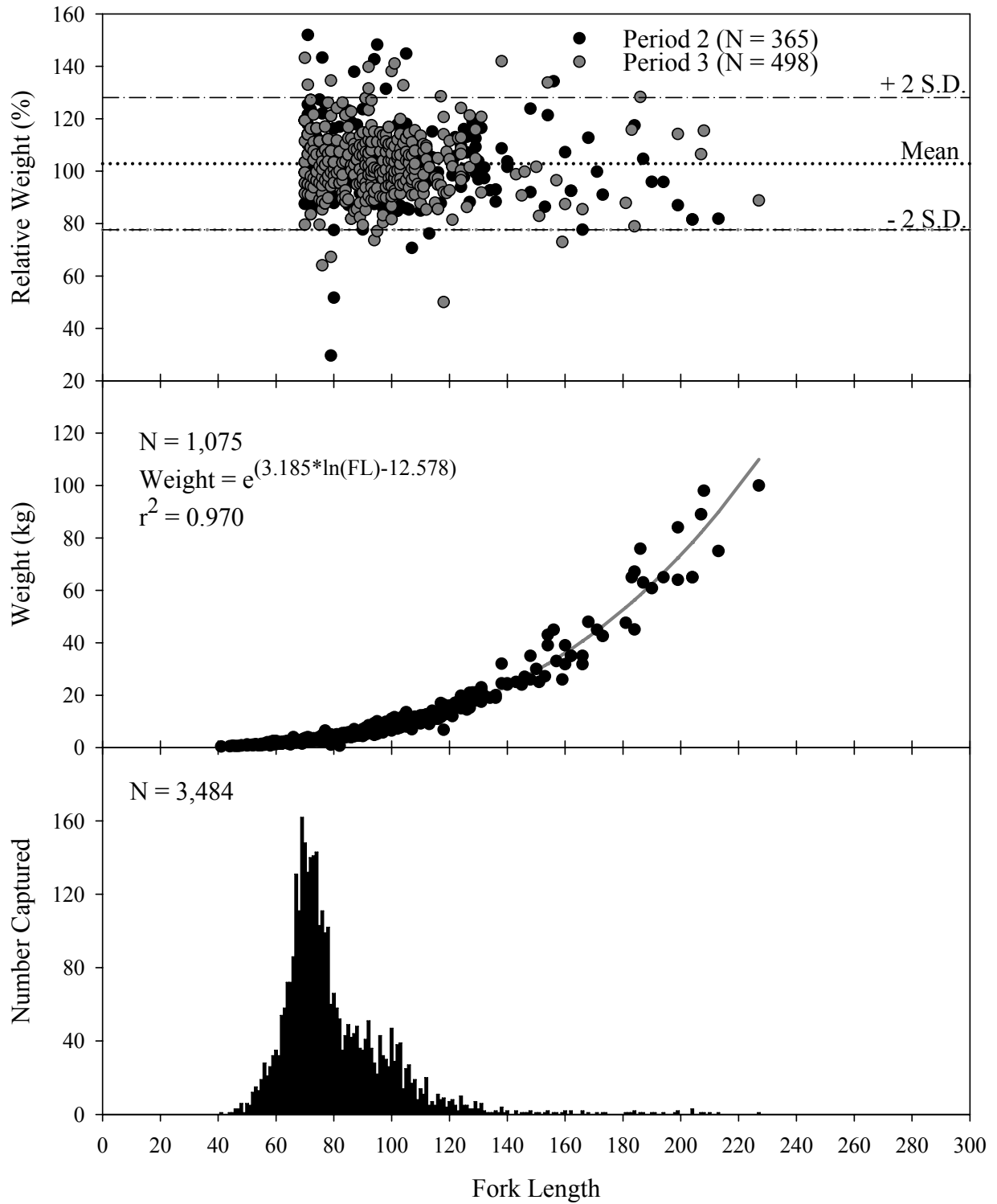


Figure 7. Relative weight, length-weight relationship, and length-frequency distribution of white sturgeon captured during John Day Reservoir stock assessment sampling, June – August 2004.

Abundance Estimates

From December 2003 through August 2004, 4,713 white sturgeon of various sizes were marked with PIT-tags by CRITFC and ODFW. Using the Schnabel multiple mark-recapture estimate, we estimated the abundance of 70-109 cm and 110-166 cm white sturgeon to be 28,794 (Table 7) and 1,279 fish respectively (Table 8). Based on length-frequency distributions and estimated abundance of fish 110-166 cm, we estimated the abundance of 110-137 cm (legal sport and commercial harvest size) white sturgeon to be 1,094 sturgeon (Table 9). Based on length-frequency distributions and estimated abundances of 70-109 cm sturgeon and sturgeon >166 cm, we estimated the abundance of white sturgeon 54-70 cm to be 12,968, and the abundance of fish >166 cm to be 457 fish (Table 9). The total estimated population of white sturgeon >54 cm in John Day Reservoir in 2004 was approximately 43,500 fish.

Table 7. Mark/recapture data and Schnabel abundance estimate of white sturgeon 70-109 cm fork length, John Day Reservoir 2004. Period one is winter sampling by CRITFC.

Period (t)	Catch (C)	Marks (M)	Recaps (R)	Mortalities		Marks at Large (Mt)	Estimate $(M_t * C) / (R + 1)$
				Unmarked	Marked		
1	2,227	1,988		72	0		
2	999	920	65	24	28	1,988	30,091
3	1,260	1,113	129	0	0	2,880	27,914
Sum	4,486	4,021	194			Estimate	28,794
						Lower 95% CI	25,034
						Upper 95% CI	33,116

Table 8. Mark/recapture data and Schnabel abundance estimate of white sturgeon 110-166 cm fork length, John Day Reservoir 2004. Period one is winter sampling by CRITFC.

Period (t)	Catch (C)	Marks (M)	Recaps (R)	Mortalities		Marks at Large (Mt)	Estimate $(M_t * C) / (R + 1)$
				Unmarked	Marked		
1	222	200		285	24		
2	106	94	10	40	17	176	1,696
3	88	67	21	0	0	253	1,012
Sum	416	361	31			Estimate	1,279
						Lower 95% CI	909
						Upper 95% CI	1,792

Table 9. Estimated abundances of white sturgeon in John Day Reservoir from 1996, 2001, and 2004, based on mark/recapture Schnabel estimates. Confidence intervals are only given for size groups for which a Schnabel estimate was performed, and not for size groups for which abundance was estimated by expansion from length-frequencies.

Size Class	Abundance by size class (95% Confidence Interval)		
	1996	2001	2004
54-69 cm	893	9,332	12,968
70-109 cm	24,590	18,334	28,794 (25,034-33,116)
110-137 cm	4,044	1,074	1,094
110-166 cm	4,400	1,290 (1,074-1,550)	1,279 (909-1,792)
70-166 cm	27,100 (23,800-30,800)	19,621	30,073
>166 cm	700	874 (443-1,618)	457
Total Abundance	30,600	29,831	43,498

Trawl and Haul Supplementation

The contracted trawler caught 321 white sturgeon in 56 trawl tows for an average of 5.7 fish per tow (Table 10). Mean trawl duration was 30 min. White sturgeon of various sizes were captured, although fish of the transportable size group of 30–90-cm fork length dominated the catch (92%, N = 293; Figure 7). Mean fork length of all fish sampled was 42.3 cm, the mean fork length of transplanted fish was 44 cm. Incidental catches of other fish species are shown in Appendix Table A-5. All suitable white sturgeon captured in 2004 were transplanted into John Day Reservoir (Table 11).

Table 10. Effort and catch of juvenile and sub-adult white sturgeon captured in the Columbia River downstream of Bonneville Dam (river kilometers 209-212) during October and November, 1993-2004.

Year, Agency	Sampling days	Number of trawls	Total catch	Mean catch	Mean trawl time (min)	Mean fishing depth (m)
1993						
NMFS ^b	3	19	564 ^a	29.7	10.0	18.6
USGS ^c	3	14	358 ^a	25.6	14.0	--
1994						
NMFS ^b	15	59	3,428 ^a	58.1	9.9	19.5
USGS ^c	5	22	365 ^a	16.6	10.0	--
1995						
NMFS ^b	12	102	5,974 ^a	58.6	10.4	20.3
1998						
NMFS ^b	14	118	10,362 ^a	87.8	8.6	17.8
1999						
NMFS ^b	14	132	4,728 ^a	32.2	12.3	18.0
2000 –2004 (Private trawlers)						
2000	15	100	5,705 ^a	57.1	20.5	11.2
2001	16	116	6,937 ^a	59.8	14.5	--
2002	16	101	5,375 ^a	53.2	17.2	--
2003	18	124	3,460 ^a	28.0	24.2	18.1
2004	9	56	321	5.7	30.0	16.4

^a Approximate number since some white sturgeon were not counted and immediately released at the capture site when tow catches were very large.

^b National Marine Fisheries Service, now NOAA Fisheries.

^c U. S. Geological Survey-Biological Resources Division

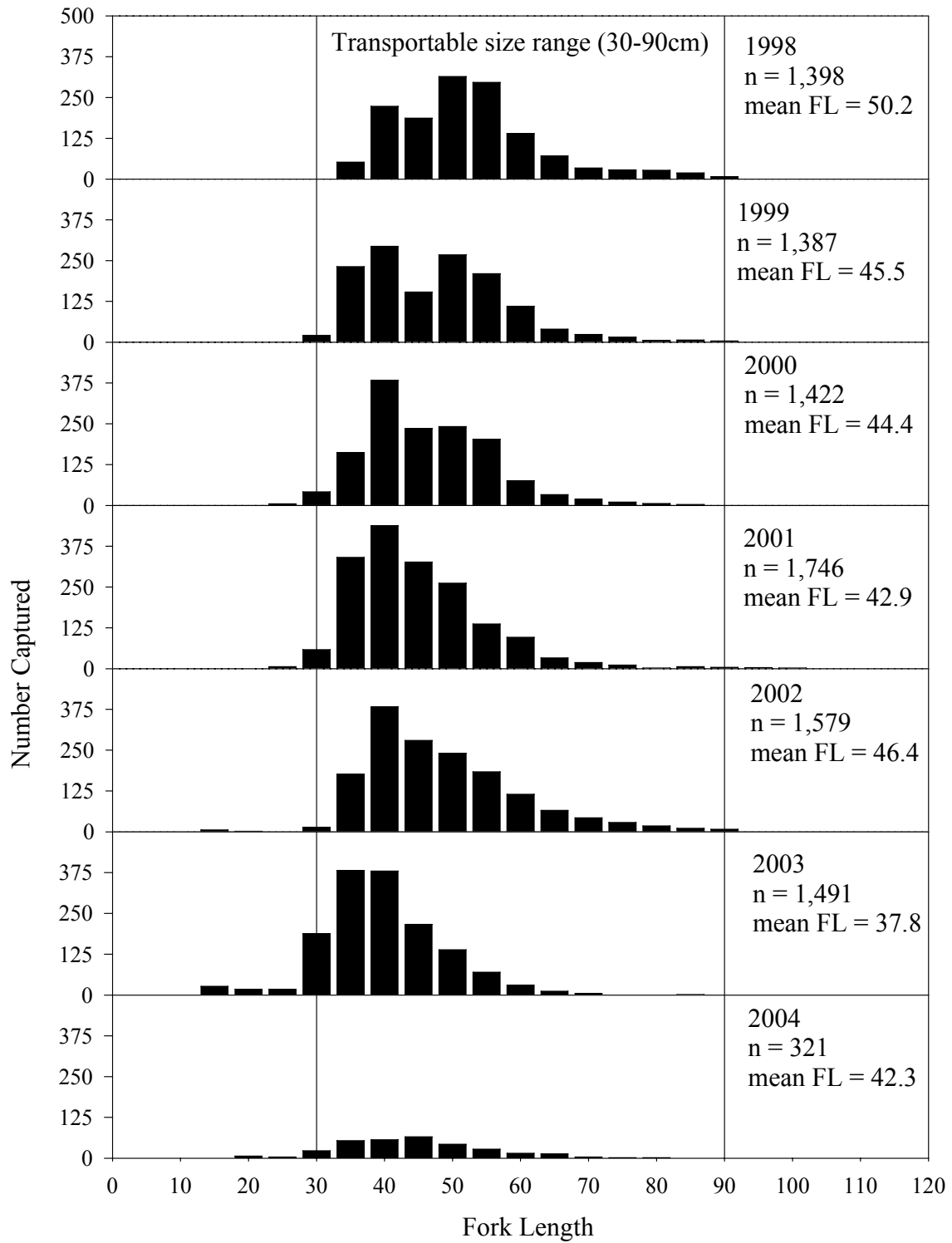


Figure 8. Length-frequency distributions of white sturgeon sampled during Trawl and Haul collections, 1994-2004.

Table 11. Number of white sturgeon transported from below Bonneville Dam to The Dalles and John Day reservoirs from 1994 – 2004.

Year	Release Reservoir		Total
	The Dalles	John Day	
1994	2,935	--	2,935
1995	5,611	--	5,611
1998	3,257	5,534	8,791
1999	77	4,171	4,248
2000	1,163	4,019	5,182
2001	1,257	5,195	6,452
2002	941	4,177	5,118
2003	10	2,941	2,961
2004	0	294	294
Total	15,251	26,341	41,592

Young-of-Year Indexing

We captured two YOY white sturgeon in The Dalles Reservoir. No YOY white sturgeon were captured in any other reservoir (Figure 9). Overall catch of white sturgeon during YOY sampling was highest in The Dalles Reservoir with 64 white sturgeon captured in 36 gill nets fished for a total of 803.1 hours (Table 13). We set 40 gill nets in John Day Reservoir and captured 27 white sturgeon in 890.0 hours of fishing. In McNary Reservoir, we caught 0 white sturgeon in 35 gill nets fished for a total of 774.5 hours. We fished 35 gill nets in Ice Harbor Reservoir for a total of 766.2 hours, and caught 4 white sturgeon. In Little Goose Reservoir we captured 3 white sturgeon in 36 nets fished for a total of 804.7 hours.

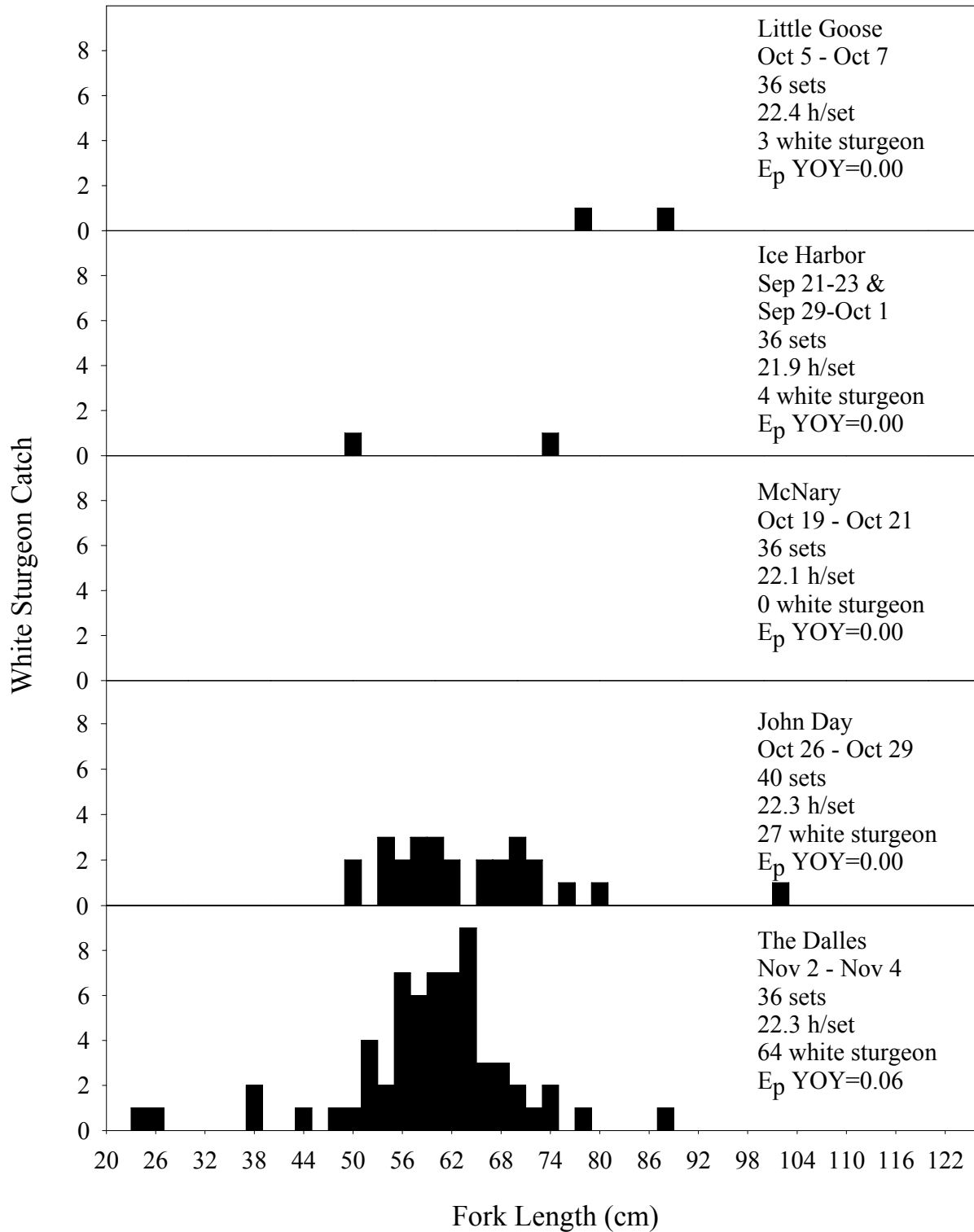


Figure 9. Length-frequency distributions and catch data for all white sturgeon captured during Young-of-Year indexing, October – November 2004.

Table 13. Young-of-year sampling gill-net effort and catch of white sturgeon in Columbia and Snake River reservoirs during October and November 2004.

