State Of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

LAKE DAVIS GRIZZLY VALLEY DAM FISH CONTAINMENT STRUCTURE 2006-2007 MONITORING SUMMARY REPORT

by

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June 21, 2012

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INTRODUCTION

Lake Davis is water storage reservoir located on Big Grizzly Creek in Plumas County, California. Big Grizzly Creek is a tributary to the Middle Fork of the Feather River, which flows into the Sacramento River. Non-native northern pike *(Esox lucius*, NP*)*, a prohibited species in California, were illegally introduced into Lake Davis sometime prior to their discovery in 1994. They are top-of-the-line predators and negatively affected the trout population as well as the ecology of the lake. The primary concern with the presence of northern pike at Lake Davis was that they would escape downstream into the Sacramento-San Joaquin Delta and be readily distributed state-wide through the State and Federal water distribution systems. While a plan was being developed to eliminate northern pike from Lake Davis, their downstream movement had to be prevented.

Water releases from Lake Davis are controlled through an intake structure that is able to draw water from three lake levels using a series of valves. The inlet valves are located at 5700 feet, 5740 feet, and 5760 feet elevation above mean sea level. All water exiting the lake must pass through these inlet valves, unless the surface water elevation is at spillway level (5775 feet) (Figure 1).

In December 1996, at the request of the Department of Fish and Game (DFG), the Department of Water Resources (DWR) installed two “graters” on the Grizzly Dam outlet structure to prevent northern pike from moving downstream. The goal of the “graters” was to shred fish as they exited the outlet pipe (Rischbieter 2000). However, there was a concern that northern pike eggs, larvae, and juvenile fish might survive the “graters.”

The Grizzly Valley Dam Fish Containment Structure at Lake Davis was constructed by DWR and put into service on September 28, 2006. It was designed to filter all water exiting the reservoir through the dam. This structure was intended to prevent the escape of all northern pike life stages (including eggs) through the dam outlet.

During the 2006-2007 strainer sampling season, lake levels never exceeded 5767 feet elevation and water levels were closely managed by DWR personnel to avoid spill (Figure 2). Allowing lake water to go over the spillway could have allowed northern pike to move downstream of the containment structure. During 2006-2007 DWR managers drew down the reservoir water level to facilitate the 2007 chemical treatment of Lake Davis to eliminate northern pike (www.dfg.ca.gov/lakedavis).

Water exiting the lake through the dam enters the containment structure through a 36-inch diameter pipe. From there it passes through one or more of the eight strainers (Figure 3). The strainers were designed to filter up to 50 cubic feet per second (cfs) of water per strainer. Water flows into each strainer from above and exits via the mesh side (1 mm) of the basket (Figure 4). Strainer number one is closest to the dam outlet while strainer number eight is the furthest (Figure 3). All eight strainers have the potential to be operational at the same time. However, based on the average flow

releases from Lake Davis the system generally operates with fewer than eight strainers. Filtered water then drops into a second large pipe where it is free to flow to the outlet (Figure 5). Freeze protection was activated December 1, 2006 through May 1, 2007 to prevent damage to the structure during extremely cold temperatures. Freeze protection works by allowing 0.7 cfs to flow through every strainer regardless of whether or not it is in service.

Since the system has been in service, a total of three northern pike have been collected. Two of the northern pike were collected from the structure by DWR staff prior to DFG involvement in strainer monitoring. DFG began cleaning and monitoring the strainers on December 1, 2006. One northern pike was collected while DFG monitored the strainers. All three northern pike specimens were deceased prior to discovery. All flow was turned off in the fall of 2007 due to the impending chemical treatment of Lake Davis to eliminate northern pike from the drainage upstream of the dam. The strainers were last checked prior to the chemical treatment on September 26, 2007 and were returned to service after the reservoir tested free of all treatment chemicals. The strainers remained in operation until subsequent field sampling verified the absence of northern pike in Lake Davis.

This report collates the data from the initiation of DFG monitoring until the last strainer check before the lake chemical treatment and attempts to determine trends or meaningful correlations to help understand the operation of the containment system and the factors that affect the biomass caught in the strainers.

METHODS

Strainers were checked and cleaned by DFG employees approximately once per week during the 2006-2007 monitoring period. Fish collection was accomplished by removing the strainers, one at a time, from the containment structure using a mechanical hoist which ran along the roof of the structure (Figure 6). The accumulated biomass in each strainer was scraped into a bag, labeled, and placed in a freezer for future analysis at the lab.

Analysis consisted of weighing and measuring all fish or fish parts that could be visually identified to species. These fish were identified to species and weighed (to the nearest gram) and their total length recorded (to the nearest millimeter). Only 10.2% of the total catch was sub-sampled due to the large amount of damage done to many of the fish as a result of high pressures that were present in the outlet and containment structure.

The data obtained from these monitoring events was analyzed in an effort to discern how the dam's operation affected the fish containment system efficacy. Fish sampling results were organized by run time, flow, species, weight, and length (Table 1). This data was used to determine the influences on catch under various outflow operations. Factors such as flow rates, which inlet valve was in operation, lake level, season, and

many others were examined for impact on the containment system's operation. This information was graphed and trends visually determined.

RESULTS

Prior to DFG strainer monitoring, the biomass was not recorded by DWR personnel unless a northern pike was found. The first northern pike specimen was captured on October 11, 2006 and measured 330 mm. The second was found on November 22, 2006 and was 355 mm (Christine Erickson, DWR 2006 personal communication). A third northern pike specimen was collected by DFG on January 25, 2007 and measured 368 mm. Three northern pike were collected during the entire 2006-2007 monitoring period.

In addition to gathering and reporting northern pike captures in the containment system, samples of all aquatic species caught in the strainers were weighed and measured. Because of the low numbers of northern pike collected in the containment system, the measurements of the other species are much more useful in gauging system efficacy and capabilities.

Analysis of the data indicated that flow rate had a significant effect on the biomass of fish collected in the sampling. As flow through the strainers increased, the biomass of fish collected increased dramatically (Figure 7). No obvious corresponding increase or decrease in biomass of fish collected resulted from other factors such as run time, lake level, or season (Figures 8-10). Figure 8 appears to show an increase in biomass around 96 hours of operation, after that the biomass tapers off. This could be explained by fish deterioration after an extended period of time, but flow rates were too inconsistent to decipher whether or not the changes in biomass were due to run time. Figure 9 indicates that biomass increased around February. However, the corresponding months in Figure 10 display an increase in flow rates throughout the same time frame, thus making the results from Figure 9 indiscernible.

