B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Moses Lake Fishery Restoration Project

Factors Affecting the Recreational Fishery in Moses Lake Washington

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Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208

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Factors Affecting the Recreational Fishery in Moses Lake, Washington

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Moses Lake Project Staff
Dave Burgess
Katrina Simmons
Rochelle Shipley
Tammy Gish

Moses Lake Project Support Staff
Jeff Korth, WDFW district biologist / BPA contact
Dr. David Bennett, University of Idaho, advisor

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I. Introduction.

The original premise behind this project (originally 'Restoration of the Moses Lake Fishery') was to return panfish angling to high historic levels. However, after preliminary investigations and lack of funds in 2001, the project direction and personnel were restructured. The Northwest Power and Conservation Council (NPCC) suggested that an expert, preferably an individual with a PhD., be contracted to provide guidance during the proposal writing process. Following the NPCC recommendation, we contracted Dr. David Bennett, a professor at the University of Idaho. Dr. Bennett led the proposal writing process, the project title was changed to 'Factors Affecting the Recreational Fishery of Moses Lake, Washington', and we commenced work in 2002.

One of the first tasks associated with writing the new proposal was to survey previously collected data and determine what was still unknown about the Moses Lake fishery. The second task was to develop a stepwise approach of objectives and tasks necessary to address the remaining uncertainties. In applying this design, we have systematically quantified the parameters acting on the Moses Lake fishery. For example, we have determined that the bottleneck for many desirable prey fishes occurs during the winter months and can be attributed to entrainment and predation. The rate of fish entrainment from Moses Lake is far higher than that in the literature. The entrainment of fishes not only impacts the resident fishery of Moses Lake, but may also result in deleterious consequences to native species via competition and/or predation in downstream systems including the Columbia River, where many of the waters from Columbia Basin lakes and creeks terminate. Predation by fishes within Moses Lake has also been identified as a key component relating to winter prey fish loss. Using the Fish Bioenergetics Model 3.0 (Hanson et al. 1997) we estimated that the walleye population of Moses Lake consumed >400,000 kg of prey fish a year.

Another possible factor that limits fish survival in Moses Lake is the presence of avian predators. Washington Department of Fish and Wildlife (WDFW) waterfowl data indicate that the abundance of common mergansers on Moses Lake, and double crested cormorants in the region has increased considerably in recent years. Waterfowl counts conducted by the WDFW and U.S. Fish and Wildlife Service during December suggest that there is an increase in the abundance of common mergansers from 1990-2004

(Appendix 1, Figure 1). Furthermore, the number of breeding cormorants within Potholes Reservoir just south of Moses Lake rose from 16 pairs in 1978 to 652 breeding pairs in 1997 (Finger and Tabor 1997).

To address the apparent increase in avian predators within the region and the impact to Moses Lake, a proposal for the continuation of the Moses Lake Project was submitted to the NPCC on January 10, 2006. During the tenure of the Moses Lake Project, we have addressed all possible factors associated with the resident fishery except for the impact of avian predators. The newly submitted proposal, 'Piscivorous Avian Resource Utilization of Moses Lake and the Relationship to Other Systems', aimed to determine the impacts of avian predators, not only on Moses Lake, but also other aquatic systems, including the Columbia River (Appendix 3).

The first Independent Scientific Review Panel (ISRP) review of the proposal culminated in a 'do not fund' designation. We addressed all of the ISRP comments and concerns regarding our submitted proposal via the 'fix-it loop' (Appendix 3). It appeared as though the ISRP focused more on the title of this proposal rather than the body of the text. Another concern of the ISRP was that the proposed work was not specifically outlined within the original proposal during the 2002 funding review (Bennett et al. 2002). However, within the 2002 proposal, number 4 of the 'Uncertainties within the Moses Lake Fishery' stated:

> The fish community within Moses Lake is diverse and not co evolved. Consequently, interspecific interactions may be amplified. Investigations regarding diet overlap and habitat overlap between species are necessary to determine whether interspecific interactions negatively impact-panfish recruitment.

Although not specifically stated, interspecific interactions include those between avian predators and the fishes of Moses Lake. This project was also regional in scope, as we proposed to investigate the impacts of avian predators on other waters and species including the Columbia River and native fishes within. Unfortunately, the second ISRP review of our proposal also resulted in a 'do not fund' designation. Consequently, the Moses Lake project (199502800) is slated to terminate March 31, 2007.