Reservoir Parameter	Reservoir Quarter ^a				
	1	2	3	4	All
Little Goose					
Gill Net Sets	9	9	9	9	36
Total Hours	200	207.9	195.5	201.4	804.7
White Sturgeon Catch (all sizes)	0	3	0	0	3
White Sturgeon Catch (FL<30 cm)	0	0	0	0	0
White Sturgeon / Set	0.00	0.33	0.00	0.00	0.08
White Sturgeon (FL<30 cm)/Set	0.00	0.00	0.00	0.00	0.00
Sets with >0 white sturgeon (all sizes)	0%	33%	0%	0%	8%
Sets with >0 white sturgeon (FL<30 cm)	0%	0%	0%	0%	0%
Ice Harbor					
Gill Net Sets	8	9	9	9	35
Total Hours	175.4	192.3	202.3	196.3	766.2
White Sturgeon Catch (all sizes)	1	2	1	0	4
White Sturgeon Catch (FL<30 cm)	0	0	0	0	0
White Sturgeon / Set	0.11	0.22	0.11	0.00	0.11
White Sturgeon (FL<30 cm)/Set	0.00	0.00	0.00	0.00	0.00
Sets with >0 white sturgeon (all sizes)	11%	22%	11%	0%	11%
Sets with >0 white sturgeon (FL<30 cm)	0%	0%	0%	0%	0%
John Day					
Gill Net Sets	10	8	12	10	40
Total Hours	223.7	173.8	271.5	221	890.0
White Sturgeon Catch (all sizes)	1	0	11	15	27
White Sturgeon Catch (FL<30 cm)	0	0	0	0	0
White Sturgeon / Set	0.10	0.00	0.92	1.50	0.68
White Sturgeon (FL<30 cm)/Set	0.00	0.00	0.00	0.00	0.00
Sets with >0 white sturgeon (all sizes)	10%	0%	67%	70%	40%
Sets with >0 white sturgeon (FL<30 cm)	0%	0%	0%	0%	0%
McNary					
Gill Net Sets	26	9			35
Total Hours	574.1	200.4			774.5
White Sturgeon Catch (all sizes)	0	0			0
White Sturgeon Catch (FL<30 cm)	0	0			0
White Sturgeon / Set	0.00	0.00			0.00
White Sturgeon (FL<30 cm)/Set	0.00	0.00			0.00
Sets with >0 white sturgeon (all sizes)	0%	0%			0%
Sets with >0 white sturgeon (FL<30 cm)	0%	0%			0%

Table 13. Continued.

Reservoir Parameter	Reservoir Quarter ^a				
	1	2	3	4	All
The Dalles					
Gill Net Sets	9	6	15	6	36
Total Hours	192.3	131.1	344.1	135.7	803.1
White Sturgeon Catch (all sizes)	9	17	30	8	64
White Sturgeon Catch (FL<30 cm)	0	2	0	0	2
White Sturgeon / Set	1.00	2.83	2.00	1.33	1.78
White Sturgeon (FL<30 cm)/Set	0.00	0.33	0.00	0.00	0.06
Sets with >0 white sturgeon (all sizes)	44%	100%	53%	50%	58%
Sets with >0 white sturgeon (FL<30 cm)	0%	33%	0%	0%	6%

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

DISCUSSION

Stock Assessment

We continue to find very little movement of white sturgeon between reservoirs (Appendix Table A-1). Since 1987, only six (<1%) marked white sturgeon have been verified from stock assessment sampling as being captured in a reservoir upstream of the original marking location, 157 (2.7%) have been captured in the reservoir immediately downstream, and ten (<1%) have been captured two reservoirs downstream. However, the majority (5,646, or 97%) of recaptured sturgeon were recaptured within the reservoir they were originally marked in.

Final ages for white sturgeon captured in 2004 were compared to ages assigned in past years and resulted in a slight decrease in length-at-age for fish from John Day reservoir. The von Bertalanffy growth curve was compared to past years (Figure 4) and there is slight increase in assigned ages. The difference between ages assigned by Reader two and those assigned by Readers one and three, were likely due to the relative inexperience of Reader two. Increases in final assigned ages by Readers one and three may reflect an unintentional bias due to our awareness that we have tended to underestimate the age of individual fish in past years (Rien and Beamesderfer 1994). When substantial interpretation is required, we may tend to age in favor of older ages. Recent growth findings further highlight the need to develop or identify more accurate and objective means to quantify growth and age (Kern et al. 2003).

Estimated total abundance of white sturgeon in 2004 was higher than in 2001 (Table 9). The increase was slight in the 110-137 cm FL size class (1,074 in 2001; 1,094 in 2004), but was most dramatic in the <110 cm FL size class (27,666 in 2001; 41,762 in 2004). Abundance of “oversize” fish (>166 cm fork length) appears to have decreased since 2001 (down from 859 to 457). Estimates of oversize abundance should be viewed with caution. The magnitude of any real changes in oversize abundance between 2004 and 2001 may not be as high as our estimates

might seem to indicate at first glance. Due to low sample sizes, these estimates are typically derived from the relative proportion of fish of this size in the catch, not direct mark-recapture abundance estimates.

Trawl and Haul Supplementation

As in previous years, transplantation of white sturgeon from below Bonneville Reservoir to The Dalles and John Day reservoirs appears to be limited by the number of appropriate size fish we are able to capture. Catch rates in 2004 were the lowest since the Trawl-and-Haul program began. In general, we have observed an apparent decline in average size of fish captured each year as Trawl and Haul has continued (Figure 8). This trend did not continue this year, with slightly increased mean sizes of captured and transported fish; however, sample sizes were very low. We examined a number of factors, including water temperature, sampling protocols, and fishing depths, and have been unable to explain the low catch rate in 2004. It is important to note that although very little mortality has been observed during handling and transport, we have occasionally received reports of dead scute-marked white sturgeon at release sites following releases of Trawl-and-Haul fish. This indicates some amount of delayed mortality is occurring, but the magnitude of this mortality is unknown at this time.

Young-of-Year Indexing

As indicated by catch rates (CPUE and E_p) during YOY sampling, recruitment was again very poor in all sampled reservoirs in 2004. Average river flow at McNary Dam between 1 April and 31 July was 113 kcfs in 2001, 249 kcfs in 2002, 205 kcfs in 2003, and 183 kcfs in 2004 (Columbia River DART web page at www.cbr.washington.edu/dart/dart.html). Over the previous four years, YOY were present in The Dalles reservoir in 2002 and 2004, McNary reservoir in 2002, and absent in all other samples.

PLANS FOR NEXT YEAR

We will conduct a stock assessment survey in The Dalles Reservoir in 2005. We will continue to pursue methods for describing sturgeon growth in Zone 6 reservoirs and will attempt to create a new model, or refine existing models, to utilize measured sturgeon growth information using PIT-tag recoveries, rather than ageing, to describe growth.

We intend to conduct Trawl-and-Haul sampling in 2005 in the same fashion as in past years. Difficulties in securing contracts for private trawlers make fishing activities impractical to conduct on anything but a “full-scale” basis. If catch rates in the trawling area remain low this year, collecting fish for Trawl-and-Haul transplant at the current location may no longer be a cost-effective option. Following 2005 sampling, we will present results and make recommendations on the future of the Trawl-and-Haul program.

We will continue YOY indexing using gill nets to collect white sturgeon in the fall of 2005. We will assist Washington Department of Fish and Wildlife personnel with creel sampling in order to assess harvest rates of white sturgeon in Bonneville, The Dalles, and John Day reservoirs.

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APPENDIX

Appendix Table A-1. Summary of within and out-of-reservoir recaptures of marked white sturgeon within the Columbia Basin, 1987-2004. Upstream 1 refers to sturgeon captured upstream of the reservoir they were marked in (no fish were recaptured more than one reservoir upstream). Downstream 1 refers to sturgeon recaptured one reservoir downstream of where they were originally marked, Downstream 2 refers to fish recaptured two reservoirs downstream, etc. Numbers of recaptures are cumulative from date of release until the end of 2004.

Reservoir	Release year	Recapture Location					
		Upstream 1	Within	Downstream 1	Downstream 2	Downstream 3	Downstream 4
McNary	1993	--	22	4	2	--	--
	1995	--	30	8	--	--	--
	<i>Total</i>	--	52	12	2	--	--
	Percent	--	78.79%	18.18%	3.03%	--	--
John Day	1989	--	6	1	--	--	--
	1990	--	122	12	1	--	--
	1991	--	17	--	--	--	--
	1996	--	527	27	3	--	--
	2001	--	1,142	2	1	--	--
	2004	--	339	2	--	--	--
	<i>Total</i>	--	2,153	42	5	--	--
Percent	--	97.86%	1.91%	0.23%	--	--	
The Dalles	1987	1	198	4	1	--	--
	1988	--	233	24	1	--	--
	1989	1	36	--	--	--	--
	1991	1	71	1	--	--	--
	1993	--	2	1	1	--	--
	1994	--	431	10	--	--	--
	1995	--	448	12	--	--	--
	1997	1	384	12	--	--	--
	2002	--	188	6	--	--	--
	<i>Total</i>	4	1,991	70	3	--	--
Percent	0.19%	96.46%	3.39%	0.15%	--	--	
Bonneville	1988	--	70	4	--	--	--
	1989	--	336	17	--	--	--
	1991	1	126	12	--	--	--
	1993	--	--	--	--	--	--
	1994	--	138	--	--	--	--
	1999	1	453	--	--	--	--
	2003	--	327	--	--	--	--
	<i>Total</i>	2	1,450	33	--	--	--
Percent	0.17%	97.77%	2.85%	--	--	--	

Appendix Table A-2. Summary of white sturgeon tagged in Bonneville Reservoir and recaptured within Bonneville and in other reservoirs.

		Released in Bonneville						
		1988	1989	1991	1993	1994	1999	2003
Number marked during regular sampling		341	2,131	1,141	--	2,332	6,143	6,333
Number marked during other sampling activities ^a		--	--	--	8a	--	--	--
Total number marked		341	2,131	1,141	8	2,332	6,143	6,333
Recaptured in McNary (upstream reservoir)	none to date							
Recaptured in John Day (upstream reservoir)	none to date							
Recaptured in The Dalles (upstream reservoir)	1988		--	--	--	--	--	--
	1989			--	--	--	--	--
	1990			--	--	--	--	--
	1991				--	--	--	--
	1992				--	--	--	--
	1993					--	--	--
	1994						--	--
	1995						--	--
	1996			1			--	--
	1997						--	--
Recaptured in Bonneville	1988	2	--	--	--	--	--	--
	1989	44	91	--	--	--	--	--
	1990	5	46	--	--	--	--	--
	1991	11	89	33	--	--	--	--
	1992		19	23	--	--	--	--
	1993	2	12	13		--	--	--
	1994	4	37	36		21	--	--
	1995	1	7	4		11	--	--
	1996		9	5		12	--	--
	1997	1	7	4		4	--	--
	1998						--	--
	1999		19	8		90	453	--
	2003							327
Recaptured in Lower Columbia River	1988		--	--	--	--	--	--
	1989	4	4	--	--	--	--	--
	1990		1	--	--	--	--	--
	1991		7	2	--	--	--	--
	1992		3	1	--	--	--	--
	1993		1	5		--	--	--
	1994			1			--	--
	1995			2			--	--
	1996		1	1			--	--
	1997						--	--
1998						--	--	
1999						--	--	

^a Sturgeon marked during radio tagging experiments.

Appendix Table A-3. Summary of white sturgeon tagged in The Dalles Reservoir and recaptured within The Dalles and in other reservoirs.

		Released in The Dalles								
		1987	1988	1989	1991	1993	1994	1995	1997	2002
Number marked during regular sampling		837	1,248	147	379	--	1,312	--	5,797	2,736
Number marked during other sampling ^{a,b}		--	--	--	--	7 ^a	2,935 ^b	5,611 ^b	--	--
Total number marked		837	1,248	147	379	7	4,247	5,611	5,797	2,736
Recaptured in McNary (upstream reservoir)	none to date									
Recaptured in John Day (upstream reservoir)	1987	1	--	--	--	--	--	--	--	
	1988			--	--	--	--	--	--	
	1989				--	--	--	--	--	
	1990				--	--	--	--	--	
	1991					--	--	--	--	
	1992				1	--	--	--	--	
	1993						--	--	--	
	1994							--	--	
	1995								--	
	1996			1					--	
	1997									
	1998									
	1999								1	
	2001									
Recaptured in The Dalles	1987	69	--	--	--	--	--	--	--	--
	1988	86	115	--	--	--	--	--	--	--
	1989	16	58	3	--	--	--	--	--	--
	1990	6	15	1	--	--	--	--	--	--
	1991	13	24	4	7	--	--	--	--	--
	1992	3	7	1	5	--	--	--	--	--
	1993	1	7	1	9		--	--	--	--
	1994	3	6	6	15		30	--	--	--
	1995						3		--	--
	1996				1		1		--	--
	1997	1	17	20	31		385	448	268	--
	1998									--
	1999									--
	2002									296
Recaptured in Bonneville	1987		--	--	--	--	--	--	--	
	1988			--	--	--	--	--	--	
	1989		4		--	--	--	--	--	
	1990	2	1		--	--	--	--	--	
	1991	1	14			--	--	--	--	
	1992		1			--	--	--	--	
	1993	1	2				--	--	--	
	1994		1					--	--	
	1995								--	
	1996					1			--	
	1997									
	1998									
	1999		1				10 ^c	12 ^c	11	--
	2003				1				1	6

		Released in The Dalles								
		1987	1988	1989	1991	1993	1994	1995	1997	2002
Number marked during regular sampling		837	1,248	147	379	--	1,312	--	5,797	2,736
Number marked during other sampling ^{a,b}		--	--	--	--	7 ^a	2,935 ^b	5,611 ^b	--	--
Total number marked		837	1,248	147	379	7	4,247	5,611	5,797	2,736
Recaptured in Lower Columbia River	1987	1	--	--	--	--	--	--	--	--
	1988			--	--	--	--	--	--	--
	1989				--	--	--	--	--	--
	1990				--	--	--	--	--	--
	1991					--	--	--	--	--
	1993					1	--	--	--	--
	1994		1					--	--	--
	1995								--	--
	1996								--	--
	1997									--
1998										
1999										

^a Sturgeon marked during radio tagging experiments.

^b Sturgeon marked as part of Trawl and Haul Program. Fish were captured in the Lower Columbia River, marked, and transported to The Dalles Reservoir in the fall of 1994 and 1995.

^c Some recaptures (7 from 1994 and all 12 from 1995 markings) were originally marked as part of the Trawl and Haul program, released into The Dalles Reservoir, and recaptured in Bonneville Reservoir in 1999.

Appendix Table A-4. Summary of white sturgeon marked in John Day Reservoir and recaptured within John Day and in other reservoirs.

		Released in John Day					
Number Marked		1989	1990	1991	1996	2001	2004
		21	516	85	4,111	3,757	3,713
Recaptured in McNary (upstream reservoir)	none to date						
Recaptured in John Day	1989		--	--	--	--	--
	1990	3	35	--	--	--	--
	1991		29		--	--	--
	1992		7	1	--	--	--
	1993	1	2		--	--	--
	1994		4	1	--	--	--
	1995		2	1	--	--	--
	1996	2	38	12	238	--	--
	1997			1	126	--	--
	1998					--	--
	1999					--	--
	2001		3	1	621	637	--
	2004	2	2		163	521	346
Recaptured in The Dalles	1989		--	--	--	--	--
	1990			--	--	--	--
	1991	1	1		--	--	--
	1992				--	--	--
	1993		1		--	--	--
	1994		3		--	--	--
	1995				--	--	--
	1996					--	--
	1997		7		9	--	--
	1998					--	--
	1999					--	--
Recaptured in Bonneville	1989		--	--	--	--	--
	1990			--	--	--	--
	1991		1		--	--	--
	1992				--	--	--
	1993				--	--	--
	1994				--	--	--
	1995				--	--	--
	1996					--	--
	1997					--	--
	1998					--	--
	1999				3	--	--
	2003					1	--

Appendix Table A-5. Summary of white sturgeon tagged in McNary Reservoir and recaptured within McNary and in other reservoirs.

		Released in McNary	
		1993	1995
		156	787
Recaptured in McNary	1993	6	--
	1994	4	--
	1995	7	13
	1996	2	10
	1997	3	7
Recaptured in John Day	1993	2	--
	1994	1	--
	1995		
	1996		2
	1997		1
	1998		
	1999		
	2000		
	2001	1	3
	2002		
	2003		
	2004		2
Recaptured in The Dalles	1993		--
	1994		--
	1995		
	1996		
	1997	2	
	1998		
	1999		
2000			
2001			
Recaptured in Bonneville	none to date		

Appendix Table A-6. Species composition from Trawl and Haul, October and November 2004.

Species	Date									Total
	10/18	10/19	10/20	10/21	10/25	10/26	11/01	11/02	11/08	
American shad	200	17	196	89	271	604	600	14	658	2,649
Cottid spp.			3		1	6	2	4		16
Unknown dace				1						9
Largescale sucker				5				1		15
N. pikeminnow		5	2	8						196
Peamouth chub	2	28	69	66	9	8	13	1		57
Sandroller		1	8	4	4	2	37	1		2
Starry flounder		9		5	3	8	11	3		39
Yellow perch					1		1			1
Tadpole					2					2
White Sturgeon	3	36	84	96	6	22	24	49	1	321
Season Total	205	96	362	274	297	650	691	73	659	3,307

Appendix Table A-7. Species composition from Young-of-Year index sampling, October – November 2004.

Species	Reservoir																				Total
	Little Goose				Ice Harbor				McNary				John Day				The Dalles				
	Disposition				Disposition				Disposition				Disposition				Disposition				
	1	2	3	All	1	2	3	All	1	2	3	All	1	2	3	All	1	2	3	All	
American Shad	1		13	14	1			1							27	27			1	1	43
Bullhead								1				1									1
Bridgelip Sucker	4		2	6	3		1	4	5		9	14	4		5	9					33
Channel Catfish	282		14	296	648		88	736	169		3	172	15		5	20					1,224
Cottid Sp.			1	1					2		3	5	5		2	7	2		1	3	16
Chinook	2		3	5									1			1		1	1	1	7
Chiselmouth	12		2	14	2		2	4	38		54	92	2			2	2		1	3	115
Coho					2		1	3													3
Carp					1			1	1			1	1			1	3			3	6
Crappie			7	7	7		40	47	1			1									55
Largescale Sucker	51		43	94	3		3	6	3		15	18	8		1	9	4		3	7	134
Pikeminnow	174		440	614	27		58	85	22		45	67	5		9	14	12	6	60	78	858
Peamouth Chub	98		558	656	148		1,151	1,299	19		92	111	4		9	13	74		332	406	2,485
Pumkinseed											1	1					1		1	2	3
Smallmouth Bass					3		3	6	1		1	2	3			3					11
Steelhead							2	2													2
Walleye							2	2			2	2	3		13	16	5	1	7	13	33
White Sturgeon	3			3	4			4					26		1	27	63		1	64	98
Whitefish	1		1	2																	2
Yellow Perch	20		17	37	58		184	242	74	38	485	597	26		274	300	25	6	90	121	1,297
All	648		1,101	1,749	907		1,535	2,442	336	38	710	1,084	103		346	449	191	14	497	702	6,426

Disposition: 1=alive and released, 2=sacrificed, 3=dead or dying at capture.

Appendix Table A-8. Abundance estimates for Zone 6 reservoirs and the Hanford Reach of McNary Reservoir, 1987 – 2004.