Brown bullhead (*Ameiurus nebulosus*, BBH) comprised a majority of the fish collected in the strainers, 96% by quantity (Figure 12) and 97% by weight (Figure 13). Other species collected were golden shiner (*Notemigonus crysoleucas*, GSH), pumpkinseed (*Lepomis gibbosus*, PSD), crayfish sp., and northern pike. Crayfish were typically found in pieces, therefore were not enumerated. These numbers were obtained from the strainer samples that could be differentiated readily by species. A majority of the fish collected were less than 150 mm (Figure 11).

DISCUSSION

Many factors may have contributed to the results of this sampling effort. Factors may include: flow rate, number of inlet valves operating, elevation of operating inlet valve, fish movement and/or life stage, season, and climate. However, due to variables of

dam operation, it is difficult to isolate the effect of most of these variables. The one variable that did induce a noticeable and significant change in the sampling effort was the flow rate. As it increased, the biomass in the strainers increased dramatically.

Other factors that may have affected the sampling include the differential head pressure between multiple strainers in operation (DWR, personal communication), the inlet valves in use, and the season. The differential head pressure between multiple strainers in operation could potentially have an affect due to the pulverization. At high flow rates, the biomass could be pulverized and then pushed through the strainers. While no live specimens could possibly survive this, it could change the amount of biomass found in individual strainers. The result of this effect would be that strainers closer to the dam would have less biomass due to a higher pressure when compared to the strainers farther away from the dam (Figures14-15). Figure 15 portrays the difference in fish condition and overall biomass in each strainer after a period of multi-strainer operation.

The inlet valves and season could have an effect based on the life history of the fish species in the lake. Since different fish species and life stages inhabit different depths in the lake, it could be expected that different inlet valves in operation would have resulted in different species composition in the strainers. The inlet valves could also affect the sampling when operations change from one valve to another. If an inlet valve has not been used for a significant period of time there could be a surge of whatever species have taken up residence in the unused valve when it is returned to operation. This surge would be a one time occurrence until the valve is cycled again, and could potentially skew the total numbers depending on the size of the sample.

It is possible that different fish species life history strategies during different times of the year could cause increased or decreased levels of total biomass as well as different species composition. For example, if one species remains primarily inactive during the winter, it is likely that numbers for that species will drop in the strainer relative to the other fish in the lake. Unfortunately, to determine the importance of any of these factors, more consistent dam operation is needed to make it possible to isolate one variable at a time as much as possible.

A final parameter that could be examined is size of fish in the strainer compared to the flow rate. Smaller fish that have lower swimming performance are more susceptible to entrainment than larger fish. Larger fish are able to escape the entrainment velocities. Under higher flow rates it is possible that larger fish could succumb to increased inlet entrainment. Another factor is that smaller fish with more delicate bodies are more likely to be rendered unrecognizable by higher pressures. This would skew the average size upward, even if there is not an actual trend toward larger fish at higher flow rates.

Much of the biomass (89.8%) in the strainer baskets could not be identified to species and included in the analysis due to physical damage. However, the sample size of identifiable fish (10.2%) was large enough to ascertain with some degree of confidence the species composition coming into the strainer system. The un-sampled biomass

could potentially have its composition determined by extrapolating the known composition to the pulverized biomass found in the strainers.

ACKNOWLEDGEMENTS

Project management during planning of this study was coordinated with Christine M. Erickson (Environmental Scientist, DWR), Ivan L. Paulsen (Senior Fisheries Biologist, DFG), Michael F. Morrison (Fisheries Biologist, DFG), Stanley J. Stephens (Staff Environmental Scientist, DFG), Randolph O. Kelly (Staff Environmental Scientist, DFG), Jason Roberts (Fisheries Biologist, DFG), Darin Olsen (Scientific Aide, DFG), and Kevin Wright (Water Services Supervisor, DWR).

Operational coordination and assistance during this study was provided by Ron Vanscoy (Watermaster, DWR), Jim Scarborough (Watermaster, DWR), Tom Higgins (Engineer, DWR), and George Heise (Engineer, DFG)

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California Department of Water Resources (DWR). 2006. Contract Title: Lake Davis Fish Containment, Grizzly Valley Dam and Reservoir. Specification No. 06-11. Letter No. H607-0248.

Hinton, R. N. and Blomquist, N. 2007 Recreation and Fisheries Monitoring at Lake Davis and Big Grizzly Creek in Plumas County, California. California Department of Water Resources (DWR).

Rischbieter, D. B. C. 2000. Structures to prevent the Spread of Nuisance Fish from Lake Davis, California. North American Journal of Fisheries Management 20(3):784-7

Figure 1 - Lake Davis showing Grizzly Valley Dam, the spillway, and outlet structure (pre-fish containment structure).