II. Field Work.

A. Site Selection Overview.

For sampling purposes, we divided the shoreline of Moses Lake into 400 m linear sites throughout four sections of Moses Lake (Figure 1). Each sample site was designated by section and site and assigned a Universal Transverse Mercator (UTM) coordinate for the specific location (Jim LeMieux 2002). A 400 m site began at the corresponding UTM coordinate and proceeded counter clockwise toward the adjacent site's UTM relative to the aspect of Moses Lake. Throughout the duration of the Moses Lake project, sites were selected using a random command in Microsoft Excel [ROUNDUP(#*RAND(),0] and done so in a stratified manner with respect to available habitat.

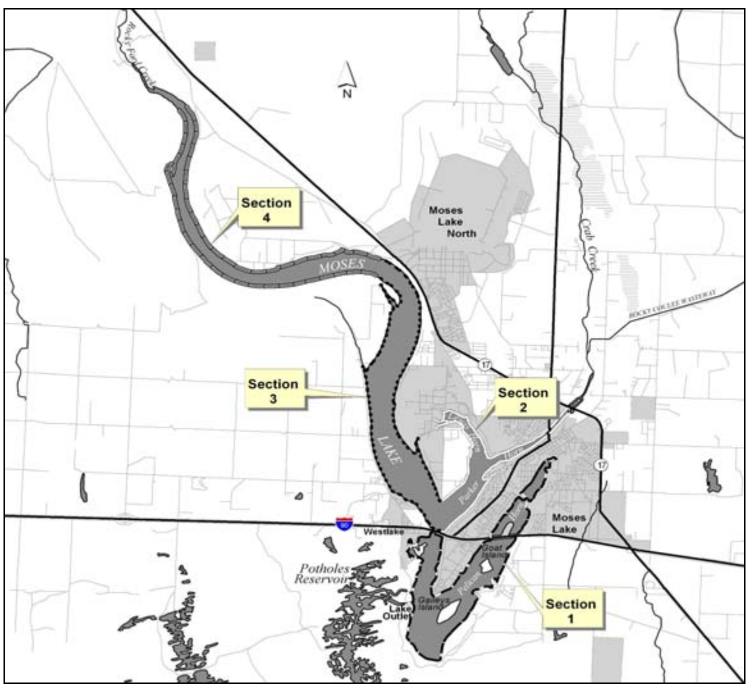

Figure 1. Spatial GIS overlay of the 4 sections and corresponding sites for Moses Lake, Washington.

B. Objective 1. Monitor Fish Community. Emphasis on Walleye.

During the tenure of this project, we have collected a substantial amount of data and performed relevant analyses. One of the factors we found to be impacting the fishery of Moses Lake is walleye predation. Using a variety of data including diet proportions and water temperature, we estimated that the walleye population within Moses Lake consumed ~400,000 kg of fish annually. Due to the high rate of consumption, we proposed and passed a fishing regulation to reduce walleye abundance while maintaining a good walleye fishery. On April 1, 2006 our proposed regulation of eight walleye 12 in or larger with one over 24 in went into effect, replacing the previous regulation of five walleye, 18 in or larger with one over 24 in. Although walleye anglers on Moses Lake generally practice catch and release strategies, our previous creel data indicate that the largest percentage of anglers that utilize Moses Lake are those that target any species of fish. Our data suggest that these anglers will keep small walleye.

1. Task 1.1 - Seasonal Fish Community Sample/Fall Walleye Index Netting (FWIN).

a. Introduction.

Even though walleye are a non-native predator, the WDFW considers them a gamefish and has regulated recreational fishing since 1973 (Steve Jackson, WDFW biologist, personal communication). However, many of those regulations were implemented without data collection or analyses. Because walleye are non-native and have not co-evolved within Moses Lake, the effects of walleye on the Moses Lake fishery were previously unknown. However, we have collected a substantial amount of data that we have used to actively manage walleye with the goal of removing extreme variation within the fishery. The objective of this task was to perform fall sampling of the Moses Lake fish community with an emphasis on walleye.

b. Methods.