Year	30-72 inch total length Ñ(95% CI)	Number of fish by total length interval (inches)					Sum	Number/ acre ^a	Pounds/ acre ^a
		24-36	36-48	48-60	60-72	72+			
<u>Hanford Reach and McNary Reservoir</u>									
1995	5,234 (3,782-9,086)	900	2,700	3,400	1,250	8,250	0.2	8	
<u>Bonneville Reservoir</u>									
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	--
<u>The Dalles Reservoir</u>									
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	--
1997	59,800 (52,400-68,100)	26,500	38,500	8,100	200	200	73,500	6.6	59
2002	33,000 (26,200-42,000)	82,900	13,500	5,900	1,200	800	104,300	9.4	104
<u>John Day Reservoir</u>									
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 pooled from estimates of other size classes, 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 2004 – MARCH 2005

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 2004 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 2004 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 sturgeon during June 26 – December 31, 2004 in Bonneville Reservoir, with an estimated harvest of 852 fish (122% of the 2004 guideline). The fishery in The Dalles Reservoir was closed to the retention of sturgeon during June 28 – December 31, with an estimated harvest of 530 fish (133% of guideline). The John Day Reservoir was closed to retention during July 12 – December 31, with an estimated harvest of 229 fish (139% of guideline).

Treaty Indian commercial fishers landed 464 white sturgeon from Bonneville Reservoir (116% of guideline), 975 from The Dalles Reservoir (108% of guideline), and 309 from John Day Reservoir (92% of guideline) during the 2004 gill net and setline fisheries. The Columbia River Inter-Tribal Fish Commission and the Yakama Indian Nation estimated an additional 269 fish were harvested from the three reservoirs (60 from Bonneville Reservoir, 172 from The Dalles Reservoir, and 37 from John Day Reservoir) during the 2004 subsistence fisheries. The treaty commercial slot limit in Bonneville Reservoir was changed from 48-60 inches to 45-60 inches beginning with the winter gillnet fishery.

Harvest guidelines for Bonneville Reservoir were reduced to 700 sport and 400 commercial kept sturgeon beginning with the 2004 season. Harvest guidelines for The Dalles Reservoir were reduced to 400 sport and 900 commercial kept sturgeon in 2003. Harvest guidelines for John Day Reservoir were reduced to 165 sport and 335 commercial kept sturgeon in 2002.

A growing interest in catch and release of oversized sturgeon will require additional monitoring of anglers (especially during non-retention seasons) in the John Day Reservoir where such activity is already established.

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 funded Project 198605000 titled: White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam. The reporting period includes activities initiated in January and concluded in December 2004.

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

Objective 1) Develop, recommend, and implement mitigation actions that do not involve changes to hydro-system operation and configuration to mitigate for lost white sturgeon productivity in impoundments where development and operation of the hydrosystem has reduced production.

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

WDFW was contracted to work on Tasks 1.3, 3.1, and 3.2 during the performance period.

Task 1.3 involved modeling of sturgeon populations in Bonneville, The Dalles and John Day reservoirs, for which WDFW supplied harvest data to ODFW. This work was presented 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. Task 1.3 also required WDFW to conduct periodic sampling of the Zone 6 recreational and commercial fisheries, and to provide technical input to the in-season management of those fisheries.

Task 3.1 involved monitoring the status of sturgeon populations in the three Zone 6 reservoirs. WDFW worked closely with ODFW to conduct a multiple pass mark-recapture study of the John Day reservoir sturgeon population (see Report A in this annual report). Another aspect of this task was working with sport-fishing guides 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 OSU 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 3.2 involved indexing annual white sturgeon recruitment in impoundments. We worked with staff from ODFW and the Columbia River Inter-Tribal Fish Commission (CRITFC) to sample for young-of-year (YOY; Age-0) white sturgeon (see Report A and Report C in this annual report) in impoundments between The Dalles and Priest Rapids dams on the Columbia River and downstream from Lower Granite Dam on the Snake River.

METHODS

Sport Fishery Census

The 2004 sport fishery census was conducted in Bonneville and The Dalles reservoirs, and that portion of the John Day Reservoir between McNary Dam and Crow Butte Island (Rkm 423; Figure 1), 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 (with WDFW having lead responsibility for this task).

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

Angling effort (angler hours) was estimated by counting anglers within index areas and expanding those counts to represent 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 angler effort index areas (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. One index area was changed in 2000 to account for a shift in Oregon bank angler effort within Bonneville Reservoir (James et al., 2001). 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 for boat anglers for that subsection. White sturgeon harvest by bank anglers was calculated in a different manner. 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. Therefore, 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 2004 was used to adjust the 2004 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. Landings by reservoir were estimated from the catch area reported on fish receiving tickets. The legal size slot for treaty Indian commercial fisheries was broadened from 122-152 cm (48-60 in) total length (TL) to 114-152 cm (45-60 in) TL in Bonneville Reservoir (beginning with the winter gillnet fishery), and kept at 122-152 cm (48-60 in) TL in The Dalles and John Day reservoirs. CRITFC and Yakama Indian Nation (YIN) conducted unstructured interviews of treaty Indian fishers to estimate subsistence harvest of white sturgeon, in each reservoir.

RESULTS

Sport Fishery Census

Bonneville Reservoir

We began our survey of the 2004 sport fishery on January 2, and continued sampling through June 25. State fishery managers opened the white sturgeon fishery to retention on January 1 and closed the fishery to retention on June 26, based on our in-season projection that harvest would reach the guideline by that date. The final estimated harvest (852) was 122% of the 700 sturgeon guideline.

Anglers fished an estimated 76,073 hours (14,401 trips) in Bonneville Reservoir during the retention season (Table 1). Angling effort for sturgeon comprised 66% (9,522 trips) of the total estimated effort. The estimated number of angler trips (and percent of total estimated effort) for other target species were as follows: 836 (6%) for anadromous salmonids, 644 (4%) for American shad *Alosa sapidissima*, 140 (1%) for walleye, 1,165 (8%) for bass, 1,975 (14%) for northern pikeminnow, and 119 (1%) for other resident fish, and 0 (0%) for anglers participating in tournaments.

Anglers made an estimated 9,522 trips for sturgeon during the retention season (Table 2); a 45% decrease in harvest and 3% decrease in angler trips from the 2003 retention period. The fishery for white sturgeon encompassed the entire reservoir, although most of the harvest occurred downstream of Hood River, Oregon (Rkm 271). Harvest per angler trip (boat and bank combined) peaked in June at 0.13 fish per trip and averaged 0.06 fish per trip for bank anglers and 0.16 fish per trip for boat anglers targeting sturgeon during the retention fishery (Table 3). The 1,642 sturgeon anglers interviewed accounted for 15% of the estimated bank effort (angler hours) and 9% of the estimated boat effort for sturgeon (Table 4).

Anglers released 23% of the legal-size catch during the retention period (Table 4), due in part to the daily bag limit regulation, which allowed retention of only one fish. 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 94%, 4%, and 2%, respectively. The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 95-138 cm FL (most of the 42-60 in TL) fish decreased from 2003 levels for both boat and bank anglers, due to the reduced guideline (Tables 6 and 7).

Since 1995, oversize catch in Bonneville Reservoir has ranged from 0.1% to 5.7% of total catch. Oversize catch increased to its highest point in 2001, and from 2001-2004 averaged nearly twenty times the 1995-2000 average (Table 8). Bonneville Reservoir has the greatest percentage increase in average oversize catch of the three Zone 6 reservoirs.

The Dalles Reservoir

We began our survey of the 2004 sport fishery on January 2 and continued sampling through June 27. State fishery managers opened the white sturgeon fishery to retention on January 1, and closed the fishery to retention on June 28. The final estimated harvest (530) was 133% of the 400 sturgeon guideline.

Anglers fished an estimated 107,612 hours (15,994 trips) in The Dalles Reservoir during the retention season (Table 1). Angling effort for white sturgeon comprised 40% (6,333 trips) of the total estimated effort. The estimated number of angler trips (and percent of total estimated effort) for other target species were as follows: 3,704 (23%) for anadromous salmonids, 928 (6%) for American shad, 2,476 (15%) for walleye, 922 (6%) for bass, 1,504 (9%) for northern pikeminnow, 103 (1%) for other resident fish, and 24 (<1%) for anglers participating in tournaments.

Anglers made an estimated 6,333 trips for sturgeon during the retention period (Table 2). The primary sport fishery for white sturgeon extended from the John Day Dam tailrace downstream to Miller Island (Rkm 327). More white sturgeon anglers fished from the bank than from boats (Table 3). The harvest per trip (boat and bank combined) peaked in June at 0.15 fish per trip. Harvest per trip averaged 0.06 for bank anglers and 0.11 for boat anglers targeting sturgeon during the retention fishery. The 1,481 white sturgeon anglers interviewed accounted for 17% of the total estimated bank effort (angler hours) and 14% of the total estimated boat effort for white sturgeon (Table 4).

Anglers released 12% of the legal-size catch during the retention period (Table 4). The percentage of sub-legal (<122 cm TL; <48 in TL), legal (122-152 cm TL; 48-60 in TL; both kept and released), and oversize (>152 cm TL; >60 in TL) white sturgeon in the sampled catch was 92%, 5%, and 3%, respectively (Table 4). This distribution of catch by size is identical to the distribution in 2003. The length distribution of the sampled harvest is presented in Table 5. Bank anglers' harvest per trip of 110-138 cm FL (most of the 48-60 in TL) fish more than doubled from the previous year, while boat anglers' harvest per trip decreased (Table 6).

Since 1995, oversize catch in The Dalles Reservoir has ranged from 0.5% to 4.5% of total catch. The 2000-2004 average catch was twice the 1998-1999 average catch, and nearly eighteen times that of 1995-1997 (Table 8).

John Day Reservoir

We began our survey of the 2004 sport fishery in John Day Reservoir on January 2 and continued sampling through July 11. The white sturgeon fishery was opened to retention on January 1, and closed to retention on July 12. The final estimated harvest (229) was 139% of the 165 sturgeon guideline.

Anglers fished an estimated 135,906 hours (24,161 trips) in John Day Reservoir during 2004 (Table 1). Angling effort for white sturgeon comprised 33% (7,959 trips) of the total estimated effort. The estimated number of angler trips (and percent of total estimated effort) for other target species were as follows: 3,869 (16%) for anadromous salmonids, 685 (3%) for American shad, 7,142 (29%) for walleye, 3,843 (16%) for bass, 6 (<1%) for northern pikeminnow, 257 (1%) for other resident fish, and 400 (2%) for tournament anglers.

Anglers made an estimated 7,959 trips for sturgeon in 2004 (Table 2). Anglers concentrated their effort for sturgeon from McNary Dam downstream past Irrigon, Oregon to Rkm 449. Harvest per trip (boat and bank combined) peaked in July at 0.07 fish (Table 3). Harvest per trip averaged 0.02 for bank anglers and 0.04 for boat anglers (Table 3). The 2,125 sturgeon anglers interviewed accounted for 12% of the estimated bank effort (angler hours) and 29% of the estimated boat effort for white sturgeon (Table 4).

Anglers released 13% of the legal-size catch during the retention period (Table 4). The percentage of sub-legal (<122 cm TL; <48 in TL), legal (122-152 cm TL, 48-60 in TL; both kept and released), and oversize (>152 cm TL, >60 in TL) white sturgeon in the reported catch was 87%, 2%, and 11%, respectively (Table 4), and is nearly identical to the distribution in 2003. The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 110-138 cm FL (most of the 48-60 in TL) fish increased for both boat and bank anglers from 2003 levels (Table 6).

Since 1995, oversize catch in John Day Reservoir has ranged from 1.3% to 12.8% of total catch. The 2001-2004 average catch was 34% higher than the 1997-2000 average catch, and over twelve times that of 1995-1996 (Table 8). John Day Reservoir has both the greatest quantity increase in oversize catch and the highest percentage of total catch attributed to oversize fish of the three Zone 6 reservoirs. It also has the lowest harvest guideline.

Treaty Indian Commercial and Subsistence Harvest

The 2004 treaty Indian commercial harvest estimates for Zone 6 were 464 white sturgeon from Bonneville Reservoir, 975 white sturgeon from The Dalles Reservoir, and 309 white sturgeon from John Day Reservoir (Table 7). The expanded legal slot size may have contributed to the harvest increase in Bonneville Reservoir. The total commercial sturgeon harvest for 2004 was landed during the winter gill net fishery in all three reservoirs. No sturgeon were

commercially harvested during the authorized January 2004 setline fishery. The treaty Indian Zone 6 subsistence white sturgeon harvest estimated by CRITFC and YIN was 269 fish (Table 7): 60 from Bonneville Reservoir; 172 from The Dalles Reservoir; and, 37 from John Day Reservoir. Forty-three percent of the subsistence harvest occurred during the winter gillnet fishery, with 6% (15), 26% (70), and 25% (67) in the spring, summer, and fall setline fisheries, respectively (Doug Case, ODFW, personal communication).

DISCUSSION

Zone 6 Sturgeon Harvest Management

In-season Harvest Estimates

Harvest guidelines were significantly exceeded in all three reservoirs this season. Much of our time was consumed by internal personnel issues, which reduced available time for in-season harvest tracking, and forced us to use a quicker but less accurate in-season harvest estimator. The personnel issues have been largely resolved and further resolution is continuing, so we should be able to use our regular in-season estimator in the future. Note that this problem did not impact our ability to produce accurate post-season estimates.

Bonneville Reservoir

Since the 1,520 fish guideline began in 1997, the recreational boat anglers' harvest per unit effort (HPUE) has declined, while their effort has increased. For bank anglers, HPUE has declined, while effort has fluctuated. The proportion of effort attributed to each group remained roughly stable from 1988 - 2002 (slightly favoring bank anglers). Beginning in 2003 the effort shifted in favor of boat anglers. Combined sport and commercial harvest has trended downward since 1997. As a result, the 2004 sport and commercial guidelines were cut to 700 and 400 fish, respectively. This guideline decrease was a primary reason for the harvest decrease in 2004. Also, in spite of a similar season length and only a small decrease in sport effort, bank HPUE dropped by 15% and boat HPUE dropped by 48% from 2003. The portion of fish harvested within the smallest 15 cm of the legal-size slot (≤ 109 cm Fork Length; i.e., 107 - 122 cm Total Length), went from 64% during the 2001 season (Langness et al. 2002) to 81% during the 2004 season. Thus, a greater portion of retained fish was composed of fish just recruiting into the legal size slot.

The 2003 Bonneville Stock Assessment (Kern et al., in press) also supports the analysis of harvest. Both approaches validate the 2004 harvest guideline reduction.

The Dalles Reservoir

There was a significant guideline increase in 1998. From 1999 through 2002, effort remained fairly stable, however, the HPUE trended down in both the boat and bank angler fisheries. Subsequently there was a 43% guideline decrease in 2003. Boat anglers have since

shown an increase in effort with a decrease in HPUE. On the other hand, bank anglers experienced a decrease in effort with an increase in HPUE. After only 2 seasons it is too early to assess the impact of the guideline reduction.

Stock abundance estimates from the 1997 The Dalles Reservoir stock assessment (North et al., 1999), supported the increase of the recreational harvest guideline to 700 fish in 1998. Season length since 1998 has shown an increasing trend, contrary to guideline changes. Size composition of the catch has also declined (75% of the 2004 harvested fish were in the smallest 15 cm of the legal-size range (≤ 124 cm Fork Length; i.e., 122-137 cm Total Length), versus 66% of the 2003 harvest, 69% of the 2002 harvest and 64 % of the 2001 harvest). These weak trends in season-length and size-composition suggest that the current guidelines may need further reduction.

The 2002 stock assessment in The Dalles Reservoir provides additional information indicating a reduction in abundance of legal-sized fish. 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).

John Day Reservoir

Recreational effort initially rose following the adoption of the 560 fish guideline in 1997. After peaking in 1999, the effort declined. Boat and bank angler HPUEs have shown a general decline since 1997. The proportion of effort attributed to each group has remained generally stable since 1989 (slightly favoring boat anglers). Size composition of the catch has shifted towards smaller fish (85% of the 2004 harvested fish were in the smallest 15 cm of the legal-size range (≤ 124 cm Fork Length; i.e., 122-137 cm Total Length), versus 83% of the 2003 harvest, 67% of the 2002 harvest and 37 % of the 2001 harvest).

The 2001 stock assessment (Kern et al. 2002) estimated a slight increase in the sub-legal population size from 25,500 in 1996 to 27,667 in 2001, and a drastic decline in the legal-sized population from 4,040 in 1996 to 1,077 in 2001. Thus, the shift in size composition of harvested fish may reflect the passing of a series of poor year-classes through the legal-size slot.

The recreational harvest guideline was not achieved in most years from 1997-2001. This inability to harvest 560 fish, combined with a lower legal-sized population abundance estimate and indications of poor recruitment into the fishery, resulted in lowering the guideline in 2002 to 165 fish. This lower guideline was achieved in the 2002 season by late August, in 2003 by late July, and in 2004 by mid July.

The oversize sturgeon target fishery in all three reservoirs has increased substantially since 1995 (Figure 2), but the John Day Reservoir fishery is the greatest immediate concern. Catch has ranged from a low of 16 in 1996 to a high of 1,037 in 2004 (Table 8). The percentage of total catch representing oversize sturgeon (from 1995 to present) has reached as high as 12.8%, and has averaged 3.4 times higher for John Day than for the other two reservoirs. Since the repeated handling of oversized sturgeon may have adverse consequences to the population (disruption of the maturation process, increased mortality of mature fish, etc.), this aspect of the

John Day fishery needs closer inspection and increased monitoring. Spawning sanctuaries (like the one for the lower Columbia River breeding population below Bonneville Dam) are not established in the Zone 6 reservoirs.

PLANS FOR NEXT YEAR

WDFW will continue to monitor Zone 6 sport and treaty Indian commercial sturgeon fisheries in 2005. We will work with ODFW during the summer of 2005 to assess the status of the white sturgeon population in The Dalles Reservoir. We will work with fishing guides to obtain breeding adult white sturgeon, from which we can collect paired gonad-tissue and blood samples, to help OSU develop methods to determine sex and stage of maturity. We will conduct young-of-year white sturgeon recruitment indexing using small mesh gill nets in Little Goose and Ice Harbor reservoirs on the Snake River and in McNary, John Day, and The Dalles reservoirs on the Columbia River. We will prepare presentations to the Fish and Wildlife Commissions of Washington and Oregon on establishing spawning sanctuaries in Zone 6 Reservoirs. These activities will be reported in next year's annual progress report.