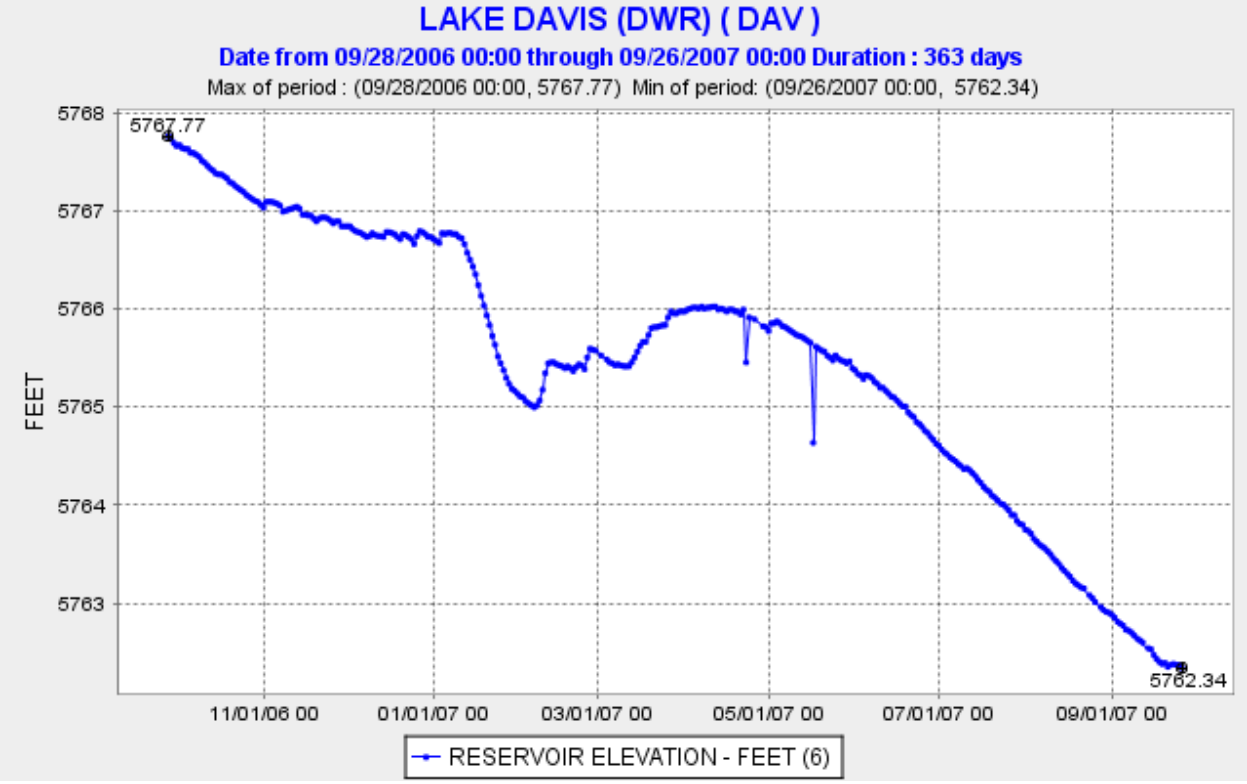

Figure 2 - Lake Davis reservoir levels throughout the 2006-2007 period of operation (DWR).

Figure 3 - Containment structure below Grizzly Dam at Lake Davis, California (DWR).

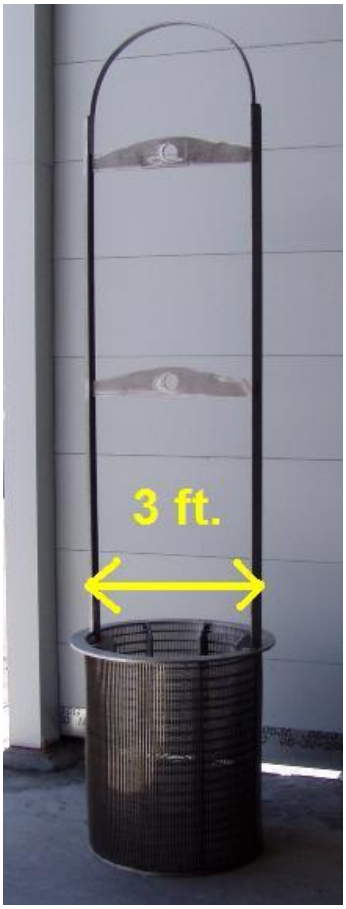

Figure 4 – One of the eight strainer baskets.

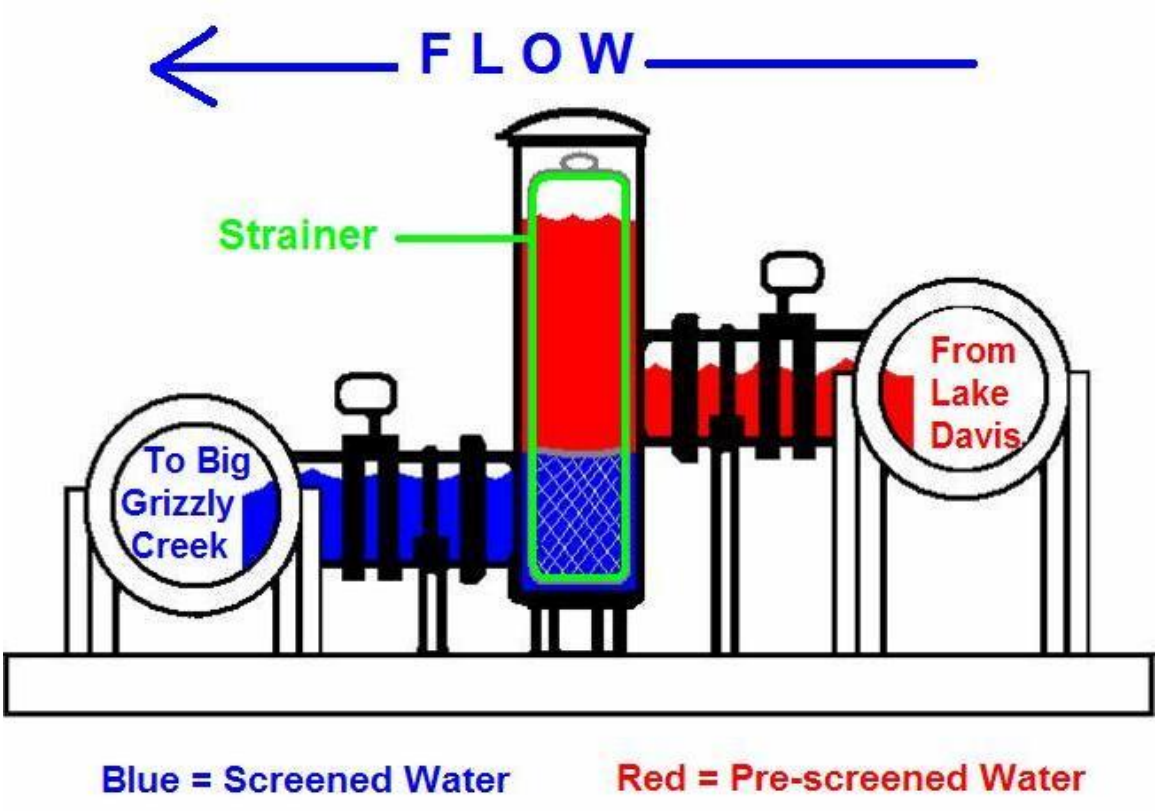

Figure 5 – Schematic of strainer operation (DWR).

Figure 6 - Using mechanical hoist to remove strainer basket from containment structure.