Data were collected in October 2005 by boat electrofishing, and in October 2005 and 2006 by gillnetting during the WDFW standard Fall Walleye Index Netting (FWIN). Twelve percent of all available sites were randomly selected for nighttime electrofishing, whereas the number of randomly selected gillnet sites was dependent on the biological threshold of 300 fish set by the WDFW. Electrofishing was conducted along the shoreline at random locations within each of the four sections using a 5.5 m (18 ft) Smith Root 5.0 Generator Powered Pulsator (GPP) electrofishing boat. We operated the electrofishing boat parallel to the shoreline at a rate of 1-1.4 km/h, maintained a distance from shore that allowed the inshore boom to fish entirely in the water, and avoided areas that exceeded 2 m (6.5 ft) in depth. To initiate fish galvanotaxis, we produced 1-2 amps by setting the voltage to low power, the frequency to 30 Hz DC, and the range to 42-48% of duty cycle (Polacek et al. 2003), depending on fish response and specific conductivity (SpC). Once fish were captured, they were immediately placed into a live well.

During October 2005 and 2006, we deployed gillnets in a method consistent with those in the Ontario Manual of Instructions for FWIN (Morgan 2002). Gillnets used were 61 m long (200') by 1.8 m deep (6') and consisted of 8 7.6 m (25') panels. Stretched mesh sizes were as follows: 25 mm (1"), 38 mm (1.5"), 51 mm (2.0"), 64 mm (2.5"), 76 mm (3.0"), 102 mm (4.0"), 127 mm (5.0"), 152 mm (6.0"). Nets were set perpendicular to shore and removed 21-27 hours later. During 2006, nets alternated between large and small mesh being set near shore.

Biological data such as species, total length (mm), and weight (g) were collected from all species captured during both electrofishing and gillnetting. Walleye that were gillnetted were dissected so that we could determine the sex as well as collect scales and otoliths for aging. In the past, we have estimated the abundance of walleye using a multiple mark-recapture method and compared it to a population estimate generated from FWIN. The results from our walleye population estimate and the FWIN were comparable. Therefore, we can now use FWIN as a viable index-sampling regime we can follow to track walleye abundance within Moses Lake during our seasonal sampling.

c. Results.

In October 2005, walleye represented 17.0% of fishes captured in FWIN gillnets (Table 1), and had a mean length of 416 mm (Table 2). During the same period but using boat electrofishing, walleye represented 5.1% of the species composition (Table 1) with a mean length of 245 mm (Table 3). During 2005 there appeared to be a difference in the mean size of walleye caught by boat electrofishing and gillnetting (Figures 2 and 3).

Using a two sample, two-tailed t-test, we determined there was a significant difference in the mean size of walleye captured by boat electrofishing and gillnetting (*df=624, P<0.001, t=16.34*). During gillnetting in 2006, smaller size classes of walleye were not captured as frequently as larger size classes (Figure 4). During 2006, walleye represented 11.0% of the fishes caught with gillnets (Table 4) and had a mean length of 432 mm (Table 5). The mean length of walleye captured in gillnets in 2006 was slightly longer than walleye gillnetted in 2005 (Figures 2 and 4); however, no significant difference in mean lengths of walleye between 2005 and 2006 was detected with a two sample, two-tailed t-test (*df=723, P>0.05, t=-1.63*). The sex ratio between 2005 and 2006 was relatively constant with 56.8% male and 43.2% female in 2005, and 55.9% male and 44.1% female in 2006. Age distribution via otolith analysis between 2005 and 2006 appeared to track well from one year to the next (Figure 5). Catch per unit effort (CPUE; mean number of walleye per net) was 34.0 and 31.9 during the 2005 and 2006 FWIN surveys, respectively. A significant difference was not detected between the 2005 and 2006 FWIN surveys with respect to the numbers of walleye caught per net (*df=20, P >0.05, t=0.281*).

Table 1. Number and species composition (%n) of fishes collected in gillnets and by nighttime boat electrofishing during FWIN 2005 on Moses Lake, Washington.