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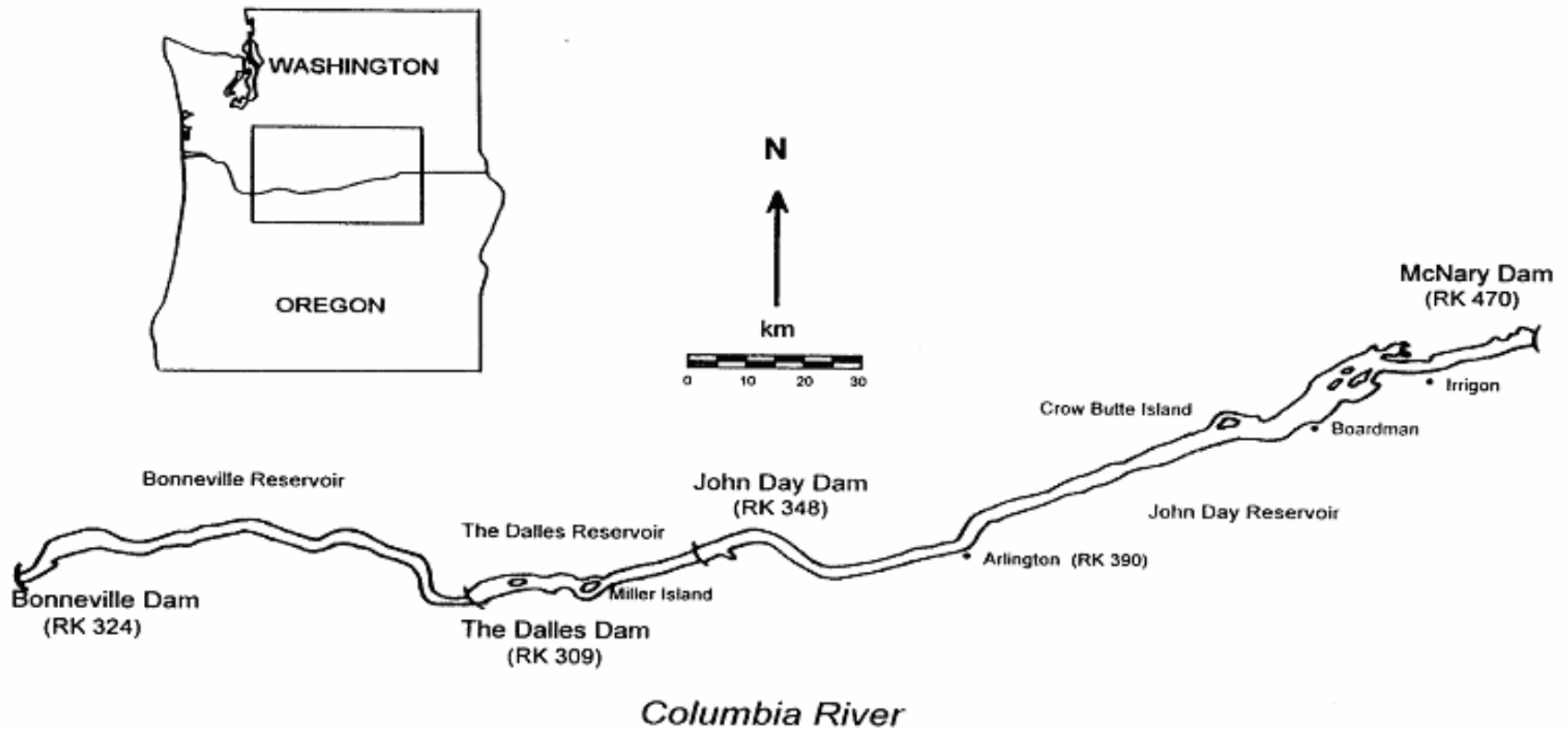


Figure 1. Location of the recreational fishery survey on the Columbia River. Bonneville and The Dalles Reservoirs, and from Arlington upstream to McNary Dam on John Day Reservoir.

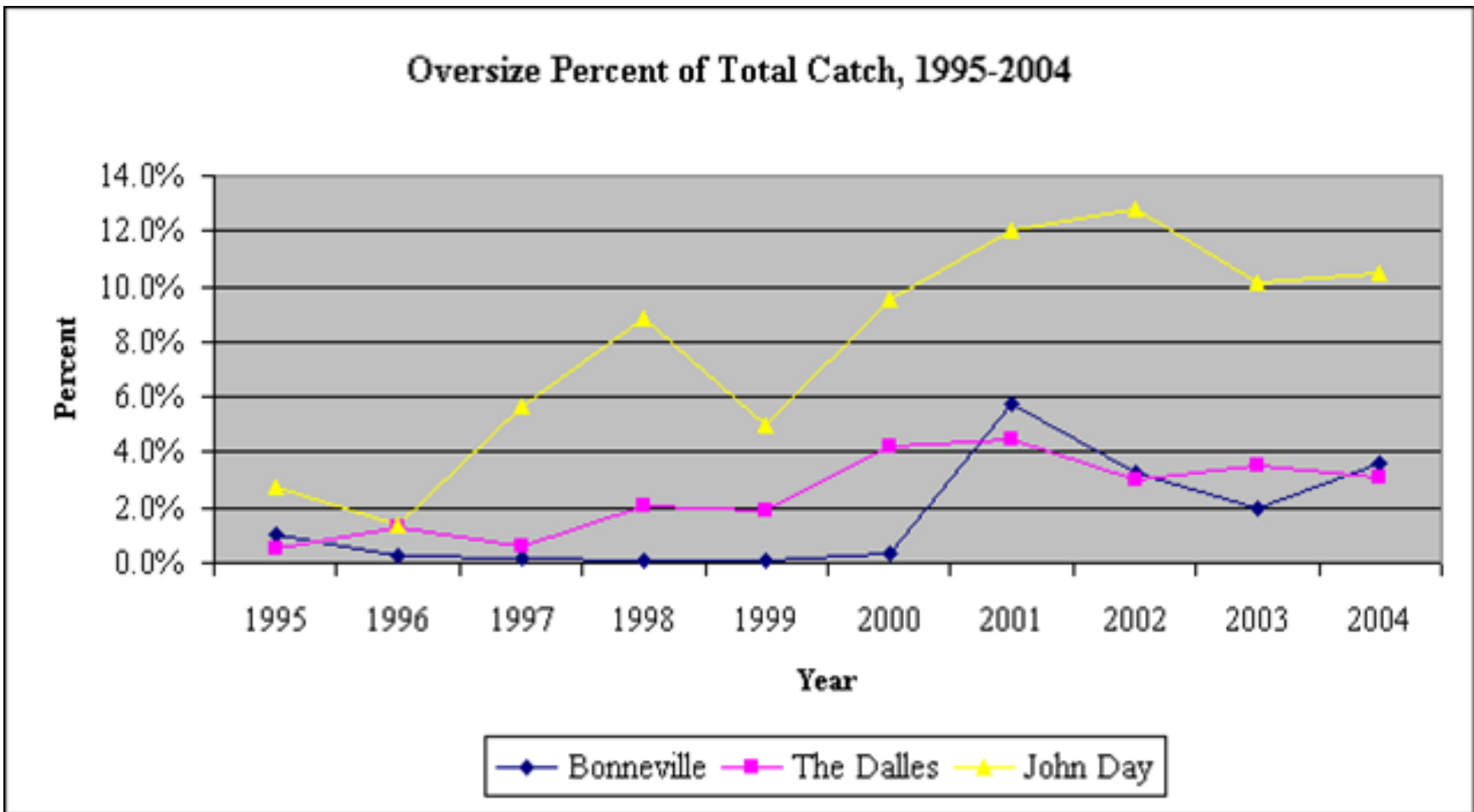


Figure 2. Percent of total sturgeon catch represented by fish over the legal size limit in Zone 6 reservoirs, 1995-2004.

Table 1. Combined Washington and Oregon recreational fishery angling effort estimates for Bonneville Reservoir, January 1 through June 25, 2004; The Dalles Reservoir, January 1 through June 27, 2004; and John Day Reservoir, January 1 through July 11, 2004.

Species Method	Bonneville		The Dalles		John Day	
	Hours	Trips	Hours	Trips	Hours	Trips
Sturgeon						
Bank	21,757	4,195	25,639	3,259	19,270	3,203
Boat	29,088	5,327	17,260	3,074	27,977	4,756
Total	50,854	9,522	42,899	6,333	47,267	7,959
Salmonid						
Bank	2,625	322	21,302	2,106	7,067	1,332
Boat	2,363	514	9,332	1,598	13,993	2,537
Total	4,988	836	30,634	3,704	21,060	3,869
Shad						
Bank	1,654	519	5,090	905	321	92
Boat	602	125	180	23	2,836	593
Total	2,256	644	5,270	928	3,157	685
Walleye						
Bank	16	8	290	39	28	14
Boat	502	132	12,756	2,437	39,777	7,128
Total	518	140	13,046	2,476	39,805	7,142
Bass						
Bank	479	122	1,145	274	182	57
Boat	4,353	1,043	3,483	648	20,028	3,786
Total	4,832	1,165	4,628	922	20,210	3,843
Northern Pikeminnow						
Bank	6,004	927	2,332	262	0	0
Boat	6,307	1,048	8,153	1,242	25	6
Total	12,311	1,975	10,485	1,504	25	6
Other						
Bank	296	110	494	103	757	207
Boat	27	9	0	0	285	50
Total	323	119	494	103	1,042	257
Tournament						
Bank	0	0	0	0	0	0
Boat	0	0	156	24	3,340	400
Total	0	0	156	24	3,340	400
Combined Total						
Bank	32,831	6,203	56,292	6,948	27,625	4,905
Boat	43,242	8,198	51,320	9,046	108,281	19,256
Total	76,073	14,401	107,612	15,994	135,906	24,161

Table 2. Combined Washington and Oregon recreational fishery harvest, and catch and release estimates for Bonneville Reservoir, January 1 through June 25, 2004; The Dalles Reservoir, January 1 through June 27, 2004; and John Day Reservoir, January 1 through July 11, 2004.

Species	Bonneville	The Dalles	John Day
White sturgeon ^a			
Legals kept	852	530	229
Sublegals released	20,168	11,039	8,610
Legals released	266	121	31
Oversize released	797	369	1,037
Total released	<u>22,083</u>	<u>12,059</u>	<u>9,907</u>
Chinook salmon ^b			
Adults kept	43	851	387
Jacks kept	26	32	6
Total kept	<u>69</u>	<u>883</u>	<u>393</u>
Released	41	234	125
Coho salmon ^c			
Kept	0	6	14
Released	0	0	0
Steelhead ^d			
Kept	8	98	295
Released	16	180	532
American shad			
Kept	1,984	5,973	5,178
Released	69	9,508	3,583
Walleye			
Kept	35	2,731	5,942
Released	58	535	2,986
Bass			
Kept	913	1,777	2,685
Released	3,683	4,072	16,979
Northern pikeminnow kept	9,116	9,947	74
Other resident fish kept	61	163	788

^a White sturgeon seasons were closed to retention June 26 – December 31 in Bonneville Reservoir, June 28 – December 31 in The Dalles Reservoir, and July 12 – December 31 in John Day Reservoir.

^b Chinook seasons were closed to retention January 1 – March 15 and May 6 – June 15.

^c Coho seasons were closed to retention April 1 - June 15.

^d Steelhead seasons were closed to retention January 1 – March 15 and May 6 – June 15.

Table 3. Estimates of recreational fishery angler trips for white sturgeon, white sturgeon harvest, and harvest per angler trip (HPUE) for Bonneville Reservoir, January 1 through June 25, 2004; The Dalles Reservoir, January 1 through June 27, 2004; and John Day Reservoir, January 1 through July 11, 2004.

Month Method	Bonneville			The Dalles			John Day		
	Trips	HPUE	Harvest	Trips	HPUE	Harvest	Trips	HPUE	Harvest
January									
Bank	183	0.03	6	194	0.00	0	218	0.03	6
Boat	348	0.04	15	113	0.04	5	170	0.00	0
Total	531	0.04	21	307	0.02	5	388	0.02	6
February									
Bank	1,003	0.04	37	513	0.01	6	643	0.01	7
Boat	932	0.10	97	397	0.16	62	231	0.02	4
Total	1,935	0.07	134	910	0.07	68	874	0.01	11
March									
Bank	748	0.07	54	594	0.12	70	395	0.00	0
Boat	915	0.06	53	595	0.09	53	652	0.06	39
Total	1,663	0.06	107	1,189	0.10	123	1,047	0.04	39
April									
Bank	995	0.02	16	769	0.06	45	416	0.00	0
Boat	766	0.15	115	684	0.02	17	1,153	0.03	30
Total	1,761	0.07	131	1,453	0.04	62	1,569	0.02	30
May									
Bank	709	0.11	81	448	0.05	22	549	0.02	13
Boat	798	0.12	97	403	0.02	7	626	0.01	4
Total	1,507	0.12	178	851	0.03	29	1,175	0.01	17
June									
Bank	557	0.06 ^a	36	741	0.07 ^a	55	715	0.04	27
Boat	1,568	0.16 ^a	245	882	0.21 ^a	188	1,300	0.03	34
Total	2,125	0.13 ^a	281	1,623	0.15 ^a	243	2,015	0.03	61
July									
Bank	0	0.00 ^a	0	0	0.00 ^a	0	267	0.00	0
Boat	0	0.00 ^a	0	0	0.00 ^a	0	624	0.10	65
Total	0	0.00 ^a	0	0	0.00 ^a	0	891	0.07	65
Combined									
Bank	4,195	0.05 ^a	230	3,259	0.06 ^a	198	3,203	0.02 ^a	53
Boat	5,327	0.12 ^a	622	3,074	0.11 ^a	332	4,756	0.04 ^a	176
Total	9,522	0.09 ^a	852	6,333	0.08 ^a	530	7,959	0.03 ^a	229

^a Harvest per angler trip calculated for the period when retention was allowed.

Table 4. Numbers of sturgeon anglers interviewed and numbers of white sturgeon kept and released reported during sampling of recreational fisheries in Bonneville Reservoir, January 1 through June 25, 2004; The Dalles Reservoir, January 1 through June 27, 2004; and John Day Reservoir, January 1 through July 11, 2004.

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal Released	Legal kept	Oversize released
Bonneville						
Bank						
January	55	133	25	0	1	0
February	237	565	270	0	5	0
March	319	801	358	6	11	3
April	256	697	210	1	2	0
May	196	571	192	1	11	0
June	118	417	212	4	7	1
Bank Total	1,181	3,184	1,267	12	37	4
Boat						
January	62	352	184	2	3	0
February	89	442	323	0	11	0
March	124	686	233	1	7	1
April	55	278	133	1	10	0
May	60	361	226	4	12	8
June	71	382	208	7	13	36
Boat Total	461	2,501	1,307	15	56	45
Combined Total	1,642	5,685	2,574	27	93	49
The Dalles						
Bank						
January	96	304	8	0	0	0
February	152	453	17	0	1	1
March	254	1,102	130	1	15	2
April	213	910	82	2	5	3
May	110	458	82	0	4	0
June	237	1,059	413	0	8	10
Bank Total	1,062	4,286	732	3	33	16
Boat						
January	29	191	25	0	1	2
February	65	337	98	0	10	2
March	158	935	338	0	19	10
April	50	248	145	3	2	3
May	57	327	131	1	1	5
June	60	331	142	4	13	10
Boat Total	419	2,369	879	8	46	32
Combined Total	1,481	6,655	1,611	11	79	48

continued

Table 4. Continued.

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal Released	Legal kept	Oversize released
John Day						
Bank						
January	39	110	9	1	1	0
February	135	291	18	0	1	0
March	164	473	12	0	0	0
April	139	348	31	0	0	0
May	98	392	44	0	1	0
June	153	623	45	0	2	16
July	35	140	10	0	0	0
Bank Total	<u>763</u>	<u>2,377</u>	<u>169</u>	<u>1</u>	<u>5</u>	<u>16</u>
Boat						
January	23	91	3	0	0	1
February	55	298	20	0	1	3
March	201	1,064	207	2	11	8
April	330	1,865	544	1	7	22
May	192	1,141	181	0	2	43
June	464	3,042	462	2	9	111
July	97	608	110	0	6	16
Boat Total	<u>1,362</u>	<u>8,109</u>	<u>1,527</u>	<u>5</u>	<u>36</u>	<u>204</u>
Combined Total	<u>2,125</u>	<u>10,486</u>	<u>1,696</u>	<u>6</u>	<u>41</u>	<u>220</u>

Table 5. Length frequencies of harvested white sturgeon measured during sampling of recreational fisheries in Bonneville Reservoir, January 1 through June 25, 2004; The Dalles Reservoir, January 1 through June 27, 2004; and John Day Reservoir, January 1 through July 11, 2004.

Fork Length (cm)	Bonneville	The Dalles	John Day	Fork Length (cm)	Bonneville	The Dalles	John Day
90				130	1	3	
91				131			
92				132		1	2
93	1			133			1
94	5			134			
95	8			135	2	1	1
96	7			136			
97	4			137			
98	10			138			
99	5			139	1	3	
100	7			140		1	
101	2			141			
102	4		1	142			
103	4			143			
104	5	1		144			
105	1			145			
106	2			146			
107	2	1	1	147			
108	2	1		148			
109	5	3	4	149			
110	1	2	2	150			
111	1	7	4	151			
112	2	2	3	152			
113		3	2	153			
114	1	3	7	154			
115		3		155			
116			2	156			
117		1		157			
118	2	6	2	158			
119	1	7		159			
120	1	1		160			
121	1	2	2	161			
122		2	3	162			
123		4	1	163			
124		3		164			
125	2	2		165			
126		4		166			
127		1		167			
128			1				
129	1	1		Total	91	69	39

Table 6. Estimated angling effort, harvest, and harvest per angler trip (HPUE) of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1987 through 2004

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

continued

Table 6 continued.

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

^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 7. Sturgeon Management Task Force (SMTF) harvest guidelines and estimated harvest of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1991 through 2004.

Fishery Year	Bonneville		The Dalles		John Day		Unspecified Harvest	Total
	Guideline	Harvest	Guideline	Harvest	Guideline	Harvest		
Recreational								
1991	1,350	2,270	100	199	100	150	0	2,619
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
Indian Commercial								
1991	1,250	999	300	457	100	39	0	1,495
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
Combined recreational and commercial fisheries								
1991	2,600	3,269	400	656	200	189	0	4,114
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

continued

Table 7. Continued.

Fishery Year	Bonneville		The Dalles		John Day		Unspecified	Total
	Guideline	Harvest	Guideline	Harvest	Guideline	Harvest	Harvest	
Indian subsistence ^a								
1991		-- ^b		-- ^b		-- ^b	-- ^b	-- ^b
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

^a The SMTF did not establish harvest guidelines for the subsistence fishery, however, the expected annual subsistence harvest was 300 white sturgeon for 1991 through 2003.

^b Not available.

Table 8. Oversize sturgeon sport catch and percent of total sport catch in Zone 6 reservoirs, 1995 - 2004.

Year	Bonneville			The Dalles			John Day		
	Oversize Catch	Total Catch	% of Total	Oversize Catch	Total Catch	% of Total	Oversize Catch	Total Catch	% of Total
1995	156	14,622	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%

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

ANNUAL PROGRESS REPORT

APRIL 2004 – MARCH 2005

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 2004 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 2004 provided conditions suitable for spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams. Optimal spawning temperatures in the four tailraces occurred for 3-4 weeks and coincided with the peak of the river hydrograph. However, the peak of the hydrograph was relatively low compared to past years, which is reflected in the relatively low monthly and annual indices of suitable spawning habitat. Bottom-trawl sampling in the Bonneville Reservoir revealed the presence of young-of-the-year (YOY) white sturgeon.