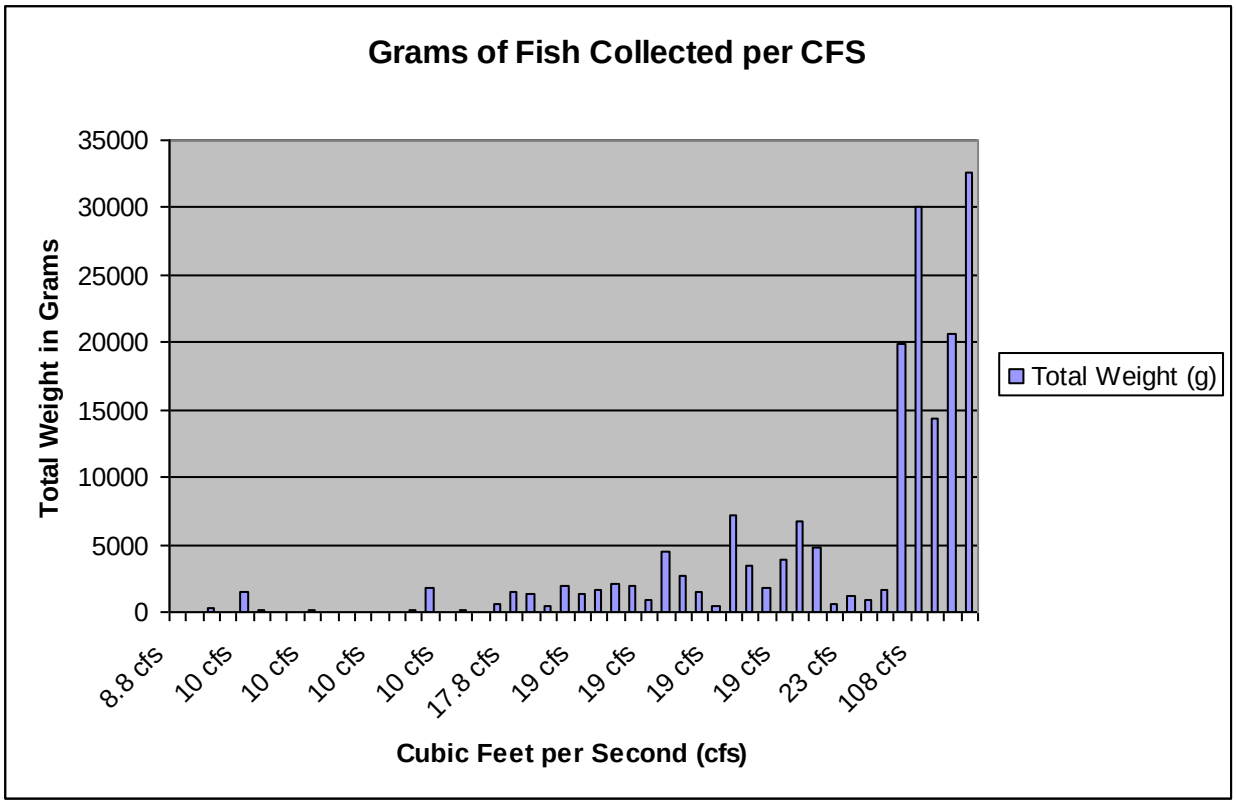

Figure 7- Fish collected (grams) per cubic foot of water passed through the strainers.

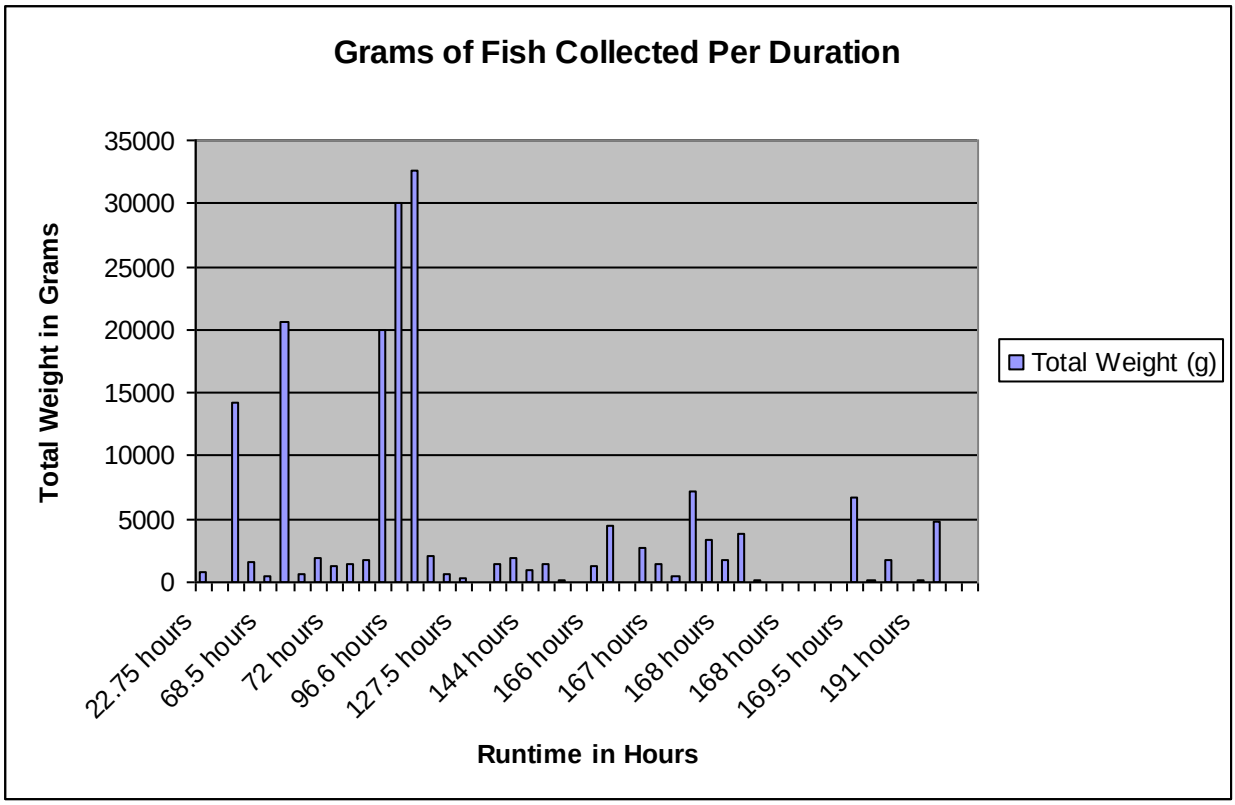

Figure 8- Fish collected (grams) per hours of operation between each individual check of the strainers.