	Number		**%n**	
Species	**Gillnet**	**Electrofishing**	**Gillnet**	**Electrofishing**
Black Crappie	604	242	25.0	5.7
Bluegill	9	138	0.4	3.3
Bullhead spp.	165	93	6.8	2.2
Carp	51	58	2.1	1.4
Lake Whitefish	2	537	0.1	12.7
Largemouth Bass	62	1	2.6	<0.1
Largescale Sucker	4	12	0.2	0.3
Longnose Sucker	3	1	0.1	<0.1
Pumpkinseed	5	28	0.2	0.7
Smallmouth Bass	21	340	0.9	8.1
Walleye	409	217	17.0	5.1
Yellow Perch	1,077	2,551	44.7	60.5
Total (n)	**2,412**	**4,218**		

Table 2. Mean, minimum, and maximum total lengths (mm) of fishes collected in gillnets during FWIN 2005 on Moses Lake, Washington.

	Total Length (mm)		
Species	**Mean**	**Minimum**	**Maximum**
Black Crappie	117	76	220
Bluegill	98	62	178
Largemouth Bass	145	103	453
Smallmouth Bass	263	97	435
Walleye	416	130	750
Yellow Perch	163	92	306

Table 3. Mean, minimum, and maximum total lengths (mm) of fishes collected by nighttime boat electrofishing during FWIN 2005 on Moses Lake, Washington.

	Total Length (mm)		
Species	**Mean**	**Minimum**	**Maximum**
Black Crappie	110	52	145
Bluegill	111	27	195
Largemouth Bass	134	28	545
Smallmouth Bass	119	61	393
Walleye	245	112	745
Yellow Perch	121	56	284

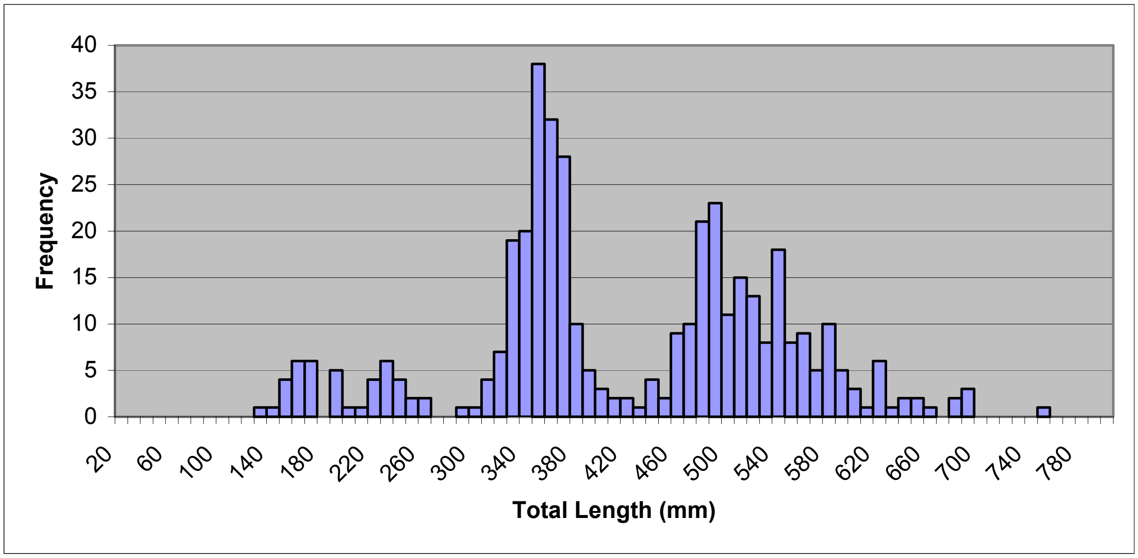

Figure 2. Length frequency distribution of walleye collected in gillnets during FWIN 2005 on Moses Lake, Washington.

