Evaluate Potential Means of Rebuilding Sturgeon Populations in the Snake River between Lower Granite and Hells Canyon Dams

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EVALUATE POTENTIAL MEANS OF REBUILDING STURGEON POPULATIONS IN THE SNAKE RIVER BETWEEN LOWER GRANITE AND HELLS CANYON DAMS

1997 Annual Report

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ANNUAL REPORT 1997

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CONTENTS

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ABSTRACT

During 1997 the first phase of the Nez Perce Tribe White Sturgeon Project was completed and the second phase was initiated. During Phase I the *Upper Snake River White Sturgeon Biological Assessment* was completed, successfully: 1) compiling regional white sturgeon management objectives, and 2) identifying potential mitigation actions needed to rebuild the white sturgeon population in the Snake River between Hells Canyon and Lower Granite dams. Risks and uncertainties associated with implementation of these potential mitigative actions could not be fully assessed because critical information concerning the status of the population and their habitat requirements were unknown. The biological risk assessment identified the fundamental information concerning the white sturgeon population that is needed to fully evaluate the effectiveness of alternative mitigative strategies. Accordingly, a multi-year research plan was developed to collect specific biological and environmental data needed to assess the health and status of the population and characterize habitat used for spawning and rearing. In addition, in 1997 Phase II of the project was initiated. White sturgeon were captured, marked, and population data were collected between Lower Granite Dam and the mouth of the Salmon River. During 1997, 316 white sturgeon were captured in the Snake River. Of these, 298 were marked. Differences in the fork length frequency distributions of the white sturgeon were not affected by collection method. No significant differences in length frequency distributions of sturgeon captured in Lower Granite Reservoir and the mid- and upper free-flowing reaches of the Snake River were detected. The length frequency distribution indicated that white sturgeon between 92 and 183 cm are prevalent in the reaches of the Snake River that were sampled. However, white sturgeon >183 have not changed markedly since 1970. I would speculate that some factor other than past over-fishing practices is limiting the recruitment of white sturgeon into larger size classes (>183 cm). Habitat, food resources, and migration have been severely altered by the impoundment of the Snake River and it appears that the recruitment of young may not be severely affected as recruitment of fish into size classes > 183 cm.

INTRODUCTION

Development of the Columbia River Basin hydroelectric system has created impoundments that have altered the habitat and movement of white sturgeon (*Acipenser transmontanus*) and their principal food resources in the Lower Snake River between Hells Canyon and Lower Granite dams. As a result, it is hypothesized that: 1) natural production of white sturgeon is less than what it was before construction and operation of the hydropower system, 2) white sturgeon rearing habitat in many areas is underseeded because of the reduction in spawning habitat caused by the hydropower system construction and operations, 3) white sturgeon production can be significantly enhanced by some combination of spawning and rearing habitat restoration, and/or supplementation, and 4) naturally spawning white sturgeon populations can be preserved and optimum rates of production can be restored while concurrently maintaining conservative tribal and recreational fishing opportunities (CBFWA 1997). However, additional data are needed to fully assess these hypotheses and develop a strategy to restore the Snake River white sturgeon population between Hells Canyon and Lower Granite dams.

Traditionally, the Nez Perce People harvested Snake River white sturgeon for subsistence purposes. However, subsistence fishing has been severely limited as a result of low sturgeon numbers between Hells Canyon and Lower Granite dams. The objective of this project is to identify means to restore and rebuild the Snake River white sturgeon population between Hells Canyon and Lower Granite dams capable of supporting a sustainable annual subsistence harvest of white sturgeon equivalent to 5 kg/ha/yr (CBFWA 1997). If the population has not changed dramatically over the last 23-28 years since the completion of Lower Granite Dam in 1975, and the closure of catch-and-keep fishing in 1970, implementation of scientifically sound mitigative strategies would be needed to realize the harvest objective.

The initial Phase I biological risk assessment was completed during 1997. This biological risk assessment identified: 1) potential mitigative actions to meet the project objective, and 2) data needs to fully assess the risks associated with applied actions. A plan to collect needed data identified by the biological risk assessment was also developed. Phase II, the data collection phase of the project, was also initiated in 1997. White sturgeon were captured, marked, and population data were collected between Lower Granite Dam and the mouth of the Salmon River.

Based on data collected during Phase II an adaptative management plan will be developed. The adaptative management plan will 1) fully assess the risks and uncertainties associated with potential mitigative actions identified by the BRAT using biological data collected, 2) make recommendations to implement alternative mitigative actions designed to restore and rebuild the white sturgeon population to obtain a sustainable annual tribal subsistence harvest of 5 kg/ha/yr (CBFWA 1997), and 3) develop an adaptive plan for the implementation, evaluation and monitoring of effects of applied mitigation action on the Snake River white sturgeon population between Hells Canyon and Lower Granite dams.

The objectives of this report are to: 1) provide a brief summary of the results of the Phase I biological risk assessment, 2) outline the multi-year study plan, and 3) present preliminary results from 1997 Phase II data collection. A more detailed summary of the biological assessment can also be found in (Hoefs *in press*). Both the *Upper Snake River White Sturgeon Biological Risk Assessment* (Carmichael *et al.*1997) and the Nez Perce White Sturgeon Multi-Year Research Plan (Hoefs 1997) are available through the Nez Perce Tribe Department of Fisheries Resources Management and the Bonneville Power Administration.

COMPLETION OF PHASE I

In 1996, a Biological Risk Assessment Team (BRAT) was assembled to develop a risk assessment for white sturgeon in the Snake River between Hells Canyon and Lower Granite dams. BRAT participants included a wide range of professionals from a variety of federal, state, private, and tribal agencies that were knowledgeable and concerned about white sturgeon ecology, the Snake River system, and regional ecological issues. In 1997, the resulting *Upper Snake River White Sturgeon Biological Assessment* documented: 1) regional white sturgeon resource objectives, and 2) potential mitigative actions that could be used to achieve regional objectives.

Regional white sturgeon resource objectives primarily addressed the preservation and/or restoration of the integrity (health, persistence, genetic diversity) of the white sturgeon population in the Snake River and the reestablishment of tribal and non-tribal harvest. The BRAT also identified a wide variety of potential mitigative actions that could achieve these objectives. These actions included: 1) restoration and supplementation of sturgeon food resources, 2) alteration of flows from Hells Canyon Dam, 3) reduction of contaminants in Lower Granite Reservoir, 4) identification and reduction of impacts of the catch-and-release fishery, 5) supplementation, and 6) permanent drawdown of Lower Granite Reservoir. These potential mitigative actions correspond with management strategies identified by the Resident Fish Managers of the Columbia Basin Fish and Wildlife Authority for white sturgeon in the Lower Snake Subregion relative to restoring a sustainable annual harvest or use equivalent of 5 kg/ha/yr (CBFWA 1997).

The risks associated with the implementation of these potential actions, as well as a no action alternative, were analyzed by the BRAT using the risk assessment process described by Lestelle *et al.* (1996). However, the BRAT was not able to fully assess the risks and effectiveness of individual mitigative actions because of lack of basic information concerning the white sturgeon in the Snake River between Hells Canyon and Lower Granite dams. General informational needs were identified as well as specific environmental and ecological information needed to fully assess the effectiveness of potential mitigative actions (Table 1). Table 1 indicates that little information exists regarding the ecology or current status of white sturgeon population in the Hells Canyon-Lower Granite reach. Without this information, there are critical uncertainties concerning rearing and spawning habitat, how rearing and spawning habitat is affected by hydropower, whether the population is currently at equilibrium or if the system is at carrying capacity, and how population dynamics of white sturgeon have been affected by isolation. This lack of information prevents a full assessment of the need for supplementation, alterations in hydropower operations, habitat restoration, and restoration of natural food resources. A rigorous evaluation of the effects of the no action alternative is also not possible without additional information.

PHASE II PLANNING

In 1997, a multi-year research plan was developed pursuant to the BRAT report (Hoefs 1997). This research will allow 1) identification and assessment of mitigative actions designed to restore, protect and enhance the sturgeon population between Hells Canyon and Lower Granite dams, and 2) establish a baseline database on population and habitat conditions to assist in monitoring and evaluating the effectiveness of applied mitigative actions. Table 2 outlines specific tasks for data collection during Phase II.

Table 1. Information needs identified by the BRAT considered fundamental to evaluating the effectiveness and need for mitigation actions in restoring the white sturgeon population in the Snake River between Hells Canyon and Lower Granite dams.

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1. The health and status of white sturgeon population;
    a. abundance estimates throughout entire reach,
    b. density by habitat type and reach,
    c. age specific growth rates (length and weight) by sex,
    d. sex ratios by age,
    e. age specific fecundity (either from this stock or surrogate stock),
    f. age at maturity for females,
    g. spawning periodicity for females,
    h. total mortality by age,
    i. physiological measures of health-developmental conditions factors, and
    j. food habitats.
2. The specific life history attributes of the population;
    a. spawning locations and timing,
    b. egg and larvae distribution patterns,
    c. young-of-the-year movement and rearing patterns, and
    d. adult movement and rearing patterns.
3. The degree and effect of entrainment and recruitment from upstream on the population;
    a. magnitude by life stage, and
    b. timing.
4. The effects of contaminants on the population.
5. The genetic characterization of the population and a comparison with other Columbia basin stocks.
6. The effect of the catch-and-release fishery on the population.

Table 2. Proposed Phase II research tasks designed to collect information to fully assess the risk and effectiveness associated with potential management actions.

Collect biological and environmental data identified by the *Upper Snake River White Sturgeon Biological Risk Assessment* that will allow identification and assessment of mitigative actions designed to restore, protect and enhance the sturgeon population between Hells Canyon and Lower Granite dams and will establish a baseline on which to assess effectiveness of applied mitigative actions.

Task 1 Assess the health and status of the Snake River white sturgeon population between Hells Canyon and Lower Granite Dams.

Task 1.1 Estimate white sturgeon abundance throughout entire reach and determine if there has been any marked change in abundance or age structure of the population over the last 25 years.

Task 1.2 Determine distribution/movements of fish, abundance of various age classes of white sturgeon per reach throughout the system and determine what environmental factors (velocity, flow, temperature, substrate) may affect distribution.