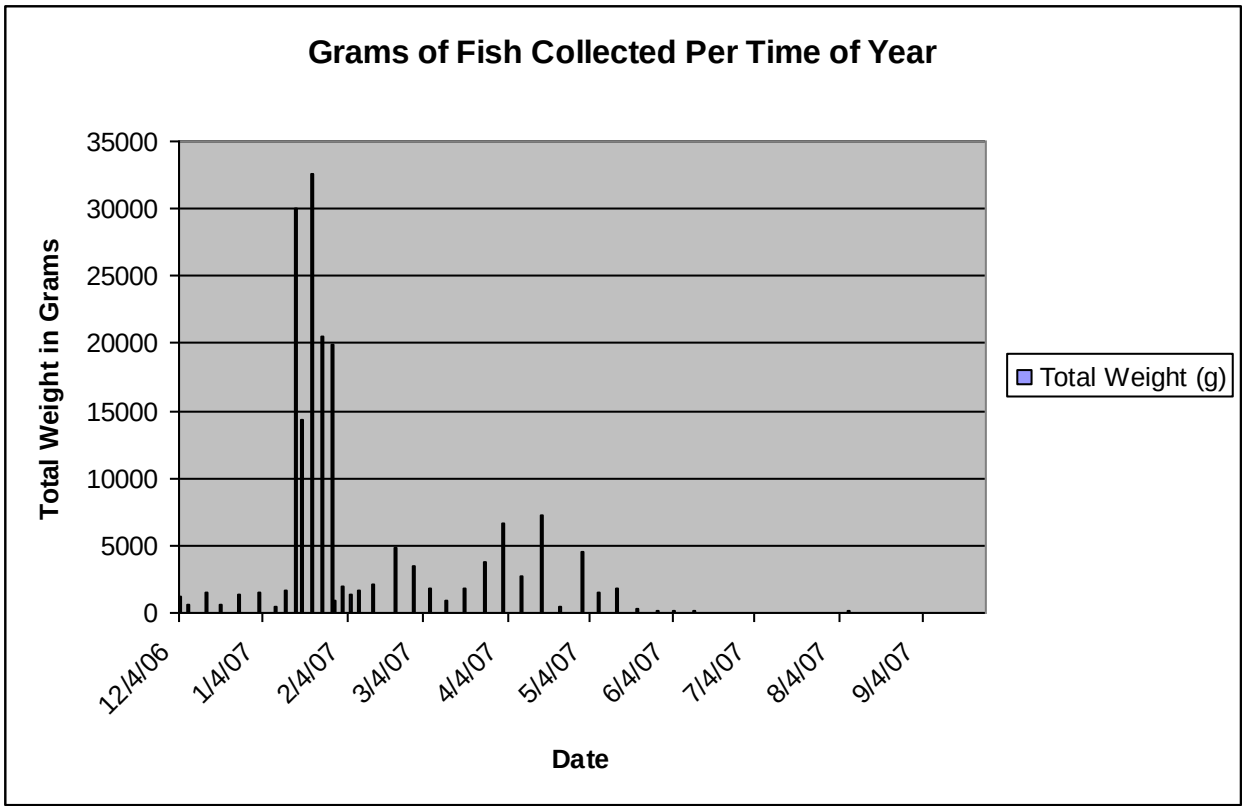

Figure 9- Fish collected (grams) in the strainers during different times of the year.

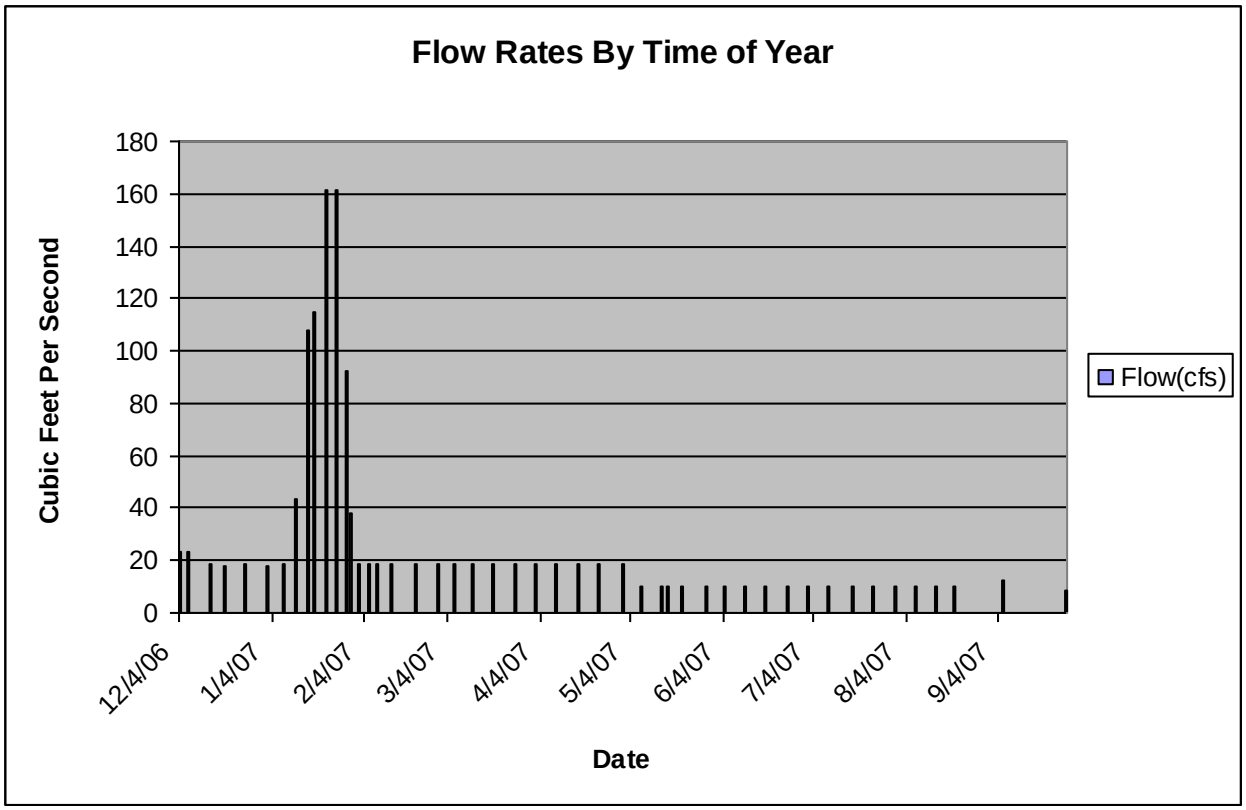

Figure 10- Summary of flow (cfs) through the strainers over different times of the year.