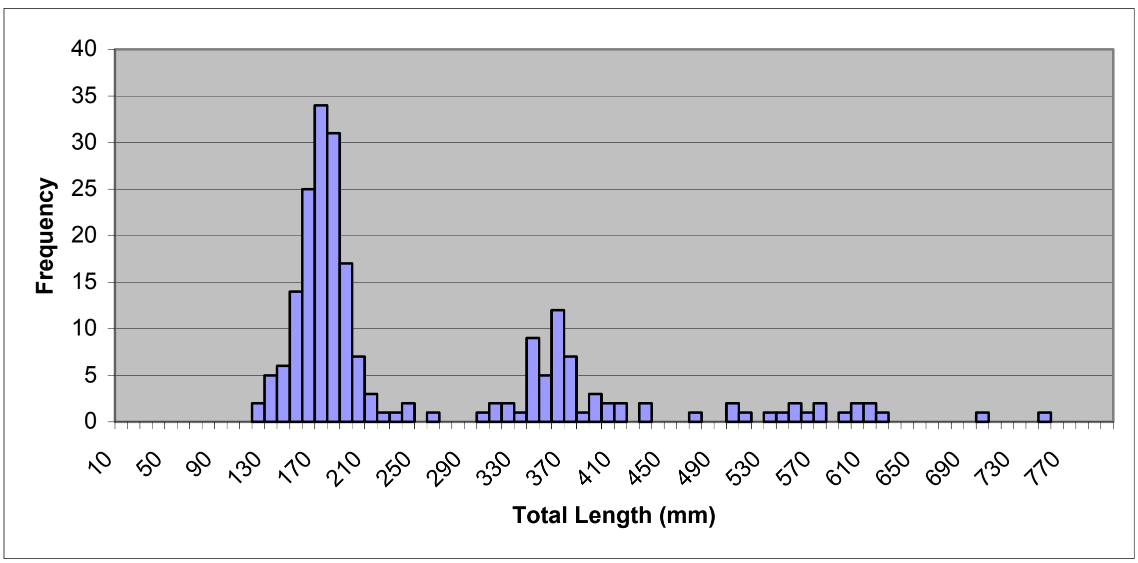

Figure 3. Length frequency distribution of walleye collected by nighttime boat electrofishing during FWIN 2005 on Moses Lake, Washington.

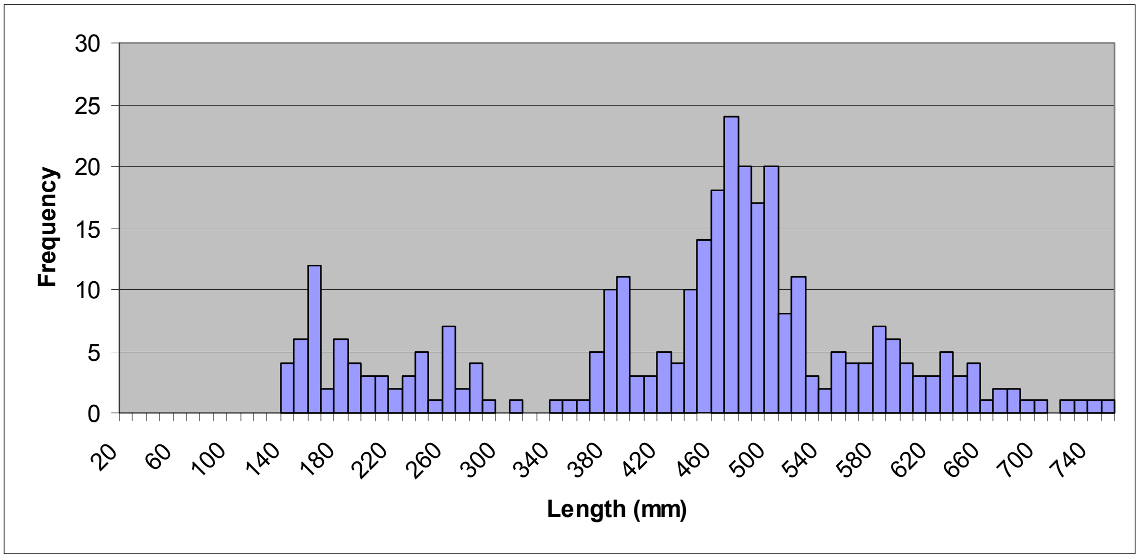

Figure 4. Length frequency distribution of walleye collected in gillnets during FWIN 2006 on Moses Lake, Washington.

Table 4. Number and species composition (%n) of fishes collected in gillnets during FWIN 2006 on Moses Lake, Washington.

Species	Number	%n
Black Crappie	419	14.4
Bluegill	37	1.3
Bullhead spp.	72	2.5
Carp	49	1.7
Largemouth Bass	351	12.1
Largescale Sucker	3	0.1
Longnose Sucker	2	0.1
Pumpkinseed	5	0.2
Smallmouth Bass	49	1.7
Walleye	319	11.0
Yellow Perch	1,599	55.0
Total (n)	**2,905**	

Table 5. Mean, minimum, and maximum total lengths (mm) of fishes collected in gillnets during FWIN 2006 on Moses Lake, Washington.