Task 1.3 Collect life history data for subadult and adult white sturgeon to model population dynamics.

Task 2 Define habitat used for spawning and rearing of white sturgeon in the Snake River between Lower Granite and Hells Canyon Dams.

Task 2.1 Define habitat used for spawning. Identify environmental conditions associated with spawning: document timing, duration, location and environmental conditions.

Task 2.2 Identify distributions of larvae and young of the year throughout the area and identify associated environmental factors that define 'nursery' habitat.

Task 2.3 Identify rearing habitat for juvenile and adult white sturgeons.

Task 3 Develop plans to address other informational needs identified by BRAT not covered by the tasks listed above.

PRELIMINARY PHASE II DATA

The primary objective of sampling in 1997 was to capture and mark white sturgeon using a stratified random design between Lower Granite Reservoir and the mouth of the Salmon River to estimate population structure, distribution and size.

Methods

White sturgeon were captured in the Snake River between Lower Granite Dam (River Kilometers; Rkm 174) to mouth of the Salmon River (Rkm 303). The Snake River between Lower Granite Reservoir and the mouth of the Snake River was divided into 8 sampling reaches (Table 3). Reaches were 14 to 18 Rkm in length.

Generally, one randomly selected reach was sampled weekly from August through November (Table 3). Two randomly selected reaches were sampled weekly in December. Areas of high densities were sampled at a greater intensity than those areas with lower densities of fish. Previously identified areas of low sturgeon densities included the two lower reaches within Lower Granite Reservoir (Lepla 1994). These sections were combined, thus reducing the sampling effort in the lower reaches in Lower Granite Reservoir by 50 percent.

Sampling sites for setlines and nets and hook-and-line fishing were also randomized within each reach. Each 0.5 kilometer of the stream reach was considered a potential sampling site. Ten sample sites were randomly chosen within a reach, and sampled with either nets, setlines or hook-and-line, depending on flow characteristics. Sampling sites were not stratified by habitat characteristics (depth, velocity, substrate type), thus catches were unbiased by habitat conditions to which white sturgeon may or may not be responding.

Concurrent with the work being done by NPT, Idaho Power Company (IPC) is assessing the status and habitat use of white sturgeon in the Hells Canyon Reach of the Snake River (Rkm 303 to Rkm 462)(IPC 1996). Because of the similarity in objectives and tasks, NPT and IPC are pursuing a formal agreement for data sharing. Pursuant to such an agreement, our work focuses on the Snake River below the mouth of the Salmon River (Rkm 303). Thus, our 1997 randomized sampling conducted for population estimations did not include the Snake River above the mouth of the Salmon River.

Table 3. Study reaches and dates sampling on Snake River.

Reach	Location	River Km Lower	River Km Upper	Length (Km)	Weeks sampled
1	L. Granite Dam - Blyton Landing	174	190.5	16.5	8/4, 9/15, 12/8
2.	Blyton Landing - Steptoe Canyon	190.5	207	16.5	8/4, 9/15, 12/8
3.	Steptoe Canyon - Clearwater River	207	224	17	8/11, 9/22, 12/8
4.	Clearwater River - Tenmile Rapids	224	240	16	8/25, 10/20, 12/15
5.	Tenmile Rapids - Buffalo Eddy		240	256	16 8/25, 11/17, 12/15
6.	Buffalo Eddy - Grand Ronde River	256	271	15	9/8, 11/3, 12/15
7.	Grande Ronde River- Cache Creek	271	285	14	9/8, 10/27, 12/1
8.	Cache Creek - Salmon River	285	303	18	8/18, 9/29, 12/1

The Clearwater River was sampled the week of October 7th using both setlines and hook-and-line. Areas where white sturgeon have been reported in the Clearwater River were targeted instead of applying a randomized sampling design because the number of white sturgeon reported in the Clearwater River is historically low. The primary objective of sampling in the Clearwater River was to document the current distribution of white sturgeon, not to conduct a population estimate.

Nets, setlines and hook-and-line sampling were used to estimate the size and structure of the white sturgeon population. Sampling with nets was limited to Lower Granite Reservoir where flow velocities were lower than in the other reaches. Nets used were rigged with lead-lines and anchors that held nets on the bottom of the channel. Nets were generally set for 24 hour periods. Net set time was recorded and catch per hour was calculated based on use of an average net of 334 m^2. Net mesh sizes varied from approximately 10 to 25 cm (stretched on diagonal). Mesh sizes were randomly assigned and mesh size bias will be evaluated in the future.

Setlines and hook-and-line sampling were used in the Snake River reaches above the confluence of the Clearwater River (RKm 224) because flows were too swift for anchored nets. Setlines consisted of 30 m of anchored bottom-line with ten gangen lines attached by snaps approximately every 3 m (as described by Lepla 1994, Apperson and Anders 1990). Gangen were rigged with circle hooks to reduce potential hooking injury. A combination of ten 14/0, and 12/0 galvanized barbed circle hooks were used on each line. Pickled squid, lamprey, and salmon were used as bait. Catch bias associated with hook size and bait type will be assessed in the future. Setlines were checked twice a day and empty hooks rebaited. Set hours were recorded and catch-per hour calculated was based on the hours a line with ten hooks was fished.

Hook-and-line sampling was also conducted. Hook-and-line was used primarily in the upper reaches of the Snake River to supplement setline sampling and when water conditions prevented use of setlines. Sixty pound or greater test Dacron line with either barbless 'J' hooks or barbless circle hooks of varying size (8/0 to 12/0) were used. A variety of bait types (e.g., lamprey, salmon, pickled squid) were also used. Bias associated with bait type, hook sizes and individual fishers will be assessed as data become available.

All white sturgeon captured were processed aboard the collection boat, or at the site of collection near the shore. White sturgeon brought aboard the boat were placed in a vinyl stretcher or large PVC trough, and their gills flushed with river water while being processed. After fish were processed they were released at their location of capture.

Fish captured were checked for previous marks and tags (tag scars, fin marks, scute marks, and missing barbels, and tags). New captures were tagged using a floy tag below the dorsal fin on the left side, and with a passive integrated transponder (PIT) tag injected near the armor of the head on the left side. Total and fork length (cm), girth (cm), and weight (0.1 kg) of the fish were measured and recorded.

Paired samples of fork length and weight were regressed for fish caught throughout the study area. Frequency distributions (fork length) were compared for fish captured in Lower Granite Reservoir (including reaches 1,2 and 3), a mid-Snake River reach (including reaches 3, 4, and 5) and upper-Snake River reach (6,7, and 8). Frequency distributions were also compared for fish captured using setlines, nets and hook-and-line. Comparisons were made using analysis of variance (ANOVA; Zar 1974, Sokal and Rolf 1981). Log transformations were used to normalize the data for the ANOVA analysis (GLM; SAS 1988).

Results

Distribution of white sturgeon in the Salmon River

During 1997, 316 white sturgeon were captured in the Snake River (Appendix A). Of these, 298 were marked. Two of the fish captured were < 38 cm and were not marked and the other 18 were recaptures. The majority of the white sturgeon were captured using setlines, however, hook-and-line sampling produced the most fish per unit effort (Table 4). Sampling with nets yielded approximately 0.05 fish per hour, whereas approximately 0.03 and 0.11 fish per hour were collected with setlines and hook-and-line, respectively.

White sturgeon captured with setlines in the Snake River between Lower Granite Reservoir and the mouth of the Salmon River ranged from 60 to 249 cm long (fork length) and averaged 98 cm. Fish captured by net ranged from 34 to 160 cm and averaged 91 cm. Using hook-and-line, fish captured ranged from 44 to 211 cm and also averaged 91 cm (Figure 1). Fork length frequency distributions of white sturgeon captured using setlines, nets, and hook-and-line did not significantly differ (F= 1.88, p= 0.1545, $\mathrm{df}_{(2, 295)}$).

In Lower Granite Reservoir white sturgeon ranged from 39.5 to 200 cm long and averaged 96 cm (Figure 2). In the mid-reaches of the Snake River fish captured were slightly larger averaging 97 cm, and exhibited a greater size range from 60 to 249 cm. White sturgeon captured in the upper reaches of the Snake River ranged from 44 to 243 cm and averaged 94 cm. No significant differences in length frequency distribution of white sturgeon captured in Lower Granite Reservoir and the mid- and upper reaches of the Snake River were detected (F= 0.49, p= 0.6116, $df_{(2, 272)}$).

Table 4. Catch and sampling effort and catch per unit effort (C/E) per reach using nets, setlines, and hook-and-line sampling in the Snake River reaches sampled in 1997.

	Nets			Setlines			Hook-and-line		
Reach	Effort*	Catch	C/E	Effort**	Catch	C/E	Effort***	Catch	C/E
1&2	485.3	25	.052	331.9	15	.045		-	-
3	965.7	57	.059	1322.9	13	.010	-	-	-
4	93.7	2	.021	996.8	3	.003	-	-	-
5	-	-	-	947.8	1	.001	109.5	3	.027
6	-	-	-	973.0	31	.032	80.6	15	.186
7	-	-	-	1305.1	76	.058	70.8	4	.056
8	-	-	-	809.1	34	.042	124.9	20	.160
Total	1544.7	83	.054	6686.6	173	.026	385.8	420	.109

*based on hours set time of net 334 m^2, ** based on hours set time for line with ten hooks, *** man-hours spent fishing.