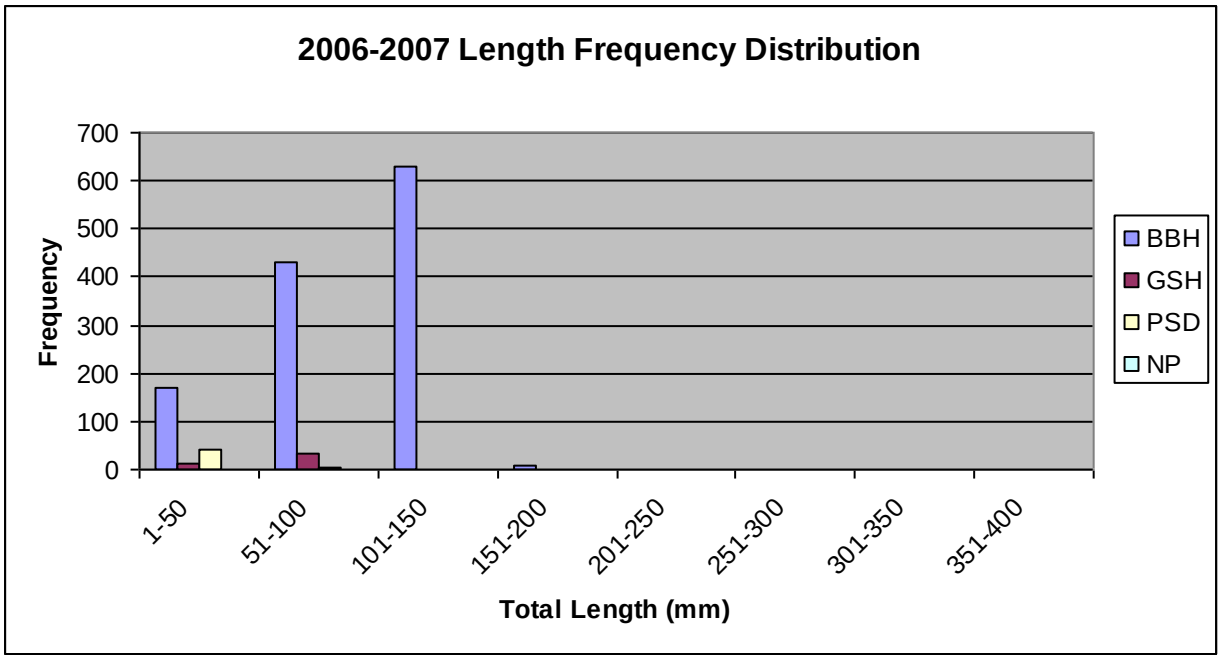

Figure 11- Length-frequency distribution of fish captured in the strainers during the 2006-2007 sampling season.

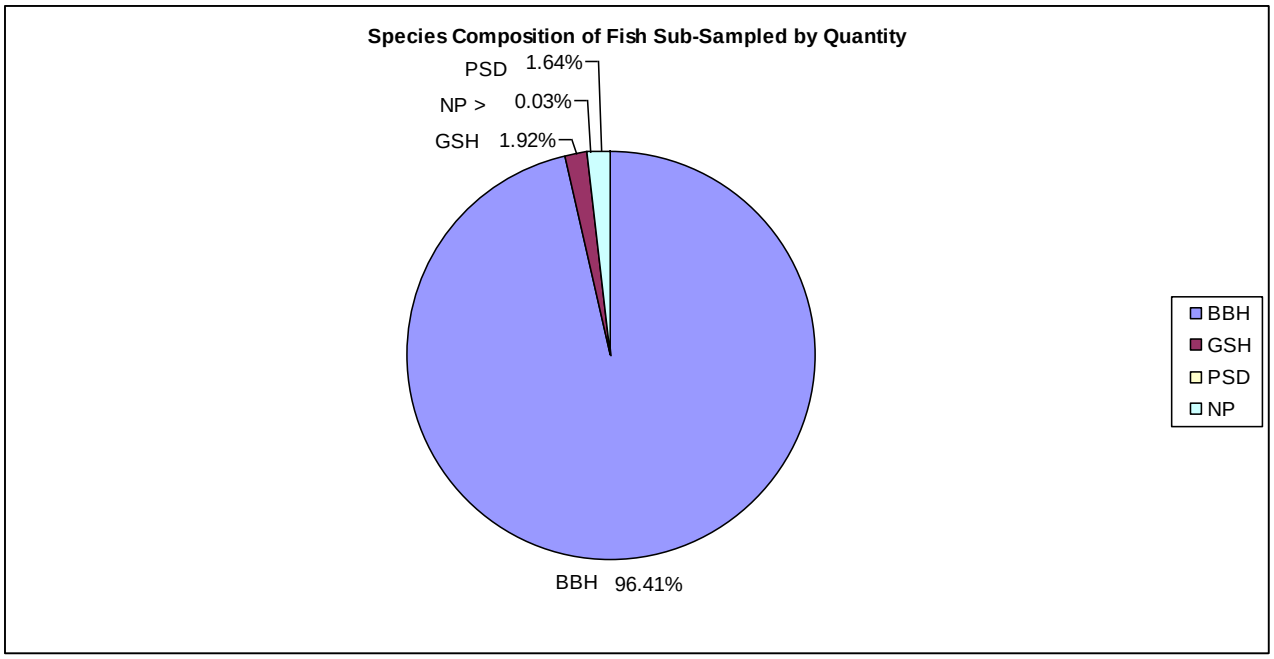

Figure 12- Species composition (number) of fish sampled during 2006-2007 strainer monitoring.

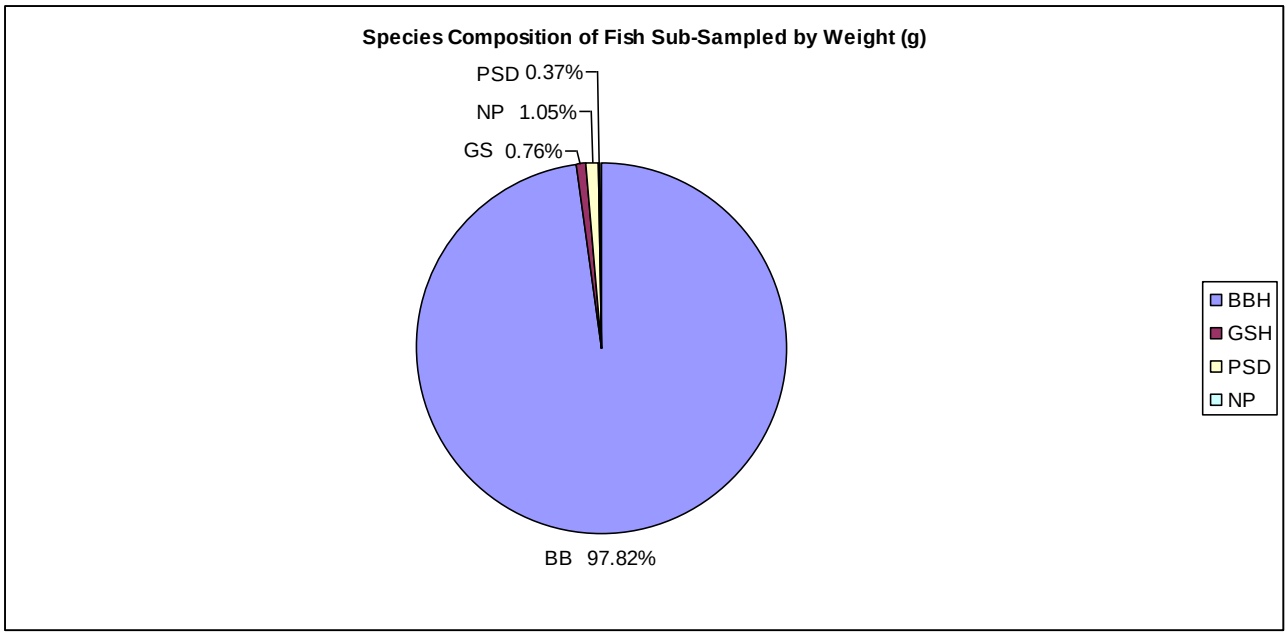

Figure 13- Species composition (grams) of fish sampled during 2006-2007 strainer monitoring.