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 Restoration and Enhancement in the Columbia and Snake Rivers Upstream from Bonneville Dam. The reporting period is 1 April 2004 through 31 March 2005.

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

- 1) Develop and implement mitigation actions that do not involve changes to hydrosystem operation and configuration.
- 2) Mitigate for effects of hydrosystem operation and configuration by developing and recommending actions that involve changes to hydrosystem operation and configuration to optimize physical habitat conditions for white sturgeon production.
- 3) Monitor and evaluate actions to mitigate for lost white sturgeon production due to development, operation, and configuration of the hydrosystem.
- 4) Assess losses to white sturgeon production due to development, operation, and configuration of the hydrosystem.

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 2004- Objective 1.
- 2) Use trawls to determine if recruitment of white sturgeon to young-of-the-year (YOY) occurred in Bonneville Reservoir – Objective 3.

In addition, the USGS continued analyses of data from past research and preparation of manuscripts describing the results for submission to peer reviewed journals. Specifically, several manuscripts describing results from predation experiments conducted from 2000 - 2003 were revised after receiving comments from reviewers. Two of the manuscripts were subsequently published; a third has been accepted for publication with revisions.

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 2004 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/>).

Young-of-the-Year Indexing

We sampled for juvenile white sturgeon during September 2004 with a 6.2-m high-rise bottom trawl (Palmer et al. 1988) to determine if recruitment to YOY 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 $\frac{1}{4}$ 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, the 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 1mm. Only white sturgeon were weighed. Generally, YOY 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 m². The proportion of positive tows (E_p) for YOY white sturgeon was calculated as the ratio of tows where at least one YOY 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 discharge and water temperatures that occurred during April through July 2004 provided conditions suitable for spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams. The river hydrograph (Figure 1) shows that daily discharge peaked at about 9 kcms at Bonneville Dam and at about 8 kcms at The Dalles and John Day dams on 29 May. Discharge peaked at McNary dams at 7.75 kcms on 28 May. These peak discharges were lower than the peak of about 10 kcms in 2003. Water temperature, one factor which determines the time period when spawning will occur, rose to optimal levels (13.3°C) for spawning by white sturgeon on 8 May in the Bonneville Dam tailrace, and on 7 May in The Dalles and John Day tailraces, and 14 May in the McNary Dam tailrace (Figure 2). The optimal spawning period was relatively long, with temperatures exceeding optimum levels (15.2°C) 27-32 days later in each tailrace. The optimal spawning temperatures in the four tailraces coincided with the period of relatively high river discharge. Our monthly estimates of the index of spawning habitat showed that the availability of habitat for spawning peaked in May at levels near the average of past years (Figure 3). However, with the exception of the Bonneville Dam tailrace, the indices of spawning habitat for the month of June were substantially lower than the average of past years.

Annual indices of spawning habitat allow comparisons of conditions among years in each dam tailrace. The annual Weighted Usable Area (WUA) index of spawning habitat for the Bonneville Dam tailrace in 2004 (70.9 ha) was higher than the median value for prior years (56.4 ha), while the indices for the other tailraces were lower than the median values (31.1 ha vs. 32.3 ha for The Dalles Dam tailrace spawning area, 49.6 ha vs. 54.9 ha for the John Day Dam tailrace spawning area, and 56.8 ha vs. 60.3 ha for the McNary tailrace spawning areas) (Figure 4).

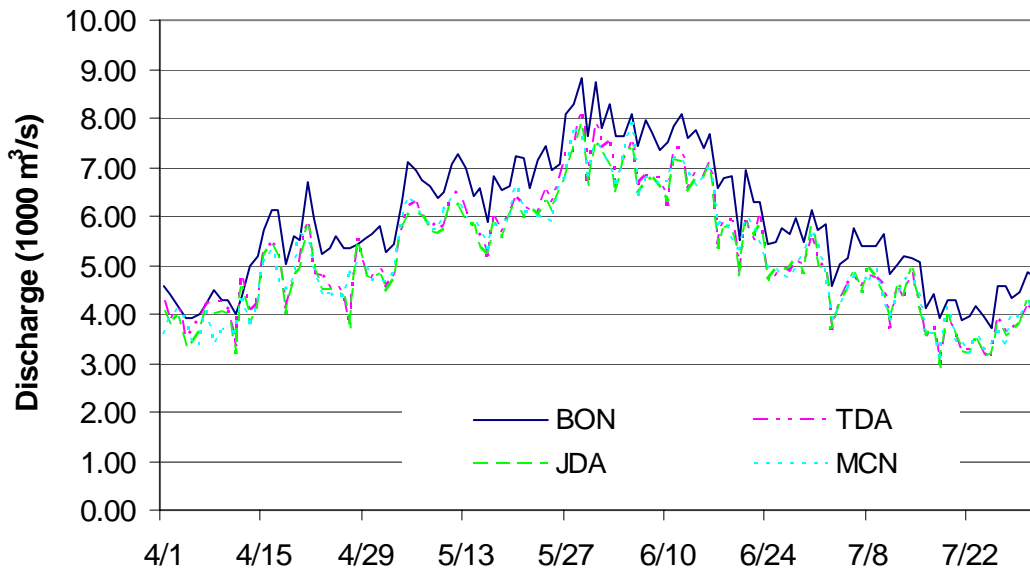


Figure 1. River discharges at Bonneville (BON), The Dalles (TDA), John Day (JDA), and McNary (MCN) dams during 2004. Data were obtained from the DART website (<http://www.cqs.washington.edu/dart/>).

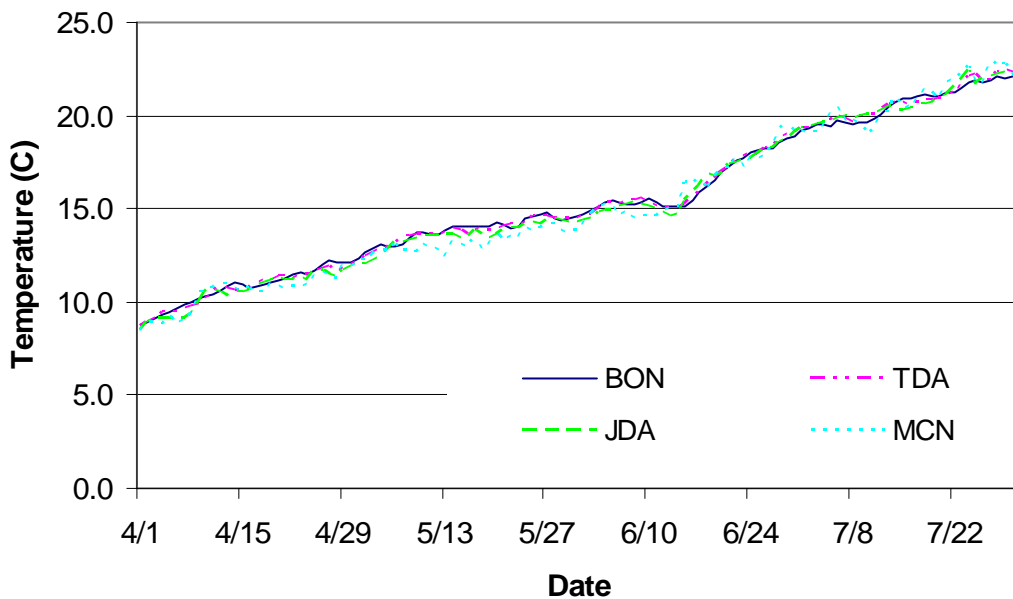


Figure 2. Water temperatures at Bonneville (BON), The Dalles (TDA), John Day (JDA), and McNary (MCN) dams during 2004. Data were obtained from the DART website (<http://www.cqs.washington.edu/dart/>). Optimal temperatures for white sturgeon spawning range from about 13° – 15° C

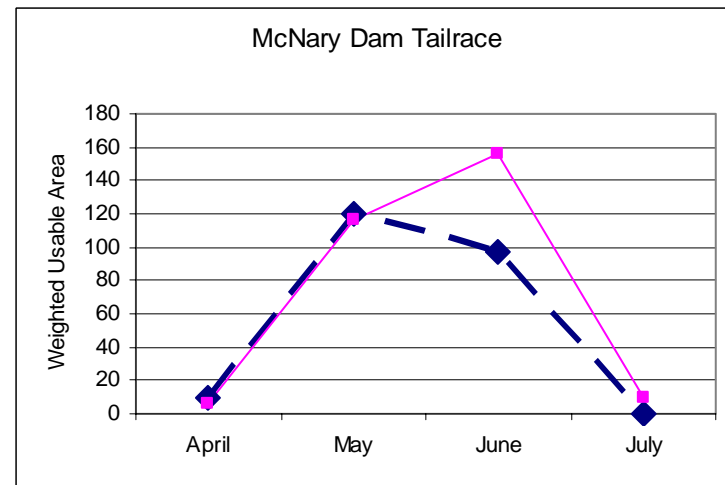
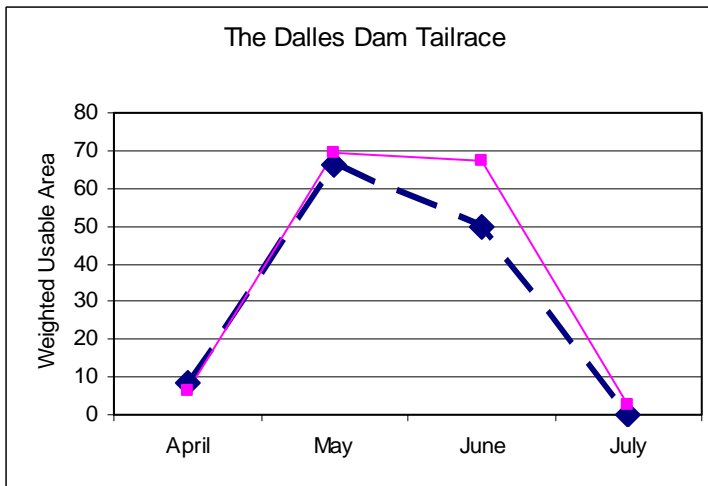
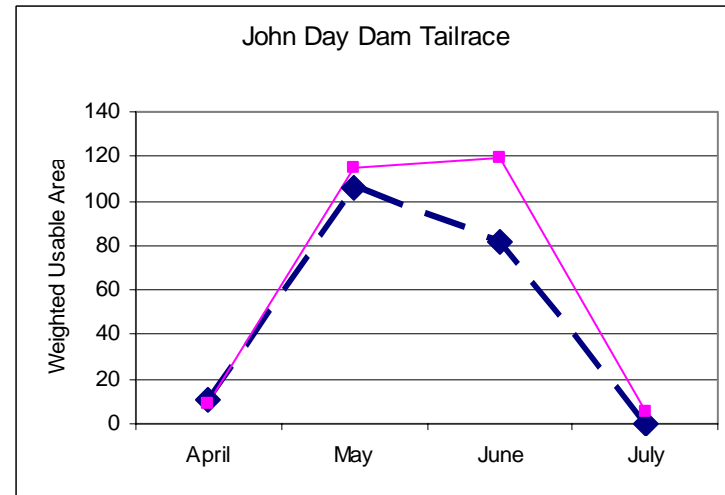
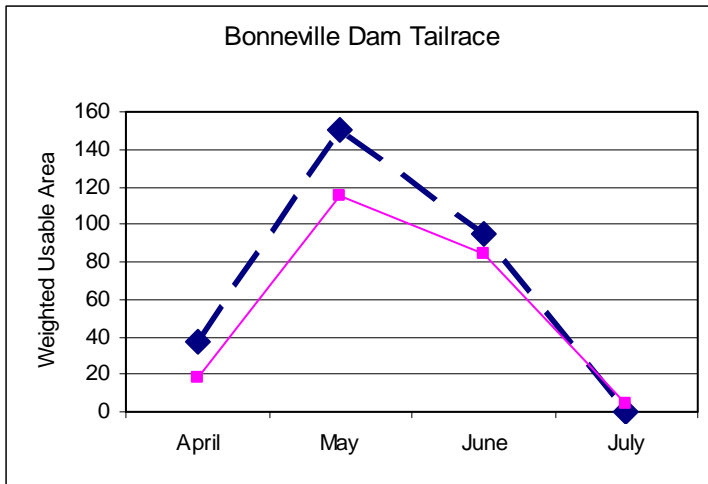


Figure 3. Dashed lines depict mean monthly indices of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon during 2004. Solid lines depict the average mean monthly index for each month during 1985-2003. Note that the scale differs on the Y-Axis among graphs.

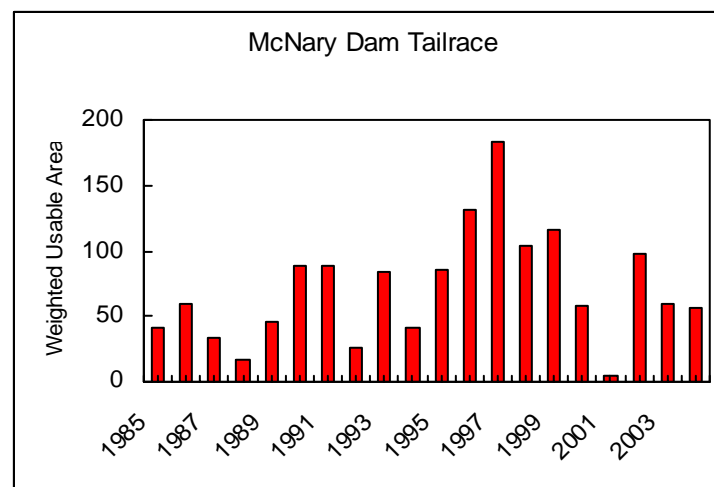
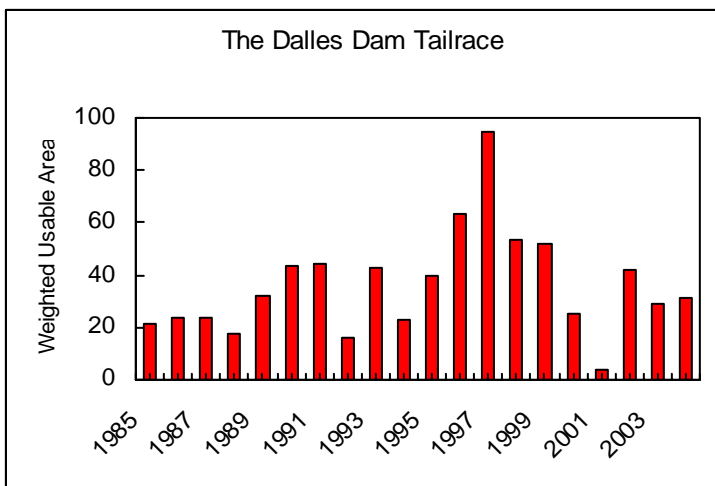
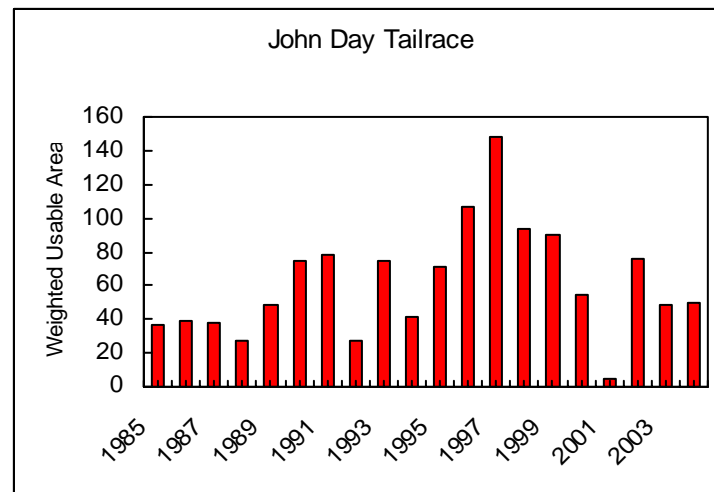
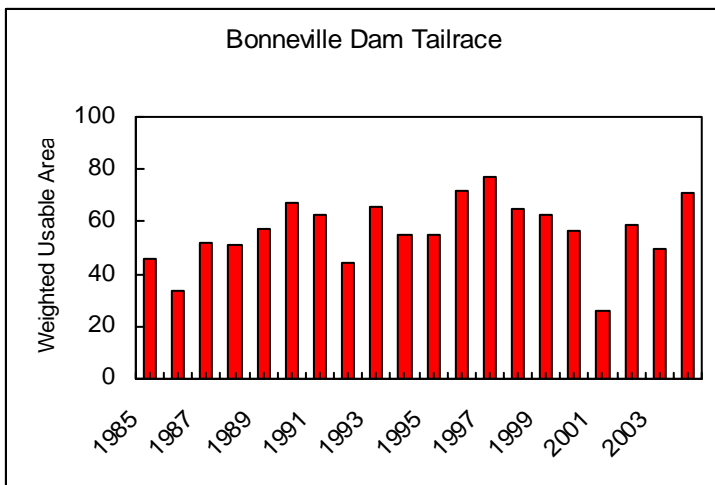


Figure 4. Annual mean composite indices of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon for each of the four dam tailraces that have been modeled (Parsley and Beckman 1994). Note that the scale differs on the Y-axis among graphs.

Young-of-the-Year Indexing in Bonneville Reservoir

The bottom-trawl sampling program was completed as scheduled during 2004. We fished the bottom trawl on 12 days from 13 September to 28 September in Bonneville Reservoir. There were no delays 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. When this happens, 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.

We captured 56 juvenile white sturgeon with the high-rise trawl during our sampling of Bonneville Reservoir, and 8 (14%) of these were YOY. Young-of-the-year white sturgeon were captured at 5 of the 11 sites (Table 1). We distinguished young-of-the-year white sturgeon from older fish by length frequency analysis (Figure 5). The YOY ranged in length from 191 to 276 mm TL and weighed 26 to 83 g. The mean length of YOY captured was 236 mm TL and mean weight was 58 g. Older juvenile white sturgeon were captured at 10 of the 11 sites (Table 1). The older juvenile white sturgeon measured 379 to 915 mm FL and weighed 200 to 3,500 g. Total lengths are reported for YOY since these smaller fish do not have fully developed caudal fins that contain a fork.

The CPUE for combined effort at each of the 11 sites sampled with the bottom trawl from 0.0 to 0.54 YOY per 2,500 m² and from 0.18 to 4.15 fish per 2,500 m² for all white sturgeon caught (Table 1). The mean CPUE for all sites was 0.13 YOY per 2,500 m² (SE = 0.06) and 0.92 fish per 2,500 m² (SE = 0.36) for all juvenile white sturgeon. The proportion of positive tows for YOY white sturgeon during 2004 for Bonneville Reservoir was 0.12.