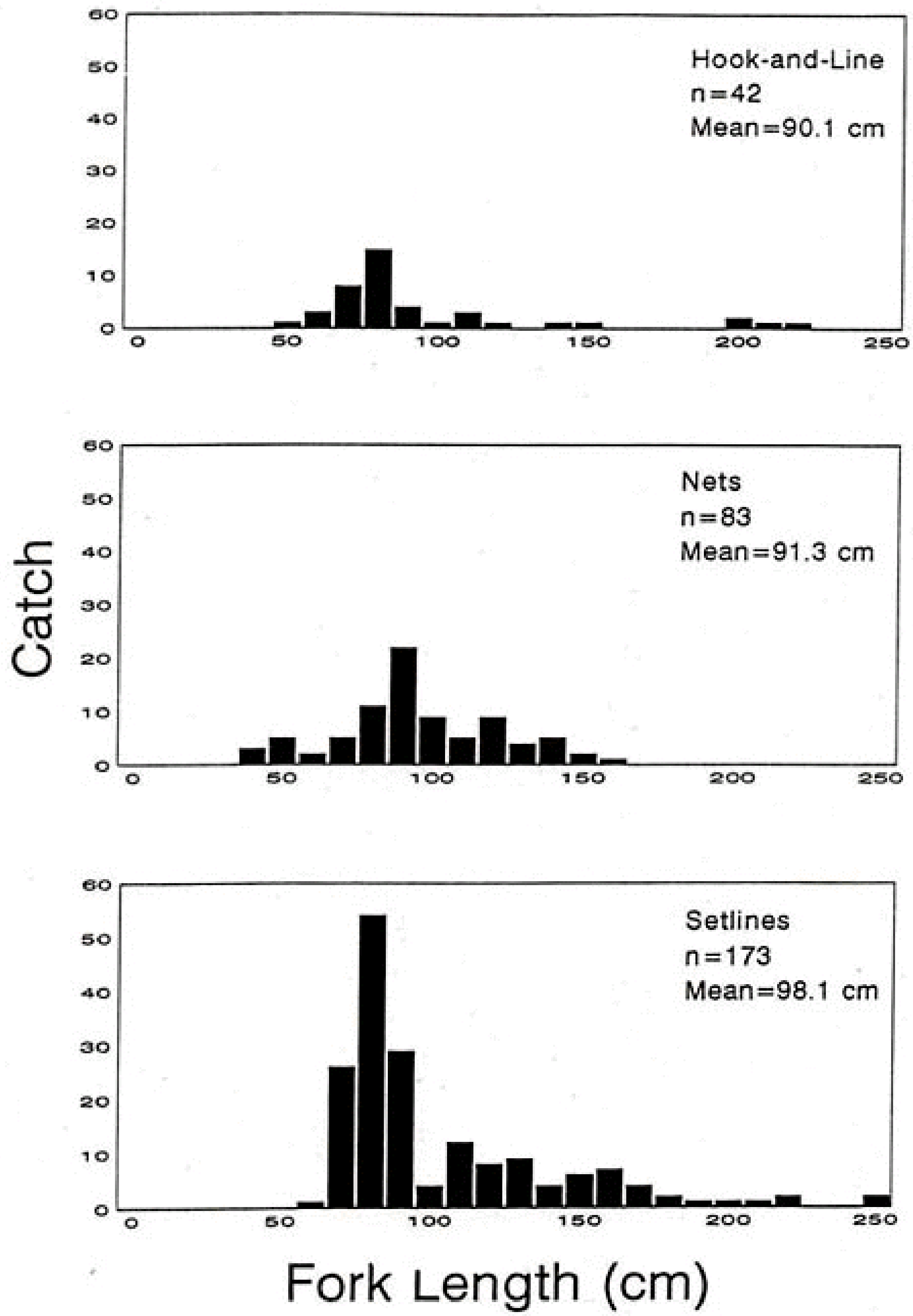

Figure 1. Frequency of white sturgeon captured throughout the Snake River between Lower Granite Reservoir and the mouth of the Salmon River using hook-and-line, nets, and setlines.

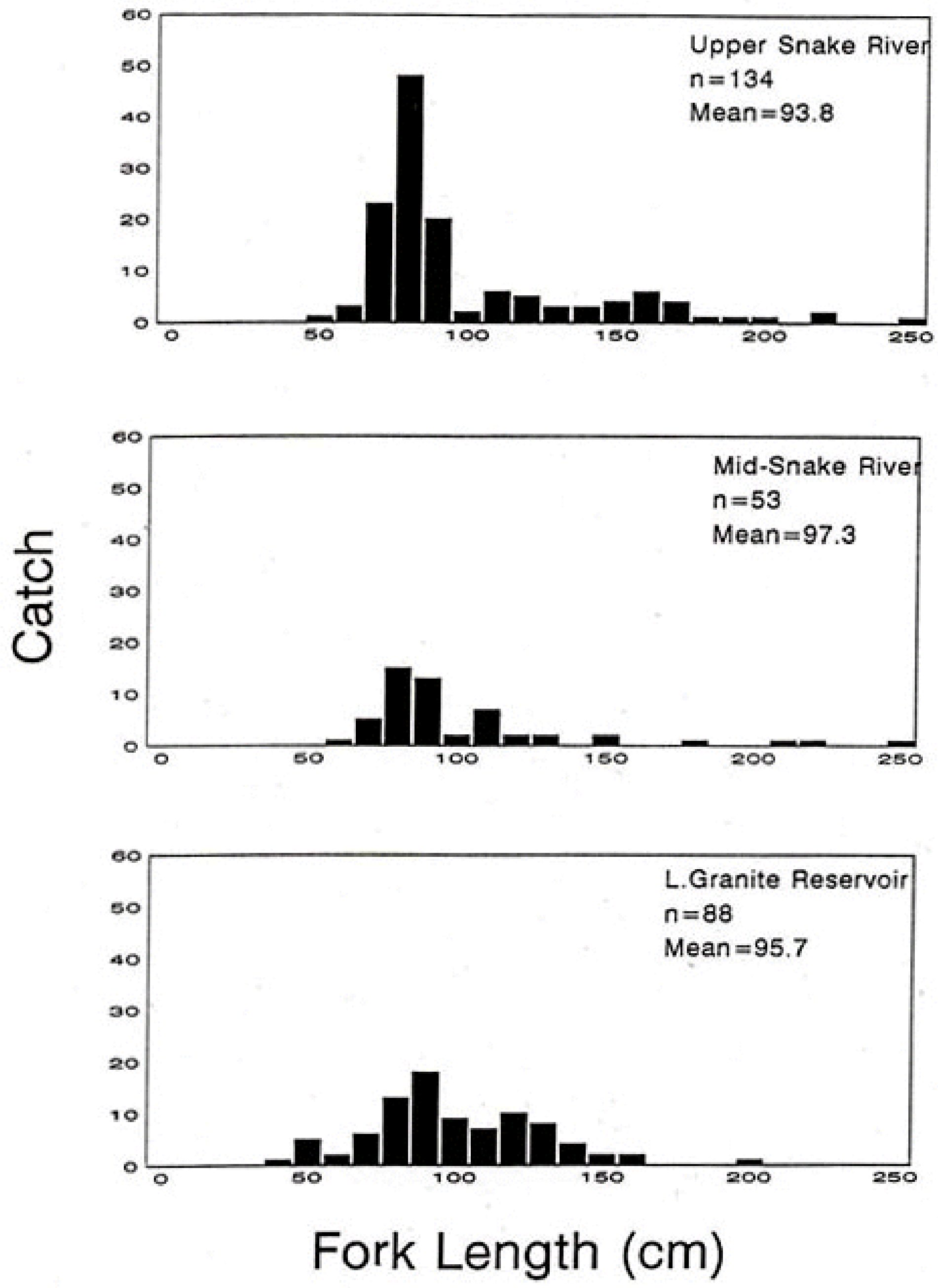

Figure 2. Frequency of whites sturgeon captured in Lower Granite Reservoir, mid-reaches and upper reaches of the Snake River in 1997.

Although length frequency distributions were not significantly different among the reaches sampled, fewer white sturgeon were collected in the mid-Snake River reaches. Catch rates between the mouth of the Clearwater River and the Grande Ronde River were generally lower than in Lower Granite Reservoir and upper Snake River reaches (Table 4). Catch rates were low in these reaches except for the first week in November when 29 fish were captured from reach six between Buffalo Eddy and the mouth of the Grande Ronde River fishing with setlines and hook-and-line.

Movements of Recaptured Fish

Sixteen white sturgeon tagged in 1997 were recaptured (Table 5). Two of these fish were captured twice. Movements of eight recaptured white sturgeon were less than 4 km. Duration between captures ranged from 3 to 345 days. Movements were both upstream and downstream. Four recaptured white sturgeon moved between 7.9 and 27.4 km throughout Lower Granite Reservoir. Three moved upstream and one downstream.

Only two sturgeon moved more than 30 km. One of these white sturgeon moved downstream close to 50 km from above Buffalo Eddy (Rkm 256) to below Clarkston, WA into Lower Granite Reservoir (Rkm 224). Another fish moved 47 km upstream. It was originally marked near the mouth of the Clearwater River (Rkm 224) and was recaptured near the mouth of the Grande Ronde River (Rkm 271). Direction of movement did not appear to be seasonal. Fish recaptured ranged between 68 to 108 cm. No difference in movement among fish of different size classes was apparent.

Five white sturgeon captured during 1997 had previously been tagged. Three of the white sturgeon had PIT tags and three had metal fin clips. One fish was doubled tagged with both a metal fin clip and a PIT tag. One of these fish was originally captured on July 16, 1990 and recaptured in July 25 1991 in Lower Granite Reservoir (Rkm 215.1). This fish was recaptured in 1997 on April 17th. It was captured approximately 2 km upstream from the original capture location and gained 9.3 kg (2.2 kg to 11.5 kg) and increased in length 32.9 cm (from 79.1 cm to 112 cm; personnel communications Ken Lepla, Idaho Power Company). Although data on the other white sturgeon that were marked were not found it was assumed from the PIT tag series and tag types they were also originally captured and marked in Lower Granite in either 1990 or 1991. Three of these sturgeon were recaptured in Lower Granite Reservoir. The other was recaptured near the mouth of Cache Creek (Rkm 285).

Table 5. Movements of white sturgeon recaptured in the Snake River during 1997.