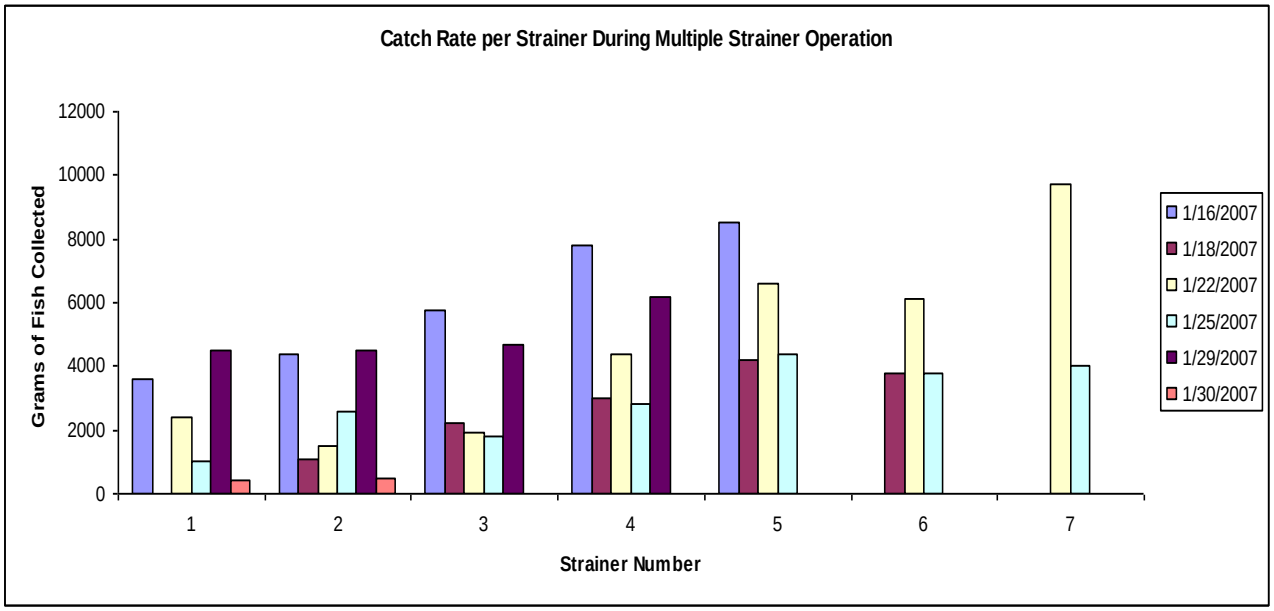

Figure 14- Fish biomass collected (grams) per strainer during multiple strainer operation. (Strainer 1 is closest to the dam).

01/25/2007: Strainer 1

01/25/2007: Strainer 5

01/25/2007: Strainer 2

01/25/2007: Strainer 6

01/25/2007: Strainer 3

01/25/2007: Strainer 7

01/25/2007: Strainer 4

01/16/2007: Strainers 1-5

Figure 15- Differences in catch results during multiple strainer operation (Rossi).

Table 1- Basic strainer sampling data table 2006-2007.