Trawl catches in Bonneville Reservoir were dominated by juvenile American shad at 42.2 % of the total catch, followed by sand rollers at 38.8%, and prickly sculpin at 11.9% of the total catch. White sturgeon were the fourth most abundant species at 3.2% of the total catch (Table 2). Catch of white sturgeon was highest at sites 15951 and 18351 (Table 1 and Table 3).

Table 1. Characteristics of bottom trawling conducted to index recruitment of white sturgeon in Bonneville Reservoir during 13 September to 28, September 2004. Young-of-the-year (YOY) 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	YOY	All ages	YOY
15052	6	1.3578	1	1	0.18	0.18
15734	6	1.4366	3	0	0.52	0.0
15951	6	1.3921	11	3	1.98	0.54
16522	6	1.3468	5	1	0.93	0.19
16851	6	1.3583	1	0	0.18	0.0
17063	6	1.3948	6	2	1.08	0.36
17374	6	1.3481	1	0	0.19	0.0
17652	6	1.3826	2	0	0.36	0.0
17911	6	1.3486	2	0	0.37	0.0
18351	6	1.3851	23	1	4.15	0.18
18523	6	1.3596	1	0	0.18	0.0
Totals	66	15.1104	56	8		

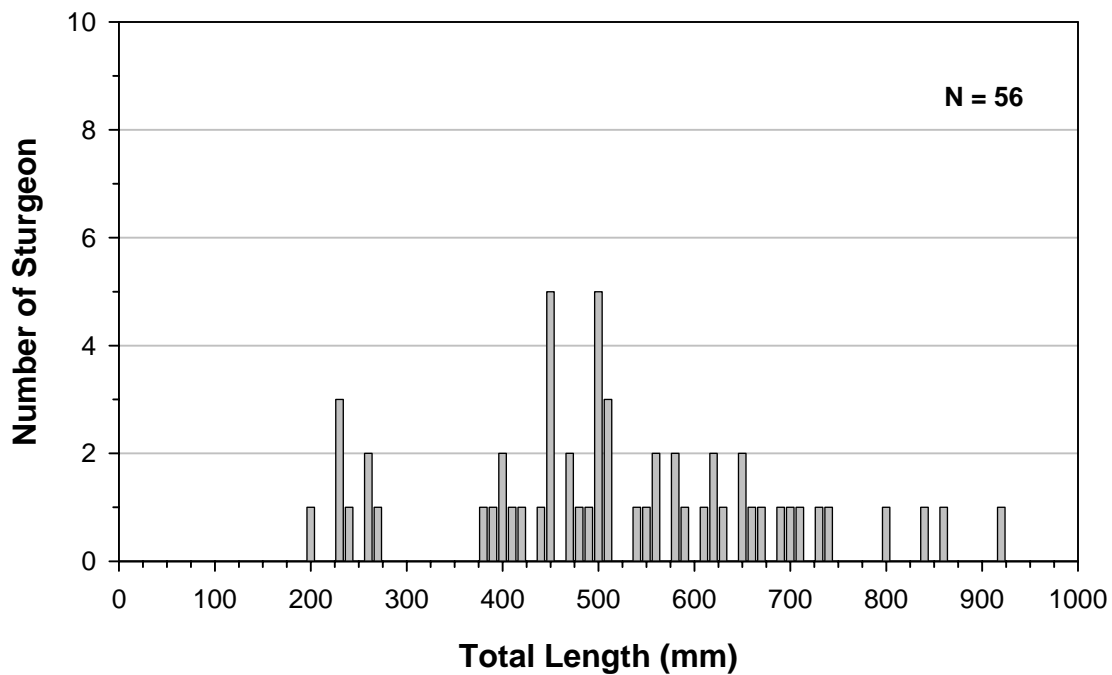


Figure 5. Length frequency of white sturgeon collected during bottom trawling in Bonneville Reservoir from 13 September to 28 September 2004.

Table 2. Number and percent of fish caught in bottom trawls in Bonneville Reservoir during fall sampling in 2004.

Common name	Scientific name	Number of Fish Captured	Percent of Catch
White sturgeon	<i>Acipenser transmontanus</i>	56	3.2
American shad	<i>Alosa sapidissima</i>	739	42.2
Chinook salmon	<i>Oncorhynchus tshawytscha</i>	2	0.1
Northern pikeminnow	<i>Ptychocheilus oregonensis</i>	14	0.8
Redside shiner	<i>Richardsonius balteatus</i>	1	0.1
Peamouth	<i>Mylocheilus caurinus</i>	23	1.3
Largescale sucker	<i>Catostomus macrocheilus</i>	4	0.2
Bridgelip sucker	<i>Catostomus columbianus</i>	4	0.2
Unidentified sucker	<i>Catostomus spp.</i>	3	0.2
Channel catfish	<i>Ictalurus punctatus</i>	5	0.3
Sand roller	<i>Percopsis transmontana</i>	681	38.8
Smallmouth bass	<i>Micropterus dolomieu</i>	8	0.5
Sunfish	<i>Lepomis spp.</i>	3	0.2
Walleye	<i>Sander vitreus</i>	1	0.1
Prickly sculpin	<i>Cottus asper</i>	209	11.9

Table 3. Species percent of catch by location caught in bottom trawls in Bonneville Reservoir during September 2004. The first 4 digits of the trawl site designation indicate the river mile to the nearest tenth, while the last digit indicates the quadrant of the river channel where the effort occurred with 1 indicating the left quadrant (looking upstream).

Common name	% of Total	Trawl Site										
		15052	15734	15951	16522	16851	17063	17374	17652	17911	18351	18523
White sturgeon	3.2	0.5	4.0	21.6	6.8	0.3	3.6	0.4	2.8	1.1	16.3	0.6
American shad	42.2	14.1	20.0	9.8	86.5	20.5	44.3	38.9	80.6	63.2	43.3	81.8
Chinook salmon	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
Northern pikeminnow	0.8	2.1	1.3	0.0	0.0	0.9	0.6	1.1	0.0	0.5	0.0	0.6
Redside shiner	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Peamouth	1.3	2.1	2.7	5.9	1.4	0.9	0.0	0.4	0.0	4.4	0.7	0.0
Largescale sucker	0.2	0.0	2.7	0.0	0.0	0.0	0.0	0.4	0.0	0.5	0.0	0.0
Bridgelip sucker	0.2	0.5	1.3	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.7	0.0
Unidentified sucker	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Channel catfish	0.3	0.0	0.0	0.0	0.0	0.3	0.6	0.4	0.0	0.0	0.7	0.6
Sandroller	38.8	43.2	49.3	45.1	2.7	76.3	38.9	53.0	8.3	17.0	9.9	3.5
Smallmouth bass	0.5	0.5	0.0	0.0	1.4	0.0	0.0	0.4	1.4	1.1	0.7	0.6
Sunfish	0.2	0.5	0.0	0.0	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Walleye	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Prickly sculpin	11.9	35.4	18.7	17.6	0.0	0.6	11.4	4.9	6.9	9.9	27.7	12.4

Plans for Next Year

During 2005, the USGS will conduct bottom trawling only in Bonneville Reservoir. The USGS will also evaluate the availability of spawning habitat during 2005 as determined by river discharge and water temperature, and will continue working on manuscripts describing results obtained in previous years.

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

ANNUAL PROGRESS REPORT

APRIL 2004 – MARCH 2005

Report D

**Developing, implementing, and evaluating a management plan for enhancing
production of white sturgeon in reservoirs between Bonneville and McNary
dams.**

This report includes: A summary of work performed to develop and implement propagation techniques, the release of white sturgeon from past propagation efforts, and the results of efforts to capture and mark white sturgeon in John Day Reservoir for population abundance estimates.

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Our sincere appreciation and thanks to Yakama Nation fishery technicians Alvin McConville, Chuck Gardee, and James Kiona; commercial fishermen Robert Brigham, Mathew McConville, Raymond Cloud 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 out to ODFW staff for assistance with data processing and summarization for reporting requirements.

ABSTRACT

Columbia River Inter-Tribal Fish Commission's mark and tagging operations for the John Day Reservoir population survey began on December 15, 2003 and was completed on February 18, 2004. This field effort marked 2,848 white sturgeon with the 11th right scute removal pattern and applied PIT tags to 1,742 of these fish. Tribal fishers set a total of 1,408 overnight gillnet sets during the 10 week sampling effort. No fish were caught in 536 sets, resulting in a mean catch per net of 2.02 fish. A combined CRITFC, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife performed the recapture effort and ODFW will provide an update of the population estimate and structure in section A of this report.

INTRODUCTION

In this report, we summarize work completed by Columbia River Inter-Tribal Fish Commission (CRITFC), under subcontract with Oregon Department of Fish and Wildlife (ODFW), from 1 April 2004 through 31 March 2005 performed to meet objectives of Bonneville Power Administration (BPA) tasks outlined under project 198605000. Some elements were completed prior to the April 1, 2004 date, but are linked to the primary tasks for the April 1, 2004 through March 31, 2005 reporting period. The primary objectives for CRITFC under this project were to perform management activities that assisted both ODFW and WDFW with respect to their management specific tasks of assessing population structure of white sturgeon and monitoring of the tribal commercial and non-tribal sport fisheries.

Our tasks for this period were to:

- 1) Capture and mark/tag approximately 3000 white sturgeon in John Day Reservoir for a population survey.
- 2) Provide field assistance to cooperating agencies conducting population survey in John Day Reservoir during the summer sampling period.
- 3) Provide assistance to cooperating agencies in conducting young-of-year (YOY) surveys in selected Columbia River and Snake River reservoirs.
- 4) Sample Zone 6 tribal commercial and subsistence fishery and work jointly with ODFW and Washington Department of Fish and Wildlife (WDFW) to estimate harvest and exploitation and characterize the commercial fishery for white sturgeon between Bonneville and McNary dam.

In addressing tasks 3 and 4, WDFW will report the results of the harvest and exploitation rates, and ODFW will report YOY surveys in their respective sections of this report.

METHODS

John Day Reservoir Population Survey

Capture, Mark and Pit Tagging

Columbia River Inter-Tribal Fish Commission captured, marked, and tagged white sturgeon in John Day Reservoir in order to perform population monitoring. The capture, mark, and pit tag operation for John Day Reservoir began on December 15, 2003 and was completed on February 18th, 2004, for a total of ten weekly fishing periods. Tribal fishers sampled John Day Reservoir from Rkm 355 to Rkm 468 (RM 220 to RM 290), in a series of 16.1 km sections, a total of seven sections in all. (Figure1). Boat restricted zones and commercial fishing sanctuaries were not sampled during the marking effort. All crews began sampling in section seven, near McNary Dam and moved downriver one section each week. We employed this strategy in an effort to mark fish throughout the entire reservoir and also to enhance fisher safety by keeping them relatively close to one another in case of mechanical problems or bad weather. A fishing week usually began on Monday and ran through Friday. Nets were checked and reset each day, with Monday being the first set day of the week and Friday being the last pull day of the week, except when limited by severe weather or mechanical problems.

Three Yakama Nation (YN) fishery technicians and three tribal commercial fishermen with crew performed all sampling operations. Each contract fisher was required to provide three crewmembers to perform marking, measuring, and tagging of white sturgeon along with any other requested data collections. Columbia River Inter-Tribal Fish Commission biologists and YN technicians were responsible for training fishers with measuring techniques, identifying marked fish, and tag application procedures. Fishery technicians recorded all data while fishers worked up the catch according to established protocol. At weeks end data was turned over to ODFW.

Fishing was performed from commercial fishing vessels with diver gill nets. Vessels consisted of one 8 m bow pickers and two 5.5 m open boats. The length of nets fished ranged from approximately 70 to 120 m, and mesh size was either 20.3 or 25.4 cm stretched mesh. A variety of materials were used for anchors and floats. Fishers were paid a daily boat lease rate and a set fee for each captured and processed white sturgeon recorded on the data sheets. Because fishers were rewarded on a catch rate basis they were motivated to search out areas they felt would be productive fishing sites within the pre-described boundaries. Each fisher was typically able to run 10 – 15 nets per day working daylight hours. The number of nets fished each day depended on catch rates and crew efficiency.

The standard operating procedure for processing white sturgeon collected with a gill net was as follows. White sturgeon were brought on board and removed from the gill net. All white sturgeon were examined for tags, tag scars, missing scutes, pectoral fin scars, and missing barbels. White sturgeon with missing scutes or tag scars were scanned

with an Avid¹ and/or a Destron Fearing¹ passive integrated transponder (PIT) tag detector. All white sturgeon were measured to the nearest cm FL and the 11th right lateral scute was removed to indicate year of capture was 2003-2004. We did not weigh fish. Fish less than 70 cm were released after scute marking. In most cases, if the fork length was equal to or greater than 70 cm FL and the fish did not possess a PIT tag (125 or 134 mghtz), a Destron 134 mghtz pit tag was injected into the musculature beneath the armor posterior of the head, near the dorsal midline. The second left lateral scute was also removed in order to identify a PIT-tagged fish (Rein et al. 1994). We used a Biomark¹ MK5 general-purpose implanter with standard 12 gauge needles to inject PIT tags. All PIT tag numbers found upon examination or applied were recorded with biological information corresponding to the fish and later entered into a database maintained by ODFW. Once processed, all fish were released.

¹ Use of trade names does not imply endorsement by CRITFC.

RESULTS

John Day Capture, Mark and PIT Tagging

Effort and White Sturgeon Catch

A total of 2,848 white sturgeon were captured in 1,408 gillnet sets, less than the 3,006 sturgeon captured in 2000-2001 effort, with an increased effort of 1,524 sets (Kappenman and Parker 2002) . We marked all sturgeon with the 11th right scute removal pattern described in the methods section. Of the 2,848 fish captured, we applied pit tags to 1,742. White sturgeon captured ranged from 37 to 262 cm FL (Figure 2), with a mean fork length of 87.2 cm. The total white sturgeon catch less recaptures consisted of 2,550 commercial/sport sub legal size (less than 48 inches or 121.92 cm), 55 commercial/sport legal size (between 48 inches and 60 inches or 121.92 cm and 152.4 cm) and 36 over legal size (greater than 60 inches or 152.4 cm). The total mean white sturgeon catch per set for all sets combined was 2.02, slightly greater than the 1.97 sturgeon per net documented in the previous sampling effort in 2000-2001 (Kappenman and Parker 2002). All of the white sturgeon captured and handled in John Day Reservoir were released back into the reservoir.

DISCUSSION

John Day Reservoir Capture, Mark and Pit Tagging

The 2003-04 tagging operation performed by CRITFC and ODFW is the fourth cooperative effort to determine population abundance and structure in John Day Reservoir. We provide a summary of CRITFC tagging efforts here, however ODFW reports the results of recapture efforts and abundance estimates. The information this cooperative effort yields will be used to update population estimates and structure, determine harvest quotas and determine the effect of ongoing mitigative activities on white sturgeon between Bonneville and John Day dams.

PLANS FOR UPCOMING YEARS

Population surveys and estimates for John Day Reservoir, young of year sampling throughout Columbia and the Snake Rivers and efforts to monitor the success of juvenile white sturgeon releases in Rock Island Reservoir are planned for 2004 -05.

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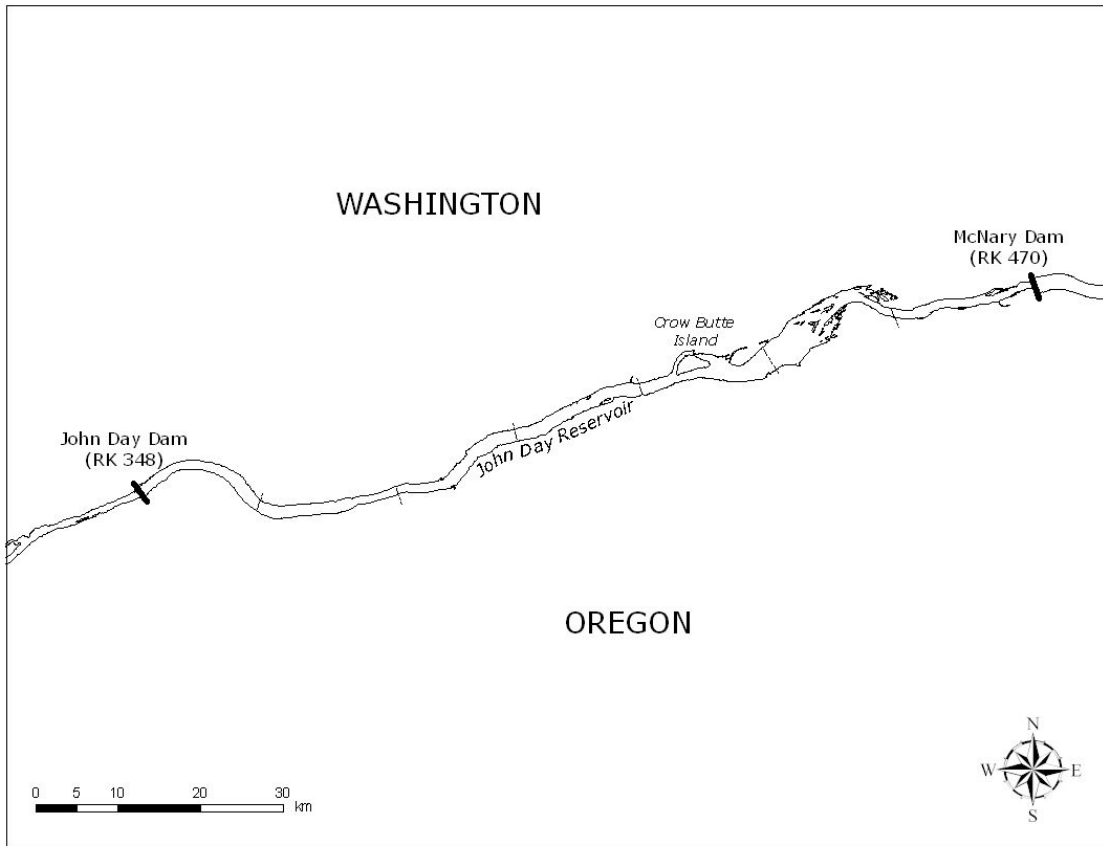


Figure 1. Map of John Day Reservoir in the Columbia River where white sturgeon marking and tagging efforts were performed in 2003-04.