Fish Identification	Fork Length	Dates	Duration (days)	Capture 1 (Rkm)	Recapture 1 (Rkm)	Recapture 2 (Rkm)	Distance Moved (Rkm)
151008190c	99.5	12/09-12/12	3	217.2	218	-	0.8
41585e5645	99	3/19-4/09	21	206.3	208.2		1.9
1f3e795951	68	7/29-9/23	56	261.5	211.6		-49.9
1510107c18	100	8/07-8/08-8/14	6	185	197.1	206.3	12.1, 9.2
1510105e4a	89	8/05-8/13	8	198.7	206.6		7.9
1f4d3c7860	83	8/19-10/27	69	284.8	284.1		-0.7
151c08093c	108	8/19-9/08	20	284.8	284.6		-0.2
1510082128	82	8/25-9/16	22	225.3	197.9		-27.4
1f4d0c6226	86	8/25-10/22	58	225.6	227.4		1.8
1510101014	88	9/10-11/04	24	259	258.2		-0.8
1f2e3a2b4e	75	5/28-9/10-11/17	345	257.9	259	255.8	1.1, -3.2
1f4d16443a	76	9/09-10/28	49	284.6	284		-0.6

1510103104	83	10/23-11/06	14	224	268.7	44.7
151010304c	100	8/07-9/24	48	197.1	223.7	26.6
1510105018	80	11/04-11/17	13	258.2	255.8	-2.4

White sturgeon distribution in the Clearwater River

Approximately 50 hours of hook-and-line and 150 hours of setline sampling were conducted in the Clearwater River during the first week of October, 1997. No fish were captured. Sampling was concentrated around Slaughter House Hole near Orofino (Rkm 67), the mouth of the North Fork near Orofino (Rkm 65), Pink House Hole near Orofino (Rkm 63), the mouth of Big Canyon Creek near Peck (Rkm 56), Big Eddy near Lenore (Rkm 45), the bridge near Cherry Lane (Rkm 34), the beach at Myrtle (Rkm 29), and Lapwai Creek near Spalding (Rkm 19).

Length-Weight Relationships

The 275 white sturgeon from which fork length (cm) and weight (kg) data were measured ranged from 34 to 211.5 cm in length and weighed between 0.2 and 82.2 kg. The allometric relationship between weight and length ($W = 2.0 \text{ E-}06\ L^{3.3281}$, Figure 3) derived for white sturgeon collected between Lower Granite Dam and the mouth of the Salmon River in 1997 appeared realistic (r^2=0.97).

Discussion

In 1997, 298 white sturgeon were marked in the Snake River between Lower Granite Dam and the mouth of the Salmon River. Recapture data from these marked fish in 1998 and beyond will allow us to develop an estimate of the population of white sturgeon in Snake River and begin to assess the degree of movement in the population.

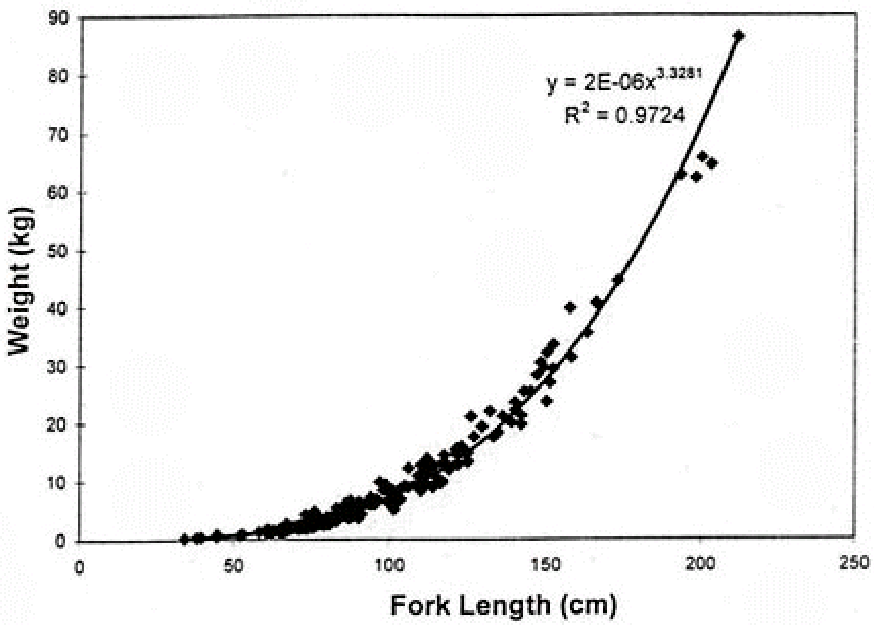

Figure 3. Fork length (cm) and weight (kg) relationship of 275 fish collected in the Snake River in 1997 between Lower Granite Dam and the mouth of the Salmon River.

Although a variety of sampling methods were employed to capture white sturgeon in 1997, fork length frequency distributions of the white sturgeon were not affected by collection method. In contrast, an earlier study conducted in Lower Granite Reservoir in 1990-91 found a significant difference in observed length frequencies of white sturgeon sampled with nets versus setlines (Lepla 1994). According to Lepla (1994), white sturgeon captured in Lower Granite Reservoir with setlines were larger than those captured using nets, with means of 127.3 cm and 62.3 cm FL, respectively. The difference in the Lepla (1994) results and our current study may be attributed to the size of the net mesh used. Lepla (1994) showed that smaller mesh nets caught smaller fish. Nets used by Lepla (1994) were less than 15.24 cm, and the majority of fish were caught using nets with mesh sizes less than 10.16 cm. In contrast, all the nets used in our study were 10.16 cm or larger, with the majority of fish captured with meshes exceeding 15.24 cm.

Although catch rates of white sturgeon in 1997 appeared higher with nets than setlines, results may be misleading. Setlines were used throughout the area sampled, whereas nets were only used in Lower Granite Reservoir, where catches of white sturgeon were higher than in the mid Snake River reaches. Although the study was designed to allow differences between sampling methods to be tested, departure from the sampling design occurred due to various reasons (i.e., weather, the migration of spring chinook and steelhead trout, etc.). This limited comparisons of method efficiency, even within similar reaches, from the data collected in 1997. However, when setlines and nets were used at the same location and within the same time frame, setlines were generally more efficient that nets. Parker (*in press*) reported a high degree of success using nets to collect white sturgeon in Lower Columbia River reservoirs. However, similar to our results, Elliot and Beamesderfer (1990) found that setlines provided the greatest catch rate per sampling week (61.4), followed by nets (49.4) and angling (34.4). Thus, net sampling is not required, except when targeting young-of- the-year (YOY) fish and in the assessment of habitat use. Setline sampling proved to be as efficient as nets in Lower Granite Reservoir, and more importantly the use of on gear type will simplify basin-wide comparisons.

Interpretation of data and comparisons among reaches was also limited due to departures from the randomized sampling design. However, catch rates from nets within Lower Granite Reservoir indicate that number of fish were greater in upper third of the reservoir. Although setline data appeared to contradict these findings, this may also be attributed to departures from the study design. Because setlines were used in the Reservoir later in the year, and the number of fish captured was small, these data are of limited use. Based on our net data the tentative finding of higher numbers of white sturgeon in the upper third of the reservoir substantiate those of Lepla (1994). Lepla (1994) could not relate these differences directly to habitat differences, although the upper sections of the reservoir where he sampled had higher velocities, larger substrates and shallower depths than areas sampled downstream. Lepla (1994) speculated that prey abundance and availability may be important in regulating habitat use of white sturgeon in Lower Granite Reservoir. He found higher densities of crayfish *Pacifactacus leniusculus* in the upper sections of the reservoir and a high correlation between crayfish and white sturgeon distributions. The stomach contents examined from three white sturgeon collected from the upper third of the reservoir during 1997 indicated that crayfish were the predominant food item of these white sturgeon.

Setline data were useful to compare mid- and upper-Snake River reaches. During 1997, densities of white sturgeon were greater in the upper-Snake River reaches. Generally, fewer fish were collected in the mid-Snake River reaches, with the exception of the reach between Buffalo Eddy and the Grande Ronde River. Within in this section, 29 white sturgeon were collected in the first week of November. The capture of white sturgeon in November corresponded with a high concentration of steelhead trout. The mid Snake River reaches are generally shallower with fewer deep pools or holes. Subsequent data on habitat use by white sturgeon will help assess the affect of depth and or other environmental factors (velocity, substrate) on white sturgeon distributions. Lepla (1994) and Parsley and Beckman (1994) showed that habitat (depth, velocity, and substrate) explained < 30 percent of the variation in the distributions of juvenile and adult fish in reservoir white sturgeon populations. Effects of habitat in free-flowing river reaches on white sturgeon distributions have not been assessed.

Differences in length frequency distributions of fish were not detectable between the reaches. Mean fork length of the fish caught in the reservoir, mid- and upper reaches of the Snake River were comparable (Figure 2). Also, no difference in size class composition for white sturgeon with total lengths <92 cm, between 92 and 183 cm and >183 cm was apparent among the fish collected from the reservoir and the mid- and upper reaches in 1997. Coon *et al.* (1975), however, found differences in the percent of the populations between 92 and 183 cm long in Lower Granite Reservoir as compared to the free-flow sections of the Snake River in Hells Canyon. According to Coon *et al.* (1975) twenty-nine percent of the population in Lower Granite Reservoir was between 92 and 183 cm, but only 3 percent of the population in the upper river were comprised of fish in this length class.

Earlier studies also found that a large proportion of the white sturgeon population was comprised of fish with total lengths < 92 cm (Coon *et al.*1975, Lukens 1985). In 1972-75, 86 percent (Coon *et al.*1975), and in 1982-84, 80 percent (Lukens 1985), of the population were comprised of white sturgeon < 92 cm (Figure 4). In addition, the proportion of white sturgeon between 92 and 183 cm, which were heavily harvested until 1970, only comprised 4 and 18 percent of the populations sampled in the 1970's and 1980's, respectively (Coon *et al*. 975, Lukens 1985). In contrast, of the white sturgeon collected during 1997, only 49 percent were < 92 cm, while 46 percent ranged between 92 and 183 cm. Before these findings can be attributed to changes in the population, or the a recovery of a size class that was over harvested, further sampling is needed. Difference in collection techniques and study design of these studies make comparisons difficult at this time. For example, the majority of the sampling in 1997 was done with setlines rigged with 12/0 and 14/0 hooks and nets with mesh sizes ranging between 10.2 and 22.9 cm. White sturgeon did not appear to recruit to the gear until they reached 90 cm in length. In earlier studies, smaller hooks and mesh sizes were used and sturgeon appeared to be recruited to the gear at smaller sizes (Coon *et al*.1977, Lukens 1984, Lepla 1994). Lepla (1994) showed that smaller hooks and smaller mesh captured smaller fish. In 1998 it is important that a wider range of hook sizes and a wider variety of mesh sizes, if nets are used, are employed to determine whether the length frequency distribution from the population collected in 1997 is reflective of the population at large or an artifact of sampling methods.