Date Cleaned	Strainer #	RunTime InHours	Flow(cfs)	5700	5740	5760	Species Code	Total Weight(g)	Total Count	Sampler
12/4/06	3	72	23	TRUE	FALSE	FALSE	Weight	1200	0	Rossi
12/7/06	1	70.5	23	TRUE	FALSE	FALSE	Weight	600	0	Rossi
12/14/06	3	167	19	TRUE	FALSE	FALSE	BBH	1458.6	276	Rossi
12/14/06	3	167	19	TRUE	FALSE	FALSE	GSH	20.5	11	Rossi
12/14/06	3	167	19	TRUE	FALSE	FALSE	PSD	5.7	5	Rossi
12/19/06	1	122.5	17.6	TRUE	FALSE	FALSE	BBH	625.8	70	Rossi
12/19/06	1	122.5	17.6	TRUE	FALSE	FALSE	GSH	21.7	16	Rossi
12/19/06	1	122.5	17.6	TRUE	FALSE	FALSE	PSD	10	12	Rossi
12/26/06	3	166	18.5	TRUE	FALSE	FALSE	BBH	1301.5	72	Rossi
12/26/06	3	166	18.5	TRUE	FALSE	FALSE	GSH	26.2	11	Rossi
12/26/06	3	166	18.5	TRUE	FALSE	FALSE	PSD	14.1	15	Rossi
1/2/07	6	145	17.8	TRUE	FALSE	FALSE	BBH	1483.9	85	Rossi
1/2/07	6	145	17.8	TRUE	FALSE	FALSE	GSH	12.8	10	Rossi
1/2/07	6	145	17.8	TRUE	FALSE	FALSE	PSD	8.5	7	Rossi
1/8/07	3	68.5	18.9	TRUE	FALSE	FALSE	BBH	492	24	Rossi
1/8/07	3	68.5	18.9	TRUE	FALSE	FALSE	GSH	5.1	5	Rossi
1/8/07	3	68.5	18.9	TRUE	FALSE	FALSE	PSD	5.7	4	Rossi
1/12/07	6	46.5	43.5	TRUE	FALSE	FALSE	Weight	1600		Rossi
1/16/07	1,2,3,4,5	96.6	108	TRUE	TRUE	FALSE	Weight	30050		Rossi
1/18/07	2,3,4,5,6	46.4	115	TRUE	TRUE	FALSE	Weight	14300		Rossi
1/22/07	1,2,3,4,5,6,7	105.36	161	TRUE	TRUE	FALSE	Weight	32600		Rossi
1/25/07	3	68.5	161	TRUE	TRUE	FALSE	NP	186.9	1	Rossi
1/25/07	1,2,3,4,5,6,7	68.5	161	TRUE	TRUE	FALSE	Weight	20387		Rossi
1/29/07	1,2,3,4	95.25	92	TRUE	TRUE	FALSE	Weight	19900		Rossi
1/30/07	2,3	22.75	38	TRUE	FALSE	FALSE	BBH	835.7	49	Rossi
1/30/07	2,3	22.75	38	TRUE	FALSE	FALSE	GSH	20.9	3	Rossi
2/2/07	7	71	19	TRUE	FALSE	FALSE	BBH	1979.9	107	Rossi
2/2/07	7	71	19	TRUE	FALSE	FALSE	GSH	3.9	4	Rossi
2/2/07	7	71	19	TRUE	FALSE	FALSE	PSD	6.4	1	Rossi
2/5/07	6	72	19	TRUE	FALSE	FALSE	BBH	1388.3	89	Rossi
2/5/07	6	72	19	TRUE	FALSE	FALSE	GSH	4.6	2	Rossi
2/5/07	6	72	19	TRUE	FALSE	FALSE	PSD	2	2	Rossi
2/8/07	7	72	19	TRUE	FALSE	FALSE	Weight	1700		Rossi
2/13/07	6	120	19	TRUE	FALSE	FALSE	Weight	2100		Rossi
2/21/07	7	192	19	TRUE	FALSE	FALSE	Weight	4800		Rossi
2/28/07	6	168	19	TRUE	FALSE	FALSE	Weight	3400		Rossi
3/6/07	7	144	19	TRUE	FALSE	FALSE	BBH	1866.7	97	Rossi
3/6/07	7	144	19	TRUE	FALSE	FALSE	GSH	10.4	8	Rossi
3/6/07	7	144	19	TRUE	FALSE	FALSE	PSD	4.4	5	Rossi
3/12/07	6	144	19	TRUE	FALSE	FALSE	BBH	961.4	50	Rossi
3/12/07	6	144	19	TRUE	FALSE	FALSE	GSH	4.8	3	Rossi
3/19/07	7	168	19	TRUE	FALSE	FALSE	Weight	1800		Rossi
3/26/07	6	168	19	TRUE	FALSE	FALSE	BBH	3818.4	254	Rossi
3/26/07	6	168	19	TRUE	FALSE	FALSE	GSH	4.3	2	Rossi
4/2/07	1	169.5	19	TRUE	FALSE	FALSE	Weight	6700		Rossi
4/9/07	3	166.5	19	TRUE	FALSE	FALSE	Weight	2700		Rossi
4/16/07	1	167.5	19	TRUE	FALSE	FALSE	Weight	7200		Rossi
4/23/07	1	167	19	TRUE	FALSE	FALSE	BBH	481.6	2130	Rossi
4/23/07	1	167	19	TRUE	FALSE	FALSE	PSD	7.7	12	Rossi
5/1/07	1	166	19	TRUE	FALSE	FALSE	Weight	4500		Rossi
5/7/07	1	143	10	TRUE	FALSE	FALSE	Weight	1500		Rossi
5/14/07	3	171	10	TRUE	FALSE	FALSE	Weight	1800		Rossi
5/16/07	1	45	10	TRUE	FALSE	FALSE	Weight	0		Rossi
5/21/07	3	127.5	10	TRUE	FALSE	FALSE	BBH	341.8	318	Rossi
5/29/07	1	191	10	TRUE	FALSE	FALSE	Weight	100		Rossi
6/4/07	3	145	10	TRUE	FALSE	FALSE	BBH	81.7	39	Rossi
6/11/07	1	168	10	TRUE	FALSE	FALSE	Weight	100		Rossi
6/18/07	3	172.5	10	TRUE	FALSE	FALSE	BBH	28.4	17	Rossi
6/18/07	3	172.5	10	TRUE	FALSE	FALSE	PSD	2.1	1	Rossi
6/25/07	1	163.5	10	TRUE	FALSE	FALSE	BBH	16.4	10	Rossi
7/2/07	3	168	10	TRUE	FALSE	FALSE	BBH	53.9		Rossi
7/9/07	1	168	10	TRUE	FALSE	FALSE	BBH		7	Rossi
7/17/07	3	168.5	10	TRUE	FALSE	FALSE	BBH	69.6	23	Roberts
7/24/07	1	168	10	TRUE	FALSE	FALSE	BBH	1.4	2	Roberts
7/31/07	3	166	10	TRUE	FALSE	FALSE	BBH	0.7	1	Roberts
8/7/07	1	170	10	TRUE	FALSE	TRUE	BBH	160.7	40	Rossi
8/14/07	3	168	10	TRUE	FALSE	FALSE	Weight	0	0	Roberts
8/20/07	1	141	10	TRUE	FALSE	FALSE	Weight	0	0	Roberts
9/5/07	3	387.5	12.4	TRUE	TRUE	FALSE	Weight	0	0	Roberts
9/26/07	1	476.5	8.8	FALSE	TRUE	FALSE	Weight	0	0	Roberts

Table 2- Total weights of identifiable and unidentifiable biomass caught in the strainers.

Total Weight Not Sub-sampled	157050 g	89.80%
Total Weight Sub-sampled	17837.1 g	10.20%
Total Weight Collected	**174887.1 g**	**100%**

Table 3- Minimum, maximum, and average lengths and weights of sampled fish.

RANGE	**Min (mm)**	**Max (mm)**	**Min (g)**	**Max (g)**	**AvgOfTotalLength(mm)**	**AvgOfTotalWeight(g)**
BBH	30	198	0.5	103.4	91.2	14.1
GSH	30	132	0.4	17.8	56.4	2.7
PSD	31	54	0.3	2.7	35.6	1.4
NP	330	368			351.0	

Table 4- All northern pike data collected from the containment system.

Northern Pike (NP)	**Date**	**Length (mm)**	**Weight (g)**	**Agency**
NP	10/11/2006	330	N/A	DWR
NP	11/22/2006	355	N/A	DWR
NP	1/25/2007	368	186.9	DFG

Table 5- Total numbers and mass of identifiable fish caught in strainers (See Figures 12-13).

Sub-Sampled Species Composition	**BBH**	**GSH**	**NP**	**PSD**	**Total**
Total Number	3760	75	1	64	**3900**
% by number	96.41%	1.92%	>0.03%	1.64%	100.00%
Total Weight (g)	17448.4	135.2	186.9	66.6	**17837.1**
% by weight	97.82%	0.76%	1.05%	0.37%	100.00%

Table 6- Grams of biomass from each strainer during multiple strainer operation (See Figures 14-15).

Date Cleaned	Strainer#	Total Weight(g)
1/16/2007	1	3600
1/16/2007	2	4400
1/16/2007	3	5750
1/16/2007	4	7800
1/16/2007	5	8500
1/18/2007	2	1100
1/18/2007	3	2200
1/18/2007	4	3000
1/18/2007	5	4200
1/18/2007	6	3800
1/22/2007	1	2400
1/22/2007	2	1500
1/22/2007	3	1900
1/22/2007	4	4400
1/22/2007	5	6600
1/22/2007	6	6100
1/23/2007	7	9700
1/25/2007	1	1000
1/25/2007	2	2600
1/25/2007	3	1600
1/25/2007	3	186.9
1/25/2007	4	2800
1/25/2007	5	4400
1/25/2007	6	3800
1/25/2007	7	4000
1/29/2007	1	4500
1/29/2007	2	4500
1/29/2007	3	4700
1/29/2007	4	6200
1/30/2007	2	395.1
1/30/2007	3	461.5