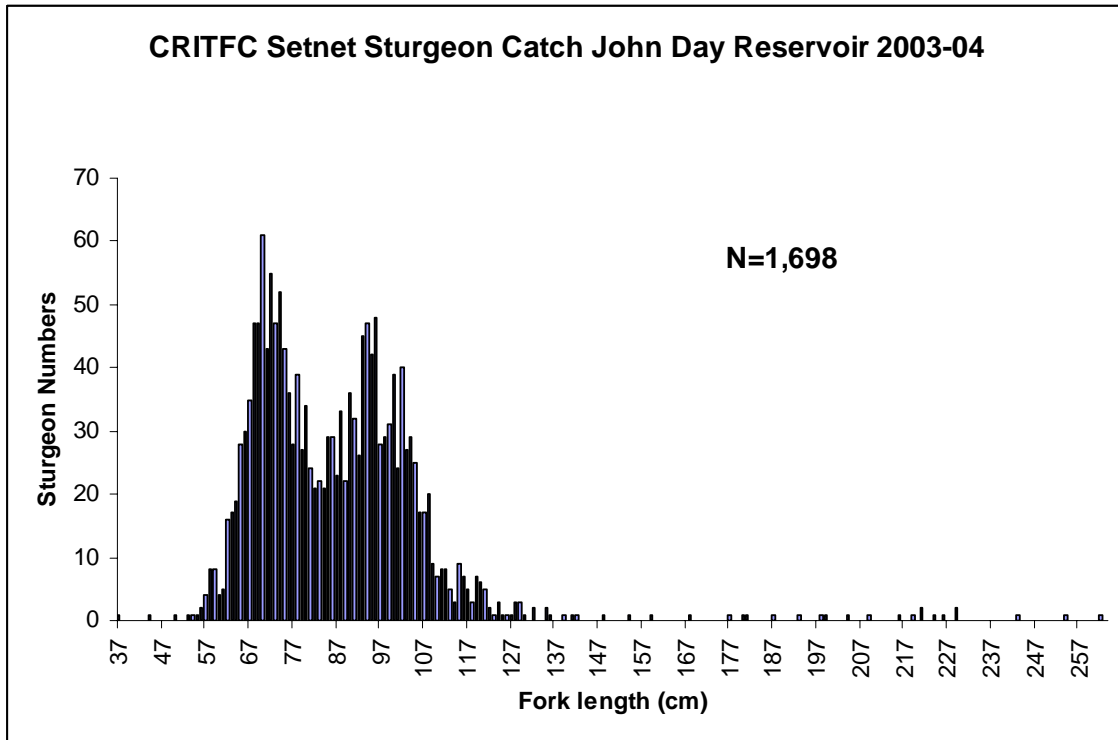


Figure 2. Length frequency distribution (1 cm increments) for white sturgeon collected with gill nets in John Day Reservoir in December 2003, January 2004, and February 2004 by tribal fishers and Yakama Nation fish technicians.

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

ANNUAL PROGRESS REPORT

APRIL 2004– MARCH 2005

Report E

**Develop methods to determine sex of white sturgeon in the Columbia River using plasma
sex steroid concentrations**

Determine spawning interval of white sturgeon in the Columbia River

This report includes: Progress update on the maturation cycle and development of methods to
determine sex and stage of maturity in wild white sturgeon.

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ABSTRACT

During 1 April 2004 through 31 March 2005, Oregon State University researchers worked on the development and optimization of a method to determine sex and stage of maturity using blood plasma indicators. Biological samples from white sturgeon in the Columbia River basin over the legal size (caught by gill net and sport-fishers, referred to as adult fish) were collected in 2004. The samples were analyzed and combined with samples collected and analyzed in 2000-2003. White sturgeon had sex- and maturity-specific levels of plasma steroids, as well as fork length. Discriminant function analysis revealed that plasma testosterone (T), 11-ketotestosterone (KT), and estradiol (E2), as well as fork length (FL) led to the correct classification of 63, 52, 97, and 87% of the non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively, that were of legal and over-legal size. In adult fish alone, these variable led to the correct classification of classification of 62, 47, 96, and 84% of the non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively. The term " non-reproductive" is used to represent the reproductive state of the fish at the time of sampling and is not meant to connote not having reached first maturity (i.e., a non-reproductive fish may have reached first maturity but is in the resting phase of the reproductive cycle). In the legal and over-legal size fish, discriminant function analysis revealed that plasma T, KT, E2, and FL were the best predictors of sex and maturity. These variables led to the correct classification of 53% of the pre-vitellogenic females, 86% of the vitellogenic females, 91% of the post-vitellogenic females, 73% of the post-ovulatory females, 14% of the atretic females, 46% of the pre-meiotic males, 88% of the meiotic males, 69% of the spermiating males, and 100% of the post-spermiating males. In the adult population alone, plasma T, E2, and FL led to the correct classification of 59% of the pre-vitellogenic females, 86% of the vitellogenic females, 91% of the post-vitellogenic females, 55% of the post-ovulatory females, 14% of the atretic females, 32% of the pre-meiotic males, 93% of the meiotic males, 63% of the spermiating males, and 100% of the post-spermiating males. It appears that the gametogenic cycle may be a 2 to 4+ year cycle in males and a 2 to 5+ year cycle in females.

INTRODUCTION

This annual report describes progress of Oregon State University (OSU) 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 2004 through 31 March 2005.

During this reporting period, OSU 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 hydrosystem. Specifically, the task was to describe the maturation cycle for white sturgeon, develop methods to determine sex of white sturgeon by measuring plasma steroid levels, and determine how reproductive plasma steroid concentrations vary at different stages of maturation to develop predictive indices for the timing of maturation.

METHODS

Collection of Fish

Gonad and blood samples were collected from sturgeon over the legal size limit (> 137-cm fork length (FL), herein referred to as adult fish) below Bonneville Dam with the help of Washington Department of Fish and Wildlife (WDFW) in June, July, and August of 2004. Fish were captured by cooperating sport-fishing guides and private sport fishers and handed off to OSU/WDFW. 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 7 μm , and stained by hematoxylin and eosin (Luna 1968). Slides were examined under a compound scope (Motic, 10x-100x), and the germ cells were scored for stage of maturation according to the protocol of Van Eenennaam and Doroshov (1998). For development of the discriminant function analysis (DFA) model, Stage 1 (differentiation of testis and ovary) and Stage 2 (proliferation of spermatogonia and endogenous growth of the oocyte) fish were considered “non-reproductive”, while males in Stages 3 - 5 (onset of meiosis through spermiation) and females in Stages 3 - 6 (early vitellogenesis through ovulation) were considered “reproductive” (Table 1). Post-spawned females (Stage 7) and males (Stage 6) and females undergoing ovarian regression (Stage 8) were considered "non-reproductive" as sex steroid levels were equivalent to levels measured in Stage 1 and 2 fish. The term "non-reproductive" is used to represent only the reproductive state of the fish at the time of sampling and is not meant to connote not having reached first maturity (i.e., a non-reproductive fish may have reached first maturity but is in the resting phase of the reproductive cycle). When assigning the spawning periodicity in recaptured females, it was assumed that the fastest cycle in a Stage 2 female with no evidence of the chorion in the oocytes was likely 3 years.

Blood was collected from the caudal veins with a heparinized vacutainer. The plasma was separated by centrifugation and stored at -80°C until steroids were extracted and analyzed

by radioimmunoassay (RIA). Fork length of each fish was measured (± 0.5 cm). Plasma calcium was not measured in the samples collected in 2004 because the Sigma Diagnostics kit used to measure total calcium is no longer being produced and hence will not be used in the DFA.

Radioimmunoassays

The steroids testosterone (T), 11-ketotestosterone (KT), and estradiol (E2) were extracted from plasma and measured by RIA following the method of Fitzpatrick et al. (1987) and modified by Feist et al. (1990). The average recovery efficiencies for T, KT, and E2 were 87, 86, and 75%, respectively.

All steroid assay results were corrected for recovery, and all samples were analyzed in duplicate. The lower limit of detection was 1.25 pg/tube for all assays, except KT (3.12 pg/tube). The intra- and inter-assay coefficients of variation for all assays were less than 5 and 10%, respectively. Steroid levels, determined by RIA, were validated by verifying that serial dilutions were parallel to standard curves and by analyzing selected samples by high performance liquid chromatography to show that steroids in plasma eluted at the same time as standards and that concentrations (as reflected by peak height) were consistent with values derived by RIA.

Statistical Analysis

Steroid concentrations and FL were compared among four classes of sex and stage of maturity (non-reproductive females (Stages 1, 2, 7, 8), non-reproductive males (Stages 1, 2, 6), reproductive females (Stages 3, 4, 5), and reproductive males (Stages 3, 4, 5)) and 9 classes of sex and stage of maturity (pre-vitellogenic females (Stages 1 and 2), vitellogenic females (Stages 3 and 4), post-vitellogenic females (Stage 5), post-ovulatory females (Stage 7), atretic females (Stage 8), pre-meiotic males (Stages 1 and 2), meiotic males (Stages 3 and 4) spermiating males (Stage 5) and post-spermiated males (Stage 6) for all fish using one-way analysis of variance (ANOVA). Steroid concentrations and FL were also compared among the 9 classes of sex and maturity for adult fish only. Mean comparisons were conducted using the Bonferroni procedure. Data reported are mean \pm sem unless otherwise stated.

Discriminant function analysis was used to develop a set of discriminating functions to predict sex or sex and maturity. The plasma and histological data from the adult fish sampled in 2004 were combined with data from the fishery fish sampled in 2000, 2001, and 2002 and the adult fish sampled in 2000, 2001, 2002, and 2003 for the refinement of the model used to predict sex and maturity in white sturgeon. The DFA was also conducted using only the adult white sturgeon captured in 2000-2004 in McNary Reservoir, Bonneville Reservoir, and below Bonneville Dam. To attain multivariate normality, the logarithms of the plasma variables T, KT, and E2 were considered for analysis. Stepwise DFA was conducted using log-transformed plasma T, KT, and E2 concentrations and FL to chose the best predictor(s) of sex or sex and stage of maturity. The significance level to enter and remain in the model was $\alpha = 0.05$. Quadratic DFA was then conducted with the variables chosen in the stepwise procedure to determine the number of observations and percent classified into the groups of sex and stage of maturity. Determination of the error rates associated with predicting sex and maturity using the chosen discriminant functions was accomplished through cross-validation (see Khattree and

Naik 2000). All analyses were conducted using the SAS System for Windows, release 6.12 (SAS Institute Inc., Cary, NC) following the procedures described in Khattree and Naik (2000).

RESULTS

Maturation cycle

A total of 799 white sturgeon have been sampled for biological material in the Columbia River between February 2000 and March 2004. Plasma sex steroid analysis and gonadal histology have been completed on 621 fish. The data reported here will include the 621 fish.

A total of 542 adult white sturgeon have been marked with spaghetti tags, scute marks, and PIT tags below Bonneville Dam (n=183 in 2000, n=98 in 2001, n=75 in 2002, n=114 in 2003, n=72 in 2004). Paired biological samples were not collected from each of these 542 individuals as some fish appeared too stressed due to long play time by sport fishers, high water temperatures, poor condition due to hooks extruding from the urogenital pore, or other unknown factors.

In 2004, 15 fish were recaptured (21% of the total fish captured in 2004). Of these 15 fish, 2 were tagged in 2000, 5 were tagged in 2001, 3 were tagged in 2002, and 5 were tagged in 2003 (Table 2). Two of these fish were recaptured in 2004 for the second time providing very useful information about spawning periodicity. Sex determined at the time of gonadal biopsy in 2004 revealed 8 females and 7 males. One of the 8 females appeared to have a 2 year cycle, while the other females had 2 - 4+ (one female), 3+ (two females), 4+ (one female), and 5+ (three females) year cycles (Table 2). Two of the 7 males appear to have had 2+ year cycles. Three males had a 3+ year cycles. One male had either a 2 year cycle or a 4+ year cycle, while another male had a 2 year cycle or a 5+ year cycle (Table 2).

The reproductive structure of the oversize white sturgeon population below Bonneville Dam was determined using the 2000-2004 data. Of the females (n=237), 62% were previtellogenic (Stages 1 and 2), 28% were vitellogenic (Stages 3 and 4), 4% were post-vitellogenic or ripe (Stage 5), 4% were postovulatory (Stage 7), and 2% were atretic (Stage 8). Of the males (n=115), 57% were non-reproductive (Stage 2), 14% were mid-spermatogenic (Stage 3 and 4), 25% were spermiating (Stage 5), and 4% were post-spermiation (Stage 6).

Comparison of Steroid Concentrations and Fork Length

Concentrations of plasma sex steroids differed significantly ($P < 0.0001$) among the four (Figure 1) and nine groups (Figure 2) of sex and stage of maturity. The Bonferroni mean comparison tests revealed that plasma T and KT were not significantly different between non-reproductive fish but were significantly higher in reproductive fish when using 4 classes of sex and maturity, with concentrations significantly greater in reproductive males compared to reproductive females (Figure 1). Plasma concentrations of E2 were significantly higher in reproductive females compared to non-reproductive fish and reproductive males (Figure 1).

Plasma T and KT were lowest in pre-vitellogenic females, post-ovulatory females, pre-meiotic males, and post-spermiated males and highest in spermiating males followed by post-vitellogenic females (Figure 2). Androgen concentrations in atretic females did not differ significantly from vitellogenic females, post-vitellogenic females, meiotic males, and post-

spermiated males. Plasma estradiol concentrations were significantly higher in vitellogenic, post-vitellogenic, and atretic females compared to all other groups (Figure 2). The mean concentration of estradiol was lower in atretic females compared to vitellogenic and post-vitellogenic females but did not differ significantly.

Fork length of all fish was 172 ± 3 cm for non-reproductive females, 155 ± 3 cm for non-reproductive males, 226 ± 2 cm for reproductive females, and 182 ± 5 cm for reproductive males. Fork length differed significantly among the 4 classes ($P < 0.0001$). The Bonferroni mean comparisons revealed that all classes were significantly different in size, except for non-reproductive females and spermiating males. For the 9 classes of sex and maturity, FL was 169 ± 3 cm for pre-vitellogenic females, 228 ± 2 cm for vitellogenic females, 215 ± 6 cm for post-vitellogenic females, 224 ± 5 cm for post-ovulatory females, 209 ± 12 cm for atretic females, 154 ± 3 cm for pre-meiotic males, 205 ± 7 cm for meiotic males, 172 ± 6 cm for spermiating males, and 197 ± 17 cm for post-spermiating males. Fork length differed significantly among the 9 classes ($P < 0.0001$). Vitellogenic females, post-vitellogenic females, and post-ovulatory females were significantly larger than all classes except pre-meiotic males and meiotic males.

For the adult population only, FL was 218 ± 2 cm for females and 200 ± 2 cm for males. Adult females were significantly larger ($P < 0.0001$) than adult males. The FL was 213 ± 2 cm for pre-vitellogenic females, 229 ± 2 cm for vitellogenic females, 215 ± 6 cm for post-vitellogenic females, 224 ± 5 cm for post-ovulatory females, 209 ± 12 cm for atretic females, 204 ± 3 cm for pre-meiotic males, 211 ± 4 cm for meiotic males, 184 ± 5 cm for spermiating males, and 197 ± 17 cm for post-spermiating males. Spermiating males were significantly smaller than all groups except atretic females and post-spermiating males.

Determination of Sex and Maturity Using Plasma Indicators

Plasma T, KT, E2, and FL were chosen in the stepwise DFA for all fish as the best predictors of sex and stage of maturity. These variables led to the correct classification of 63, 52, 97, and 87% of the non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively (Table 3). By comparison, 25% of the total number of fish would be correctly classified into their respective groups by chance alone. Overall, 74% of the fish were correctly classified. In the cross-validation of the model predicting sex and stage of maturity in these fish, 38%, 51%, 5%, and 15% error was associated with predicting non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively.

In the stepwise DFA for all fish using 9 classes of sex and maturity, plasma T, KT, E2, and FL were chosen as the best predictors of sex and maturity. These variables led to the correct classification of 53% of the pre-vitellogenic females, 86% of the vitellogenic females, 91% of the post-vitellogenic females, 73% of the post-ovulatory females, 14% of the atretic females, 46% of the pre-meiotic males, 88% of the meiotic males, 69% of the spermiating males, and 100% of the post-spermiating males (Table 4). By comparison, 11% of the total number of fish would be correctly classified into their respective groups by chance alone. Overall, 69% of the fish were correctly classified. The cross-validation revealed 47%, 20%, 36%, 64%, 86%, 55%, 31%, 39%, and 100% error associated with predicting pre-vitellogenic females, vitellogenic

females, post-vitellogenic females, post-ovulatory females, atretic females, pre-meiotic males, meiotic males, spermiating males, and post-spermiating males.

In the adult white sturgeon population alone, plasma T, KT, E2, and FL were chosen as the best predictors of sex and stage of maturity. These variables led to the correct classification of 62, 47, 96, and 84% of the non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively (Table 5). Overall, 72% of the fish were correctly classified. In the cross-validation of the model predicting sex and stage of maturity in these fish, 40%, 63%, 5%, and 16% error was associated with predicting non-reproductive females, non-reproductive males, reproductive females, and reproductive males, respectively.

In the stepwise DFA for the adult fish using 9 classes of sex and maturity, plasma T, KT, E2, and FL were chosen as the best predictors of sex and maturity. These variables led to the correct classification of 59% of the pre-vitellogenic females, 86% of the vitellogenic females, 91% of the post-vitellogenic females, 55% of the post-ovulatory females, 14% of the atretic females, 32% of the pre-meiotic males, 93% of the meiotic males, 63% of the spermiating males, and 100% of the post-spermiating males (Table 6). Overall, 66% of the fish were correctly classified. The cross-validation revealed 46%, 16%, 5%, 73%, 86%, 77%, 33%, 33%, and 100% error associated with predicting pre-vitellogenic females, vitellogenic females, post-vitellogenic females, post-ovulatory females, atretic females, pre-meiotic males, meiotic males, spermiating males, and post-spermiating males.

DISCUSSION

Of the fishery fish sampled in 2000-2002, < 1% of the females were vitellogenic (Stage 3), while close to 8% of the males were undergoing meiosis or spermiating (Stages 3 and 5). Of the adult fish sampled in 2000-2004, 62% of the females were pre-vitellogenic (Stages 1 and 2), 28% of the females were vitellogenic (Stages 3 and 4), 4% were post-vitellogenic or ripe (Stage 5), 4% were postovulatory (Stage 7), and 2% were 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 \geq 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, 61% were non-reproductive (Stage 2), 8% were mid-spermatogenic (Stage 3 and 4), 29% were spermiating (Stage 5), and 2% were post-spermiation (Stage 6). Eight percent of the adult females in this study were capable of or had spawned successfully, while 31% 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. 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.). 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. These females underwent atresia during vitellogenesis or post-vitellogenesis.

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 2000-2004 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. Females H113751 and H115030 are the first recaptured females that may have a 2-year gametogenic cycle. In 2001, H113751 was found to have post-ovulatory follicles present in gonadal tissue indicating that she successfully spawned. She was recaptured in 2004 with vitellogenic follicles. If she had a biennial cycle, she would have spawned in 2003. If she did not spawn in 2003, she would be a potential spawner in 2005 for the first time since 2001 (4 year cycle). Female H115030 was vitellogenic in 2002 and 2004 suggesting that she may have spawned in 2003 and may be able to spawn in 2005. All of the other recaptured females to date have 3 to 5+ 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 3 to 5+ year cycle in the majority of females and that 8% 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 20-33%, even with consideration of capture gear and location biases.