The length frequency distribution for 1997 suggests that white sturgeon between 92 and 183 cm are prevalent in the reaches of the Snake River that were sampled. Although caution is advised when comparing previous studies, we noted that this was not the case in the 1970 and 1980's, when few white sturgeon > 92 were found (Coon *et al.*1977, Lukens 1985). It is apparent, however, that

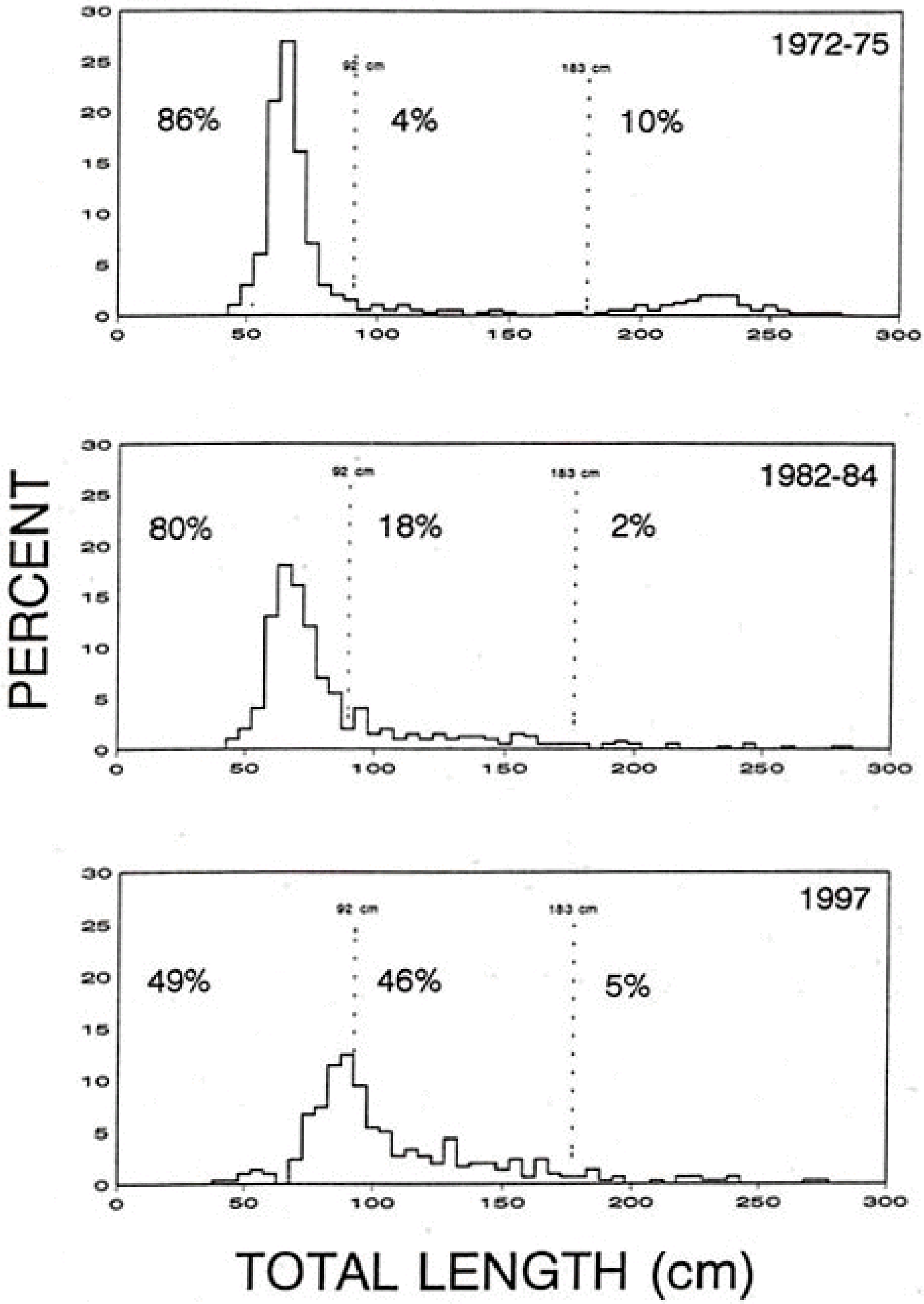

Figure 4. The length (total length) frequency distributions of sturgeon sampled from the Hells Canyon reaches of the Snake River, 1997, 1982-84 (Lukens 1985), and 1972-75 (Coon et al. 1977) and the percent of the populations < 92 cm, between 92 and 183 cm, and >183 cm.

the abundance of white sturgeon >183 has not changed markedly since 1970. In fact, the percent of fish >183 cm appears to have decreased slightly, from ten percent in 1972-75, to three and five percent in 1982-84 and in 1997, respectively (Figure 4). Given that the sampling designs and techniques employed were not identical the data suggest that, although white sturgeon between 92 and 183 cm have apparently increased in abundance, sturgeon >183 cm apparently have not. This may indicate that some factor other than past over-fishing practices is limiting the recruitment of white sturgeon into larger size classes (>183 cm). Habitat, food resources, and migration have been severely altered by the impoundment of the Snake and Columbia Rivers and it appears that recruitment of young white sturgeon has been less severely affected than recruitment of fish into size classes > 183 cm.

Both Lukens (1985) and Lepla (1994) suggested that white sturgeon condition in the Snake River has improved since the early 1970's. Although not statistically significant, a shift in the length-weight relationship was apparent between studies conducted in 1972-75, 1982-84, and 1990-91 (Figure 5, Coon *et al*. 977, Lukens 1985, Lepla 1994). Lukens (1985) suggested that white sturgeon condition improved between the 1970's and 1980's, particularly for large sturgeon. Because few white sturgeon >183 cm are typically captured, data from these sturgeon can significantly affect the relationship (Sokal and Rohlf 1981, Zar 1974). Thus, inferences on changes in the condition of the population should be based only on total populations responses as Lepla (1994) observed for white sturgeon in Lower Granite Reservoir in 1990-91. In 1997, the length-weight relationship of sturgeon was comparable to that found by Coon *et al.* (1977) for 1972-75 (Figure 5). In addition, analysis of length-weight data in 1997 from populations from Lower Granite Reservoir and the free-flowing reaches of the Snake River were not significantly different (F=1.26,p= 0.2889, $df_{(2,275)}$). Our results suggest that condition in white sturgeon have not changed since 1972-75 and that the condition of white sturgeon in the reservoir and the free-flowing reaches of the Snake River we sampled are not different.

Similar to other studies, movement of white sturgeon in the river was varied (Coon *et al.* 1977). Coon *et al.*(1977) found that white sturgeon < 92 cm in length generally tended to move downstream, while larger sturgeon, although movements were localized, moved both upstream and

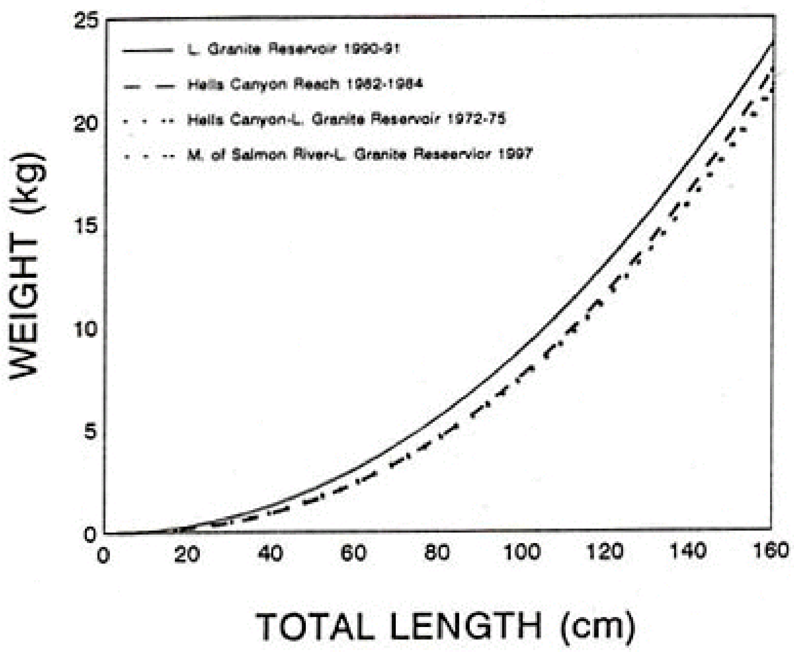

Figure 5. Length-weight relationships for white sturgeon captured in the Snake River in 1972-75 (Coon *et al.* 1977), 1982-84 (Lukens 1985), 1990-91 (Lepla 1994) and in 1997.

downstream. The white sturgeon we recaptured ranged from 68 to 108 cm. Ten of these were < 93 cm. No discernable directional movement was apparent. White sturgeon of all sizes moved upstream and downstream and covered distances ranging from 0.8 to 49.9 km. Tracking movement and habitat use of white sturgeon of different sizes throughout the Snake and Salmon Rivers between Lower Granite and Hells Canyon dams will help to clarify habitat use and movement throughout the system.

Although we did not find any white sturgeon in the Clearwater River in October this does not indicate that white sturgeon do not utilize the Clearwater River. Use may be seasonal or numbers may be low enough that they were undetected. We will continue to periodically sample for white sturgeon in the Clearwater River throughout the year.

PLANS FOR 1998

Specific sampling plans and objectives for 1998 are outlined in the multi-year Study Plan (Hoefs 1997). In 1998, we will continue to capture white sturgeon using a randomized design between Lower Granite Dam and the mouth of the Salmon River. Recapture data and new capture data will be used to estimate population size and collect additional population data as outlined by Task I (Table 2). To complete Task I we intend to expand our sampling to include the Salmon River and begin measuring environmental conditions at locations were white sturgeon are sampled. We intend also to begin our assessment of habitat use by white sturgeon for spawning and rearing (Task 2). This will be accomplished by tracking habitat use and movement of juvenile, adult and spawning white sturgeon using techniques developed and used in the Columbia River Basin by other white sturgeon researchers (see Hoefs 1997).

Sampling in 1997 indicated that: 1) catch rates of white sturgeon in Lower Granite Reservoir using setlines were comparable to those of nets and that catch rate per sampling week with setlines was generally greater, and 2) white sturgeon < 92 cm were not fully recruited to the sampling gear. Thus, in 1998 net sampling should be employed only when targeting young-of- the-year (YOY) white sturgeon and in the assessment of habitat use. This modification will allow a greater sampling continuity between reaches and reduce the some of the problems we encountered in 1997 with multi-gear sampling. Secondly, sampling designed to target fish <92 cm needs to be incorporated into

1997 sampling protocols. The inclusion of a greater diversity of hook sizes (including 8/0 and 10/0 hooks) on setlines, and by randomizing sampling locations will target a greater size range of white sturgeon and a wider range of habitat types. These efforts should eliminate these sources of sampling bias and will provide more accurate population age structure, distributions and population age data.

REFERENCES

Apperson, K., and P.J. Anders. 1990. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1989. Idaho Department of Fish and Game and Bonneville Power Administration. Contract Number DE-A179-88BP93497, Project 88-65. Portland, OR.

Carmichael, R., L. Lestelle, L. Mobrand, D. Statler, R. Carter, D. Bennett, J. Chandler, K. Lepla, T. Cochnauer, J. DeVore, T. Rien, R. McMullin, M. J. Parsley, and A. Seamans. 1997. Upper Snake River White Sturgeon Biological Risk Assessment. Prepared for Nez Perce Tribe by Mobrand Biometrics Inc. Vashon Island, WA.

Columbia Basin Fish and Wildlife Authority. 1997. Draft Multi-year implementation plan for resident fish protection, enhancement and mitigation in the Columbia River Basin. CBFWA Tech. Planning Document. Portland, OR.

Coon, J.C. and R.R. Ringe, and T.C. Bjornn. 1977. Abundance, growth and movements of white sturgeon in the mid-snake river. Research Technical Completion Report Project B-026-IDA. Idaho Water Resources Research Institute. University of Idaho. Moscow, ID.

Elliott, J.C. and R.C. Beamesderfer. 1990. Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River Reservoir. Calif. Fish and Game 76:174-190.

Hoefs, N.J. *in press* Evaluation of potential means of rebuilding sturgeon populations in the Snake River between Lower Granite and Hells Canyon dams. 1996 Annual Report. *in* K.J. Beiningen (*editor*). Sturgeon and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Report to Bonneville Power Administration (Project 86-50). Portland, OR.

Hoefs, N.J. 1997. *DRAFT* Phase Two: Multi-year study plan to evaluate potential means of rebuilding sturgeon populations in the Snake River between Lower Granite and Hells Canyon Dams. Nez Perce Tribe Department of Fisheries Resource Management and Bonneville Power Administration. Contract Number 97-AM-30423, Project 97-09. Portland, OR.

Idaho Power Company. 1997. Status and habitat use of white sturgeon in the Hells Canyon Complex. Formal Consultation Package for Relicensing. Hells Canyon Project, FERC no. 1971. Volume 1. Idaho Power Company. Boise, ID.

Lepla, K.B. 1994. White sturgeon abundance and associated habitat in Lower Granite Reservoir, Washington. Thesis. University of Idaho. Moscow, ID.

Lestelle, L.C., L.E/ Mobrand, J.A. Lichatowich, T.S. Vogel. 1996. Ecosystem diagnosis and treatment (EDT) Applied Ecosystem Analysis- A Primer. BPA Department of Fish and Wildlife. Portland, OR

Lukens, J.R. 1985. Hells Canyon White Sturgeon Investigations. Idaho Department of Fish and Game, River and Stream investigations, Job Performance Report, Project No. F-73-R-7. Idaho Fish and Game, Boise, ID.

Parker, B.L. *in press*. Report E *in* K.J. Beiningen (*editor*). Sturgeon and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Report to Bonneville Power Administration (Project 86-50). Portland, OR.

Parsley, M.J and L.G. Beckman. 1994. White Sturgeon Spawning and Rearing Habitat in the Lower Columbia River. North American Journal of Fisheries Management 14:812-827.

Sokal, R.R. and F.J. Rohlf. 1981. *Biometry*. W.H. Freeman, San Francisco. CA.

Zar, J.H. 1974. *Biostatistical Analysis*. Prentice-Hall, Englewood Cliffs, New Jersey.

APPENDIX A

White Sturgeon data

Appendix A. White Sturgeon data collected in 1997.

	Date	Tag numbers PIT	FLOY	Sampling Method	Location (Rkm)	Lengths Fork (cm)	Total (cm)	Girth (cm)	Weight (kg)	Comments
1	022597	41596c6c32	1	n	178.3	83	98	39	5.4	
2	030497	4158602432	2	n	209.5	109.5	128	44.5	10.3	
3	030497	41590b4d1b	3	n	210.0	106	122	41.5	8.9	
4	030497	415862461b	4	n	201.9	67	79	29	2.7	
5	030597	4158650c6f	5	n	209.5	96	110.5	42	6.9	
6	030597	4158504c75	6	n	205.1	117	135	48	13.2	
7	030597	415857286a	7	n	206.4	67	77.5	29	2.7	
8	031897	415845481b	8	n	206.8	86	101	42.5	6.2	
9	031997	415848282e	9	n	201.1	87.5	103	40	6.6	
10	031997	4158562d47	10	n	206.3	121	142	54	15.4	metal fin clip 1538
11	031997	41585e5645	11	n	206.3	99	114	47	9.4	
12	031997	4158596e01	12	n	206.4	94	106	43	7.2	
13	032097	.	.	n	.	34	40	14	0.2	Not tagged
14	040297	.	.	n	.	140	160.7	60.5	23.5	EPA contaminant study
15	040897	41584d0916	13	n	206.8	90	102	40.5	6.4	
16	040997	41585e5645	11	n	208.2	.	.	.	.	Recapture
17	040997	4158467f18	14	n	206.6	85.5	97.5	37.5	4.9	
18	040997	1f4d373528	15	n	206.6	60	68	23	1.5	
19	041797	4158670177	16	n	217.2	112	128	52	13.9	fin tag 1369 PIT 7f71302567a
20	041797	4158470f08	17	n	217.2	112	127	49	11.5	PIT 7f7f775d00
21	041797	41591c0703	18	n	218.0	113	130	51	13.2	
22	041797	4158683316	19	n	218.0	117.5	135	54.5	14.4	
23	052897	1f4e7f3163	20	hl	257.9	75	80	32	3.3	
24	052897	1f4d1e0076	21	hl	257.9	83	94	35	4.2	
25	052897	1f4d047c14	22	hl	257.9	74	83	35	3.1	
26	052897	1f2e3a2b4e	120	hl	257.9	75	88	28.5	3.0	
27	070997	1f50142f4e	154	hl	286.4	101	114	40.5	8.5	
28	071497	4158461e41	37	hl	286.4	193	218	84	62.6	
29	071497	1f4d122959	38	hl	286.4	74	82	27	2.4	
30	071497	1f4d323131	39	hl	286.4	74	85	32	3.2	
31	071497	1f4d0e2c5a	40	hl	286.4	53	60	19.5	0.9	
32	071497	1f4d10156f	41	hl	286.4	44	51	17	0.7	
33	072997	1f2e452a44	42	hl	261.5	101	113.5	40.5	6.3	
34	072997	1f3e795951	43	hl	261.5	68	78	20.5	1.8	
35	080597	1510104121	44	sl	191.5	119	132	50.5	11.9	
36	080597	1510082c0c	45	n	185.0	98	112	46.5	8.4	
37	080597	1510082062	46	n	185.0	89	100	39.5	5.9	
38	080597	1510100e42	47	n	185.0	75.9	91	40.5	4.9	
39	080597	1510107c18	49	n	185.0	100	109	46.5	8.5	
40	080597	1510100c5a	51	n	185.8	97	110	48.5	9.8	
41	080597	1510083678	52	n	185.8	87.5	100	32	4.5	
42	080597	1510101912	53	n	185.8	90	100	36	5.6	
43	080597	1510101914	54	n	186.6	73	83	30.4	2.4	
44	080597	1510100a18	55	n	186.6	82	91	33	3.6	
45	080597	1f4d42755d	56	n	186.6	52	59	29	0.8	