The DFA models were least effective in distinguishing non-reproductive female from non-reproductive male white sturgeon. The misclassification of non-reproductive females as non-reproductive males appears to be the result of increasing plasma T prior to the increase in E2 associated with vitellogenesis. Because T is a precursor to E2, plasma T levels increase just prior to vitellogenesis and continue to remain elevated during vitellogenesis as E2 concentrations remain high (Doroshov et al. 1997; Webb et al. 2001b). The misclassification of non-reproductive males as non-reproductive females was the result of a large portion of these males having plasma concentrations of T below 4 ng/ml. It is unclear at this time why wild white sturgeon males in Stage 2 of gonadal development are not producing T at concentrations greater than or equal to 4 ng/ml. It appears that spermatogonia proliferation (Stage 2) in cultured white sturgeon is associated with increased circulating androgen concentrations regardless of age or size (Feist et al. 2004). Plasma T and KT have been found to be negatively correlated with liver concentrations of p,p'-DDE (a lipophilic environmental contaminant) in non-reproductive male white sturgeon in the lower Columbia River indicating the potential adverse effects of pollutants on white sturgeon reproduction (Foster et al. 2001; Feist et al. 2005; Webb et al. In Press). The reduced concentration of androgens in Columbia River males must be further investigated. Though 100% of the post-spermiated males were correctly classified (n=4), the cross-validation

revealed that all 4 males were misclassified. A higher sample size of post-spermiated males is needed to determine error rates for this class. The DFA models for all fish and adult fish only were similar.

The DFA model for the prediction of 9 classes of sex and maturity in all fish was most effective at distinguishing post-spermiated males followed by post-vitellogenic females, meiotic males, vitellogenic females, post-ovulatory females, spermiating males, pre-vitellogenic females, pre-meiotic males, and atretic females. In the adult population only, a higher percentage of pre-vitellogenic females and meiotic males were correctly classified and a lower percentage of post-ovulatory females, pre-meiotic males, and spermiating males were correctly classified compared to the model developed for all fish. There is a high misclassification rate of pre-vitellogenic females and post-ovulatory females as the steroid concentrations in both of these classes are very low. It is very difficult to classify atretic females as the degree of follicular atresia will influence steroid production and therefore the class into which the females are classified. Misclassification of meiotic and spermiating males is biologically justifiable due to the elevated androgen concentrations in both of these classes. Though 100% of the post-spermiated males were correctly classified (n=4), the cross-validation again revealed that all 4 males were misclassified reiterating the need for a higher sample size of post-spermiated males.

Though error does exist in the classification of sex and stage of maturity of white sturgeon using blood plasma (29% error overall for 4 classes and 44% error for 9 classes), this technique does have some advantages over the biopsy method. The biopsy method of identifying sex and maturity, while highly accurate under some circumstances, is subject to error and may be detrimental to the fish when conducted by untrained or inexperienced personnel. The use of plasma steroids is accurate in the classification of reproductive (96-97%; Stages 3, 4, and 5), vitellogenic (86%; Stages 3 and 4), and post-vitellogenic (91%; Stage 5) females. The collection of a blood sample is much less technical and potentially harmful to the fish compared to the collection of gonadal tissue. This may prove useful in certain situations to assess a population for the number of reproductive females (vitellogenic and ripe) in any given year.

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Table 1. Stages of gonadal development identified from gonadal biopsies of white sturgeon based on classifications described in Van Eenennaam and Doroshov (1998).

	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 2. Oversize white sturgeon recaptured in 2004 below Bonneville Dam. Fish identification is the spaghetti 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 was determined by sex steroid concentrations (these fish are denoted by *). Two fish were recaptured for the second time (identified by **). Fish H109984 was first recaptured in 2002, while fish H113746 was first recaptured in 2003.

Fish ID	Year Tagged	Fork Length (cm) (yr tagged / 2004)	Field Sex	Stage of Maturity (yr tagged / 2004)	Spawning Periodicity
H115012	2002	205 / 205	Male	Stage 2* / Stage 2	2 or 4+ yr
H115076	2003	190 / 192	Male	Stage 2 / Stage 2	3+ yr
H109984**	2000	210 / 206/ 204	Male	Stage 2* / Stage 2 / Stage 2	2 or 5+ yr
H109985	2000	194 / 199	Male	Stage 2* / Stage 2	2+ yr
H073339	2003	240 / 242	Male	Stage 4 / Stage 2*	2+ yr
H073327	2003	212 / 213	Male	Stage 2 / Stage 3	3+ yr
H073342	2003	203 / 207	Male	Stage 2 / Stage 2*	3+ yr
H115030	2002	238 / 239	Female	Stage 4 / Stage 3	2+ yr
H113746	2001	233 / 236	Female	Stage 2 / Stage 4	5+ yr
H113751	2001	243 / 242	Female	Stage 7 / Stage 4	2 or 4 yr
H115020	2002	206 / 204	Female	Stage 7 / Stage 4	3 yr
H113765	2001	259 / 256	Female	Stage 2 / Stage 7	4+ yr
H073326	2003	226 / 236	Female	Stage 2 / Stage 3	3+ yr
H113746**	2001	245 / 245/ 242	Female	Stage 2 / Stage 4 / Stage 4	5+
H113730	2001	214 / 221	Female	Stage 2 / Stage 4	5+ yr

Table 3. Classification summary for determination of sex and stage of maturity from the quadratic discriminant function analysis for all white sturgeon using log-transformed plasma testosterone, 11-ketotestosterone, estradiol, and fork length. Data are percentages (n), with the correctly classified percentages in bold.

<u>True Sex</u>	<u>Classification</u> Non-reproductive Females	<u>Determined</u> Non-reproductive Males	<u>From</u> Reproductive Females	<u>Predictors</u> Reproductive Males	Total n
Non-reproductive Females	63 (187)	26 (76)	4 (11)	7 (23)	296
Non-reproductive Males	28 (49)	52 (90)	0 (0)	20 (35)	174
Reproductive Females	0 (0)	1 (1)	97 (79)	2 (2)	82
Reproductive Males	9 (5)	4 (2)	0 (0)	87 (45)	52

Table 4. Classification summary for determination of sex and stage of maturity from the quadratic discriminant function analysis for all white sturgeon using log-transformed plasma testosterone, 11-ketotestosterone, estradiol, and fork length. Data are percentages (n), with the correctly classified percentages in bold. Pre-Vit=pre-vitellogenic female; Vit=vitellogenic female; Post-Vit=post-vitellogenic female; Post-Ov=post-ovulatory female; Atretic=atretic female; Pre-Meiotic=pre-meiotic male; Meiotic=meiotic male; Sperm=spermiating male; Post-Sp=post-spermiating male.

Classification Determined From Predictors										
<u>True Sex</u>	Pre-Vit Fem	Vit Fem	Post- Vit Fem	Post- Ov Fem	Atretic Fem	Pre- Meiotic Male	Meiotic Male	Sperm Male	Post-Sp Male	Total n
Pre-Vit Fem	53(148)	2(6)	0(0)	22(62)	2(6)	16(44)	3(9)	3(1)	0(0)	278
Vit Fem	0(0)	86(60)	8(6)	1(1)	3(2)	1(1)	1(1)	0(0)	0(0)	71
Post-Vit Fem	0(0)	0(0)	91(10)	0(0)	0(0)	0(0)	0(0)	9(1)	0(0)	11
Post-Ov Fem	9(1)	9(1)	0(0)	73(8)	9(1)	0(0)	0(0)	0(0)	0(0)	11
Atretic Fem	0(0)	14(1)	14(1)	30(2)	14(1)	14(1)	0(0)	14(1)	0(0)	7
Pre-Meiotic Male	22(37)	0(0)	0(0)	9(15)	2(3)	46(78)	16(28)	5(9)	0(0)	170
Meiotic Male	0(0)	0(0)	0(0)	0(0)	0(0)	6(1)	88(14)	6(1)	0(0)	16
Sperm Male	8(3)	0(0)	0(0)	3(1)	3(1)	3(1)	14(5)	69(25)	0(0)	36
Post-Sp Male	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	100(4)	4

Table 5. Classification summary for determination of sex and stage of maturity from the quadratic discriminant function analysis for adult white sturgeon using log-transformed plasma testosterone, 11-ketotestosterone, estradiol, and fork length. Data are percentages (n), with the correctly classified percentages in bold.

<u>True Sex</u>	<u>Classification</u> Non-reproductive Females	<u>Determined</u> Non-reproductive Males	<u>From</u> Reproductive Females	<u>Predictors</u> Reproductive Males	Total n
Non-reproductive Females	62 (105)	31 (53)	3 (5)	4 (6)	169
Non-reproductive Males	25 (19)	47 (35)	0 (0)	28 (21)	75
Reproductive Females	2 (2)	1 (1)	96 (77)	1 (1)	81
Reproductive Males	0 (0)	16 (7)	0 (0)	84 (37)	44

Table 6. Classification summary for determination of sex and stage of maturity from the quadratic discriminant function analysis for adult white sturgeon only using log-transformed plasma testosterone, 11-ketotestosterone, estradiol, and fork length. Data are percentages (n), with the correctly classified percentages in bold. Pre-Vit=pre-vitellogenic female; Vit=vitellogenic female; Post-Vit=post-vitellogenic female; Post-Ov=post-ovulatory female; Atretic=atretic female; Pre-Meiotic=pre-meiotic male; Meiotic=meiotic male; Sperm=spermiating male; Post-Sp=post-spermiating male.

Classification Determined From Predictors										
<u>True Sex</u>	Pre-Vit Fem	Vit Fem	Post- Vit Fem	Post- Ov Fem	Atretic Fem	Pre- Meiotic Male	Meiotic Male	Sperm Male	Post-Sp Male	Total n
Pre-Vit Fem	59(89)	2(3)	0(0)	16(25)	1(2)	16(25)	5(6)	1(1)	0(0)	151
Vit Fem	0(0)	86(60)	9(6)	1(1)	3(2)	1(1)	0(0)	0(0)	0(0)	71
Post-Vit Fem	0(0)	0(0)	91(10)	0(0)	0(0)	0(0)	0(0)	9(1)	0(0)	11
Post-Ov Fem	27(3)	9(1)	0(0)	55(6)	9(1)	0(0)	0(0)	0(0)	0(0)	11
Atretic Fem	0(0)	14(1)	14(1)	30(2)	14(1)	14(1)	0(0)	14(1)	0(0)	7
Pre-Meiotic Male	25(18)	0(0)	0(0)	4(3)	3(2)	32(22)	25(18)	11(8)	0(0)	71
Meiotic Male	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	93(14)	7(1)	0(0)	15
Sperm Male	7(2)	0(0)	0(0)	3(1)	0(0)	10(3)	17(5)	63(18)	0(0)	29
Post-Sp Male	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	100(4)	4

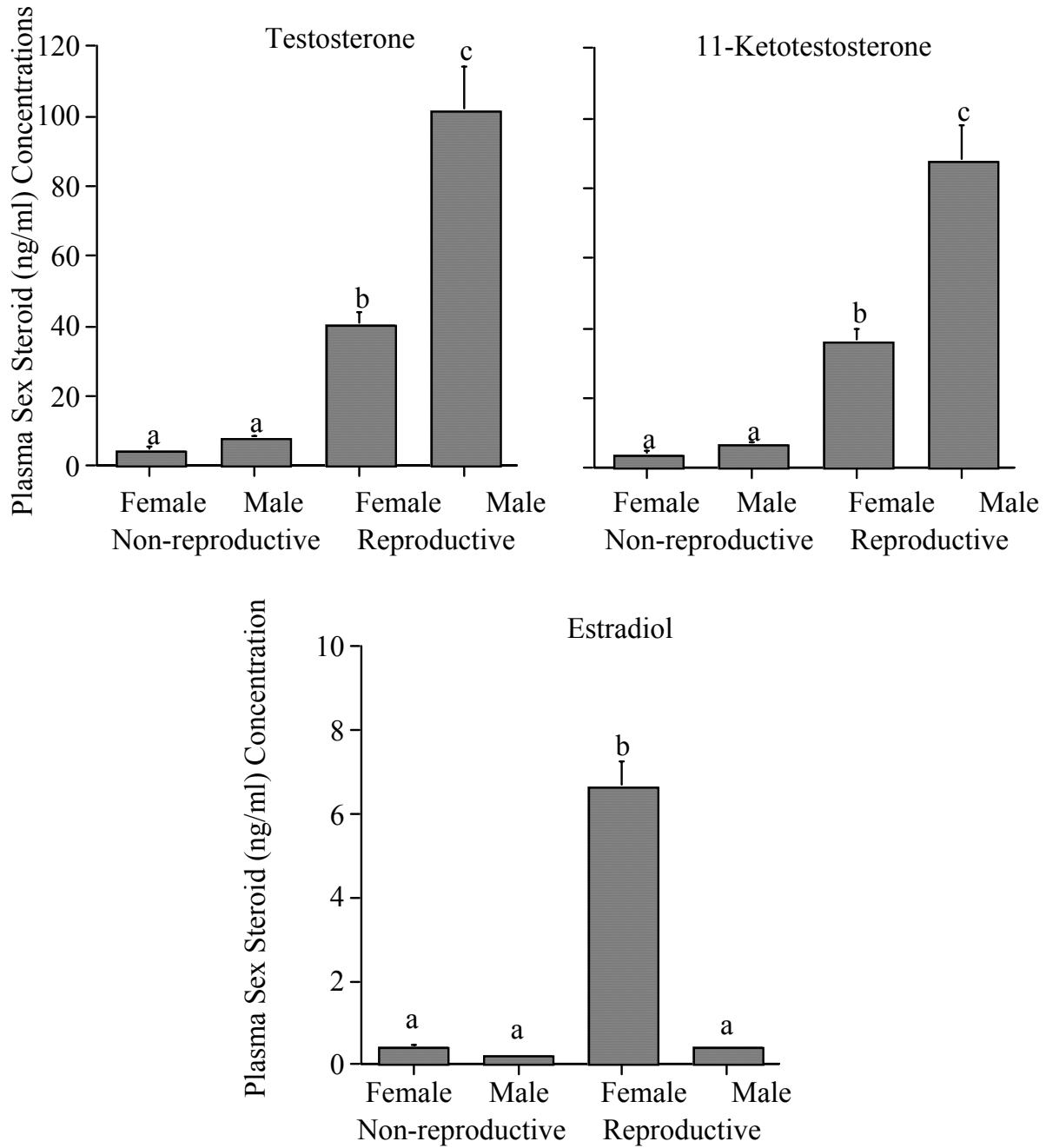


Figure 1. Plasma sex steroid concentrations in white sturgeon captured in the Columbia River basin in 2000-2004 (mean + SE). Different letters denote statistically significant differences between the groups (non-reproductive females, n=297; non-reproductive males, n=175; reproductive females, n=83; and reproductive males, n=54).

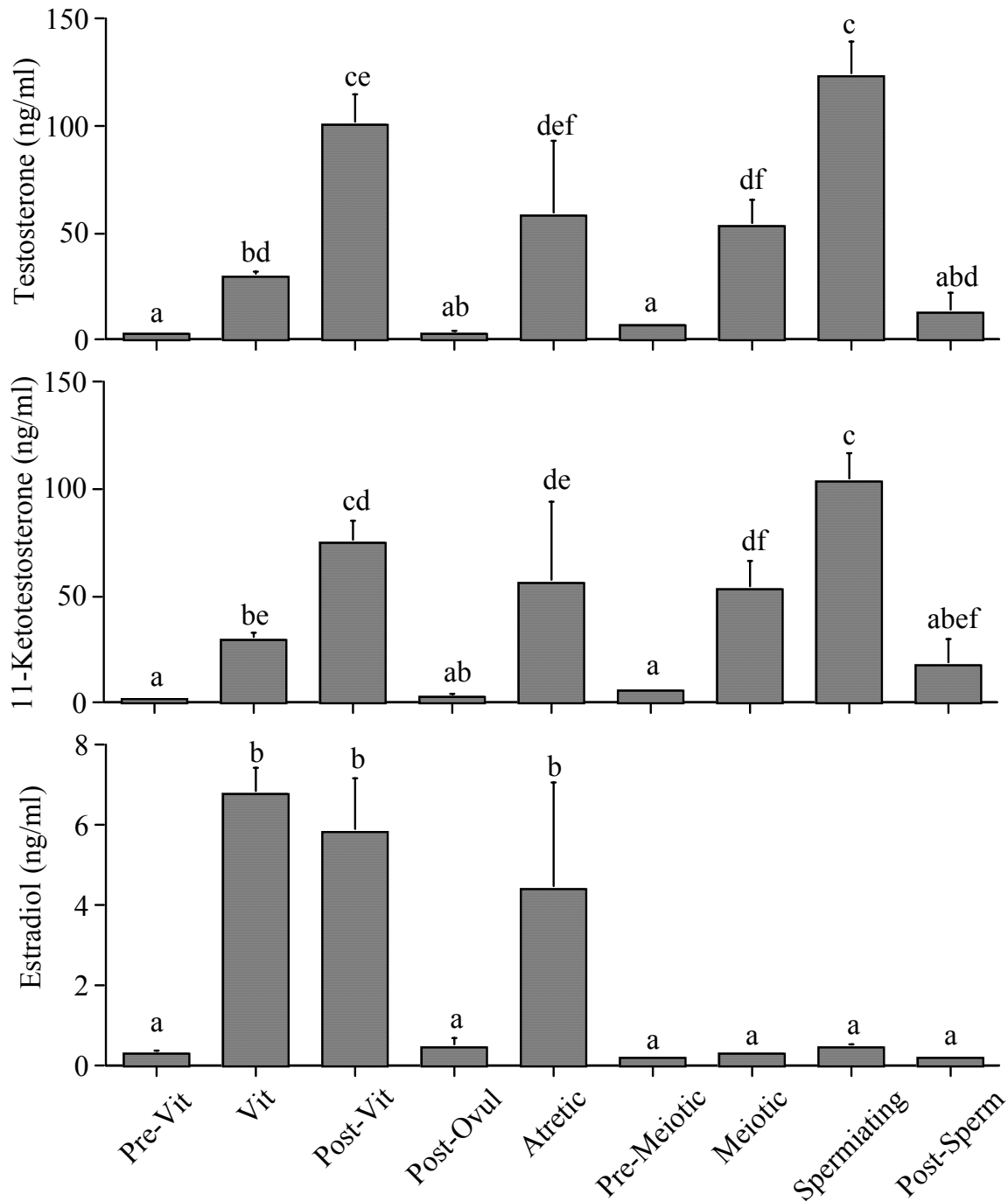


Figure 2. Plasma sex steroid concentrations in white sturgeon captured in the Columbia River basin in 2000-2004 (mean + SE). Different letters denote statistically significant differences between the groups (pre-vitellogenic females, n=280; vitellogenic females, n=71; post-vitellogenic females, n=12; post-ovulatory females, n=11; atretic females, n=7; pre-meiotic males, n=170; meiotic males, n=17; and spermiating males, n=37; and post-spermiated males, n=4).