Appendix A. continued

46	080597	151010440e	57	n	186.6	77	87	28	2.5	
47	080597	1510105e02	58	n	186.6	82	91.5	36.5	4.0	
48	080597	1510105e4a	59	n	198.7	89	103	37.5	5.5	
49	080597	1f4d343c24	144	n	217.2	44.5	51	17	0.7	
50	080597	151008391a	145	n	217.2	78	90	30.5	3.0	
51	080597	1f4d30382c	146	n	.	80	90	34	3.9	
52	080597	1510085039	147	n	.	82	93.5	35	4.1	
53	080597	1510085161	148	n	.	115	129	48	10.8	
54	080597	1f4d2e4c1a	149	n	.	148	165	71	30.4	
55	080597	1f4d335908	150	n	.	133	150	52	17.6	
56	080697	1f4d100a7a	60	n	198.7	44.5	51	18	0.6	
57	080697	1f2e34156a	61	n	198.7	39.5	45.5	17	0.4	
58	080697	1510103a18	132	n	185.8	83	93	35	4.0	
59	080697	1f4d0c4c3c	.	n	185.0	88	98	38	4.8	
60	080697	1510085a3a	.	n	185.0	67	76	28	2.0	
61	080697	1510106e41	.	n	185.0	109	121	48	10.9	
62	080697	1510082a76	.	n	185.0	138	152	59	20.5	
63	080697	1f4d387c60	.	n	185.0	89	97	40	4.7	
64	080697	1510082161	.	n	185.0	80	91	33	3.7	
65	080797	1510107c18	49	n	197.1	.	.	.	.	Recapture
66	080797	1510103222	62	n	206.0	89	103	37	.	
67	080797	1510106e64	63	n	206.0	120	138	52	.	
68	080797	1f2e345a25	64	n	202.7	41.5	48	15.5	.	
69	080797	1f2e345a25	64	n	202.7	41.5	48	15.5	.	
70	080797	1510104c5c	66	n	182.8	123	139	67	16.0	
71	080797	151010304c	179	n	197.1	100	112.5	55.5	.	
72	081297	.	50	n	209.2	.	.	.	.	Recapture
73	081297	1510085c44	67	n	212.7	147	160	66	28.2	
74	081297	1510104a49	128	n	213.2	103.5	117.5	43	8.8	
75	081297	1510101172	129	n	213.2	134	148.5	65	18.0	
76	081297	1510105411	130	n	213.2	114	127	51	12.5	
77	081397	1510105e4a	59	n	206.6	.	.	.	.	Recapture
78	081397	1510085c20	68	n	219.6	160	184	66	.	
79	081397	1f2e2e0c79	69	n	206.6	84	97.5	35	4.4	
80	081397	1510082e5e	72	n	206.6	94	108	42	6.5	
81	081397	1f4d0e790d	77	sl	206.0	61.5	69.5	26	1.5	
82	081397	1510083274	78	sl	206.8	76	86.5	30.5	3.2	
83	081397	1510101409	.	hl	382.9	72.5	81.5	25.5	2.1	
84	081397	1510102822	.	hl	382.9	70.5	77	25.5	2.1	
85	081497	1510107c18	49	n	206.3	.	.	.	.	Recapture
86	081497	1510082e60	73	n	206.6	90	102	33	3.6	
87	081497	1f4d4c7157	74	n	206.6	140	155	65	22.1	
88	081497	1510083956	75	n	206.3	127	139	54	17.6	
89	081497	151010623e	76	n	206.3	105	120	47	9.2	
90	081497	1f4d376f6e	126	n	218.8	73	83	26	2.2	
91	081497	1510101416	127	n	222.0	80	91	28	2.8	
92	081497	1510080c3e	.	hl	369.7	58	66	22.5	1.3	
93	081997	1510082e10	79	hl	284.8	65.5	71	23.5	1.7	
94	081997	1f4d363f1f	81	hl	284.8	118	128.5	51	12.8	

Appendix A. continued

95	081997	1510085e31	82	hl	284.8	143	153	63	25.4	
96	081997	1f4d3c7860	83	hl	284.8	83	90.5	32	3.1	
97	081997	1f4d2f075e	84	hl	284.8	66	75	24	1.6	
98	081997	1510083912	85	hl	284.8	72.5	81.5	29	2.6	
99	081997	151c083150	86	hl	284.8	69.5	78.5	26.5	1.9	
100	081997	1510083e51	87	hl	284.8	87	95.5	32	3.6	
101	081997	151c08093c	88	hl	284.8	108	119.5	44	9.4	
102	081997	1510085018	89	hl	284.8	70	80.5	25.5	2.0	
103	081997	1f4d2e2145	90	hl	303.0	75.5	86.5	23.5	2.2	
104	082097	151c085052	91	hl	296.1	70	77	27	2.2	
105	082597	1510082128	92	n	225.3	82	94	35	4.3	
106	082597	1f400c6226	93	n	225.3	86	96.5	31	3.9	
107	082697	1f4d0c5137	125	hl	255.0	66	73	24	1.6	
108	082797	1510082626	94	sl	227.7	122	135	48.5	12.8	
109	082897	1510101668		hl	32.2	134.5	149	53.5	18.4	
110	090897	151c08093c	88	hl	284.6	.	.	.	.	Recaptue
111	090897	151010561a	122	hl	283.2	71.5	82	25.5	2.2	
112	090897	1f4d091b70	123	hl	284.6	78	88	26.5	2.6	
113	090897	1510081821	124	hl	261.8	211.5	227	97	86.2	
114	090997	1510101640	121	hl	284.6	76	85.5	30	3.1	
115	091097	1510101a1e	113	hl	.	203	223	72	64.4	
116	091097	1510102219	114	hl	.	78	87.5	29	3.0	
117	091097	151010061a	115	hl	.	198	220	80.5	62.1	
118	091097	1f4d1c6810	116	hl	259.0	72.5	80	27	2.4	
119	091097	1510101014	117	hl	259.0	88	99.5	32.5	4.2	
120	091097	4159042321	119	hl	259.0	91	101	33	4.4	
121	091097	1f2e3a2b4e	120	hl	259.0	.	.	.	.	Recapture
122	091597	1f4d2c1058	95	n	197.1	61	66	25.5	1.7	
123	091597	1510106161	96	n	197.1	112	123.5	50.5	9.3	
124	091697	1510082128	92	sl	197.9	.	.	.	.	Recapture
125	091697	1510082220	97	sl	197.9	73	82	29.5	2.7	
126	091697	1510103a49	99	sl	197.9	121.5	137	54	15.7	
127	091697	1510083642	100	sl	197.9	110.5	120.5	48	11.6	
128	091697	1510082130	195	n	197.9	73	87	33	3.1	
129	091697	1510084a40	196	n	197.9	125	143	53.5	13.4	
130	091697	1510106152	197	n	197.9	91	107	37	6.2	
131	091697	1510084962	199	sl	197.9	125	140.5	52	14.8	
132	091697	1510082e59	200	sl	197.9	129.5	142	61	19.3	
133	091697	1510085c3c	.	n	197.9	44.5	52.5	19	0.9	
134	091797	1f4d323032	111	sl	197.9	68.5	79	26.5	1.8	
135	091797	1f3e7c1017	112	sl	197.9	71	82	30	2.3	
136	091797	151008390e	183	n	.	83	95	35.5	4.3	
137	091797	1510082156	184	n	.	94	104.5	37	5.9	
138	091797	1f2e490b5f	185	n	.	80	90	31	3.5	
139	091797	1510082e42	186	n	.	90	102.5	36	5.3	
140	091797	1510083c54	187	n	.	65	73.5	26.5	1.7	
141	091797	151008504c	188	n	.	77.5	90.5	31.5	3.4	
142	091797	151008517a	189	sl	196.3	121	144	53	14.6	
143	091797	151008212a	190	sl	196.3	200	222	89	65.5	

Appendix A. continued

144	091797	1510107c6a	191	sl	197.9	110	122	48	10.7	
145	091797	1510082479	193	sl	197.9	90	101	35	4.8	
146	091797	1510083150	194	sl	197.9	72	80.5	29.5	2.5	
147	091797	.	.	n	.	38	43	15.5	0.3	
148	092397	1f3e795951	43	sl	211.6	.	.	.	.	Recapture
149	092397	1510102c48	180	sl	214.0	136	153	58.5	21.1	
150	092397	1510083641	181	sl	221.2	80	88	30.5	2.9	
151	092397	1510083e70	182	sl	214.0	149	170	76	29.5	
152	092497	1510101922	178	sl	223.7	151	164	63.5	26.8	
153	0924.97	151010304c	179	sl	223.7	106	119	53	12.2	Recapture
154	092997	1510082842	108	sl	292.0	114	126.5	45	9.3	
155	092997	1f4d044947	109	sl	292.0	78	86	26	2.9	
156	092997	1f4d13463b	110	sl	292.0	80.5	89.5	28	3.1	
157	100197	1f4d4e2422	101	sl	288.8	61.5	69	21	1.4	
158	100197	1f4d136f12	102	sl	288.8	66	74	24	1.8	
159	100197	1510085c60	103	sl	.	65	78	25	1.6	
160	100197	1510082131	104	sl	.	84.5	97	34	4.2	
161	100197	1f4d42282a	105	sl	.	63	71	22.5	1.4	
162	100197	1f4d194d2e	106	sl	292.0	66	74	23	1.5	
163	100197	1f4d11067d	107	sl	292.0	62	71	21	1.2	
164	100197	1f4d392338	157	sl	287.2	73	81	28	2.4	
165	100197	1510081252	158	sl	287.2	100	113.5	39	7.7	
166	100197	.	169	sl	.	63	72	24	1.4	
167	100197	.	170	sl	.	65	71	22	1.1	
168	100197	.	172	sl	288.8	114	126	43	8.9	
169	100197	.	173	sl	288.8	71	82	27	2.2	
170	100197	.	174	sl	284.8	101	112.5	35	5.6	
171	100197	.	175	sl	284.8	75	87.5	28	2.5	
172	100197	.	176	sl	284.8	74	80	25	2.3	
173	100197	.	177	sl	284.8	66	75	23	1.3	
174	100297	1510104250	159	sl	284.8	76.5	87	31	3.3	
175	100297	1510104072	161	sl	284.8	73.5	80	24	2.0	
176	100297	1510103149	162	sl	284.8	158	175.5	61	31.2	
177	100297	1516101902	163	sl	284.8	69	78	24	2.1	
178	100297	1516107c2a	165	sl	284.8	77	83.5	27.5	2.5	
179	100297	1516100126	166	sl	284.8	76.5	88	26	3.1	
180	100297	1516103826	167	sl	284.8	65	72	23.5	1.7	
181	100297	1510103831	168	sl	284.8	76	82	28	2.8	
182	102197	1510083208	156	sl	224.1	74.5	87.5	23	2.2	
183	102297	1f4d0c6226	93	sl	227.4	.	.	.	.	
184	102297	1510101664	152	sl	228.2	126	153	60.5	21.0	
185	102297	1510104218	153	hl	259.0	63	72.5	23.5	1.5	
186	102297	1510082a70	154	sl	224.1	110	117.5	40	8.3	
187	102297	1510102460	155	sl	224.1	89	103	38	5.6	
188	102397	1510103104	151	sl	224.1	82.5	94	31.5	3.4	
189	102797	1f4d3c7860	83	sl	284.1	.	.	.	.	recapture
190	102797	1f4d187606	401	sl	272.7	75	85.5	27	2.5	
191	102797	1510104256	402	sl	276.3	125	139	51	13.3	
192	102797	1f4d36332b	403	sl	276.3	86	97	33	4.3	

Appendix A. continued

193	102797	1f4d1e3a3c	404	sl	276.3	73	85	26	4.3
194	102797	1510104172	405	sl	276.3	126	139.5	69	0.0
195	102797	1510104423	406	sl	273.9	166	182	76.5	40.4
196	102797	1510084e42	407	sl	274.7	77	88	29.5	2.7
197	102797	151008345c	408	sl	274.7	164	190	86	.
198	102797	1f4d026131	482	sl	272.7	73	82	24.5	1.9
199	102797	151008364a	483	sl	271.9	65	71	22.5	1.4
200	102797	1510082848	484	sl	271.9	80.5	88.5	28	2.9
201	102797	1510083a58	486	sl	271.9	73.5	81.5	24	1.7
202	102797	1f3e793575	487	sl	271.9	90	99.5	33	3.6
203	102797	1510101c28	488	sl	276.3	75	88	27.5	.
204	102797	1510104019	489	sl	276.3	153	169.5	65	.
205	102797	1510082c40	490	sl	276.3	151	170	67	.
206	102797	1510104e79	491	sl	277.1	71	81	25.5	.
207	102797	1f2e51657d	493	sl	277.1	72	81.5	27	.
208	102797	1510107c7e	495	sl	277.1	105.5	119	43	.
209	102797	1510084e4e	496	sl	284.0	84	92	34	4.1
210	102797	1510102a71	497	sl	284.1	70.5	80.5	28	2.3
211	102797	1510104c4e	498	sl	284.1	109.5	126.5	45	9.3
212	102797	1510082019	499	sl	284.1	79.5	91.5	28	2.9
213	102897	1f4d16443a	121	sl	284.0	76	87	30.5	3.0
214	102897	1f3e79101a	409	sl	276.3	69	76.5	28.5	2.2
215	102897	151010545a	410	sl	276.3	78.5	88	30.5	2.9
216	102897	1f4d036f22	411	sl	277.1	75	87	25.5	2.0
217	102897	1f4d4a7fab	412	sl	277.1	71	79	24	1.7
218	102897	1510082c4c	413	sl	284.0	152	172	72	33.4
219	102897	1f4d071e6f	414	sl	284.1	79	89	28	2.4
220	102897	1f4d011a19	415	sl	284.1	87	101	33	4.4
221	102897	1f3e781c0f	416	sl	284.1	74.5	86	28	2.9
222	102897	1f4d1b3e3b	417	sl	284.1	77	85	27	2.5
223	102897	151010147c	418	sl	272.7	65	74	24	1.7
224	102897	1f4d462b23	419	sl	277.1	63	72	23	1.5
225	102897	1f4d05721d	420	sl	279.5	62	70	21	1.4
226	102897	1f2ec7601	421	sl	279.5	82	92	31	3.3
227	102897	1f4d034c45	422	sl	276.3	85	94	33	4.0
228	102897	1510101634	423	sl	276.3	110	123	46.5	9.2
229	102897	1f4d324a18	424	sl	276.3	71	83	25	2.2
230	102897	1f4d5223111	425	sl	273.9	65.5	78	26	1.9
231	102897	151010295c	452	sl	276.3	184	206	82.5	.
232	102997	1510107c4e	426	sl	277.1	163	181	70	35.4
233	102997	1510105c40	427	sl	276.3	142	156	68	19.8
234	102997	1510101978	428	sl	276.3	72	81	26.5	2.5
235	102997	1f4d4c5771	429	sl	276.3	89	101	34.5	4.7
236	102997	151010517e	443	sl	271.9	72.5	81.5	27	2.4
237	102997	1510104268	444	sl	271.9	81	91.5	27.5	2.6
238	102997	1510100e56	445	sl	271.9	79	87.5	27	2.4
239	102997	1f4d091f6c	446	sl	271.9	80.5	92	28	2.5
240	102997	1510103242	447	sl	274.7	116.5	129.5	45	9.7
241	102997	1510100076	448	sl	276.3	116.7	129.5	48.5	10.0

Appendix A. continued

242	102997	1510102020	449	sl	277.1	126	143	48	.	
243	102997	1510103056	453	sl	284.0	76	85	24.5	2.2	
244	102997	1510102a20	454	sl	284.0	71.5	79	22	1.9	
245	102997	151008015c	478	sl	284.0	78.5	84.5	30	3.4	
246	102997	1510083e74	.	sl	284.0	140	173	50.5	.	
247	102997	1510084409	.	sl	272.7	75	86	23.5	2.1	
248	102997	1510082904	.	sl	284.0	150	165	68.5	32.0	
249	102997	1510081916	.	hl	284.8	50.5	55.5	21	.	
250	102997	151010622e	.	sl	272.7	84	94	31	3.7	
251	102997	1510105902	.	sl	272.7	72.5	80.5	27	2.5	
252	110497	1510101014	117	sl	258.2	.	.	.	.	recapture
253	110497	1510100908	433	sl	258.2	68.5	78	26.5	1.8	
254	110497	1f4d0e176f	434	sl	268.7	67	78	20	1.4	
255	110497	1f4d000a0a	435	sl	262.3	60	71	24.5	1.6	
256	110497	1510107a2a	436	sl	259.0	142	155	58	21.2	
257	110497	1510105018	437	sl	258.2	80	89.5	30	3.2	
258	110497	151008312a	438	sl	258.2	75	88	27	2.4	
259	110497	1f4d313231	439	sl	258.2	72	81.5	28	2.3	
260	110497	151010427a	441	sl	258.2	93	109.5	39	6.2	
261	110497	1510084111	442	sl	257.4	82	93	31	4.2	
262	110497	151010423a	.	sl	257.4	74	83	26	2.4	
263	110597	1f3e7d0620	244	sl	268.7	85	107	35	5.2	
264	110597	1510103449	245	sl	268.7	101.5	111	39	6.5	
265	110597	1510085c26	246	sl	262.3	76	87.5	28	2.5	
266	110597	1510105e0e	247	sl	259.0	173	191	77	44.4	
267	110597	151008007a	249	sl	259.0	103.5	114.5	40.5	6.9	
268	110697	1510103104	151	sl	268.7	83	91.5	30.5	3.1	recapture
269	110697	1f3e7b5f49	226	sl	270.3	77	88	32	3.6	
270	110697	1f4d3f597c	230	sl	262.3	82.5	92	31	3.3	
271	110697	14d0171f6e	230	sl	270.3	118	132	52	12.9	
272	110697	1f4d4f566f	231	sl	262.3	72.5	80.5	28	2.5	
273	110697	1f4d373e1f	232	sl	262.3	77	88	30.5	3.7	
274	110697	1f3e793179	233	sl	262.3	101	113	38	5.8	
275	110697	1f2e3b433a	234	sl	262.3	88	97	34	3.9	
276	110697	1f4d327d65	235	sl	258.2	101.5	117	35	5.2	
277	110697	1f3e7a1a0f	238	sl	258.2	84	93	34.5	3.8	
278	110697	1f4d0d0106	239	sl	257.4	88.5	99.5	34	4.4	
279	110697	1510083a0e	241	sl	257.4	76	88	26	2.4	
280	110697	151008340a	473	sl	262.3	89.5	101	34	4.8	
281	110697	1510083a19	474	sl	257.4	145	162	61	25.3	
282	111097	1f4d177e7f	471	hl	258.2	78	88	33	3.5	
283	111797	1f2e3a2b4e	120	hl	255.8	.	.	.	.	recapture
284	111797	1510105018	437	hl	255.8	.	.	.	.	recapture
285	120197	1510101856	224	sl	284.8	157.5	176	76	39.6	
286	120297	1510106112	216	sl	284.8	75	85	29	2.6	PIT tag 7f70d775e
287	120297	1510085c28	217	sl	284.8	66.5	72	23	1.6	
288	120297	151008500e	220	sl	284.8	166	185	78.5	40.6	
289	120297	1510107660	222	sl	289.6	219	233	94	.	
290	120297	1510107649	223	sl	298.5	81	91.5	29.5	3.2	

Appendix A. continued

291	120297	1f3e750f1f	468	sl	289.6	84.5	90.5	33	3.9	
292	120297	151008410a	469	sl	289.6	243	267	100	.	
293	120297	1f4d353f20	470	sl	284.8	83	91.5	32	3.4	
294	120397	1f4d1b2257	211	sl	275.1	60.5	67	19.5	1.1	
295	120397	1510085e24	212	sl	275.9	220	237	92.5	.	
296	120397	1510107619	213	sl	277.6	72.5	79	24.5	1.9	
297	120397	1510082e70	214	sl	277.6	67	75.5	24.5	1.7	
298	120397	1510106459	215	sl	284.8	71.5	80.5	29.5	2.7	
299	120397	151008211e	462	sl	281.6	152	163.5	70.5	29.3	
300	120397	151008213e	463	sl	281.6	132	146	65	22.0	
301	120397	1f4d47430a	464	sl	279.2	66	74	20	1.3	
302	120397	1510082464	465	sl	279.2	139	151	60	20.1	
303	120397	1510085131	466	sl	279.2	150	163.5	65	23.6	
304	120397	1510082e1e	467	sl	279.2	172	191	68.5	.	
305	120497	1510085a06	203	sl	275.1	65	75	27	1.9	
306	120497	1510107a0a	205	sl	277.6	80	91	30	3.4	
307	120497	1510083666	206	sl	277.6	81	92.5	30	3.2	
308	120497	1510085c5a	208	sl	277.6	81	90	30	3.4	
309	120497	1510082224	209	sl	279.2	95.5	103.5	38.5	6.0	
310	120497	1510082e64	210	sl	283.2	83.5	90	34.5	4.2	
311	120997	151008190c	.	sl	217.2	99.5	107.5	39.5	6.5	
312	121297	151008190c	.	sl	218.0	.	.	.	.	recapture
313	121797	1510106116	.	sl	267.1	207	236	99.5	.	
314	121797	1510082e68	.	sl	267.1	249	275	105	.	
315	121797	1510106e56	.	sl	267.9	110	120	52	12.7	
316	121897	1510105164	461	sl	258.2	118	129.5	49	12.5	