		Total Length (mm)	
Species	**Mean**	**Minimum**	**Maximum**
Black Crappie	117	74	200
Bluegill	119	67	169
Largemouth Bass	145	87	475
Smallmouth Bass	234	97	434
Walleye	432	132	744
Yellow Perch	134	88	288

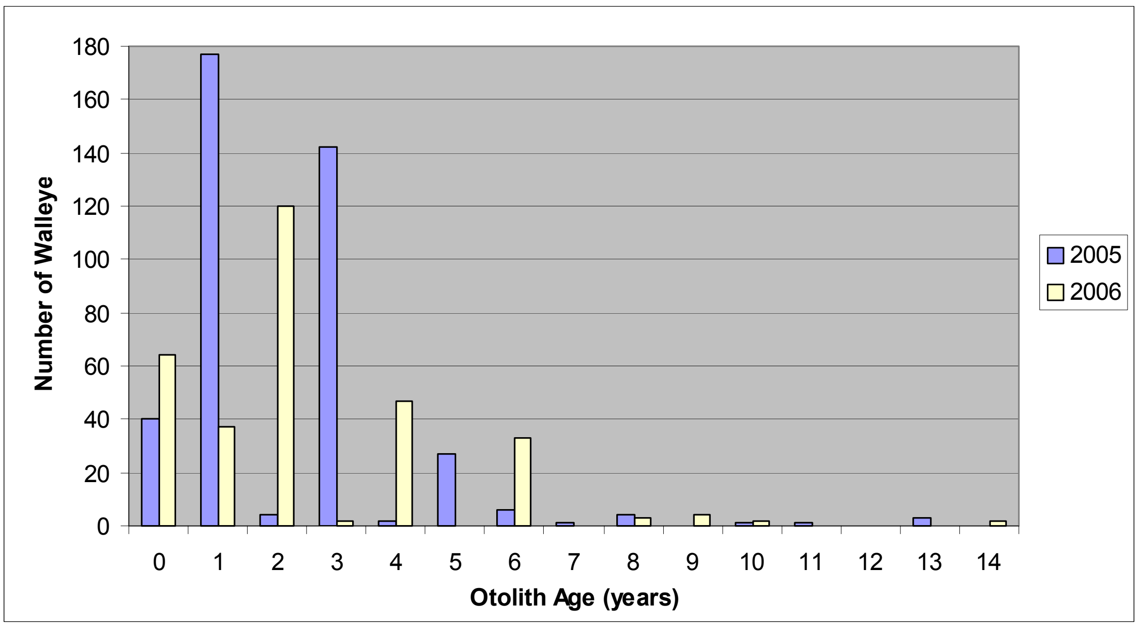

Figure 5. Otlolith ages of walleye collected during FWIN 2005 and 2006 on Moses Lake, Washington.

d. Discussion.

The walleye population within Moses Lake appears to be static with respect to CPUE or mean number of walleye per net. One of the concerns with a walleye population is their ability to shape or even exhaust a prey source (Hartman and Margraf 1992). During our winter and spring sampling efforts to quantify losses associated with predation (Task 2.2), yellow perch were surprisingly absent. However, our previous surveys indicated that yellow perch are abundant, and regularly found within the diets of walleye (Burgess et al. 2007). Prior to the 2006 FWIN, we were concerned that the walleye population had greatly reduced the yellow perch abundance. However, our results during the FWIN indicated that perch were present and abundant, representing 44.7%, 60.5%, and 55% during 2005 gillnetting, 2005 electrofishing, and 2006 gillnetting surveys, respectively (Tables 1 and 4).

In April 2006, the WDFW applied our new walleye regulation of eight walleye 12 in or larger with one over 24 in. The premise behind this regulation was to reduce the standing crop of walleye through an increase in exploitation while still preserving a good walleye fishery. Comparisons between 2005 and 2006 FWIN results indicate that the number of walleye per net has decreased, and the mean size has increased. Though these data were not statistically significant, they may indicate the beginning of a trend. Furthermore, the harvest of walleye appears to have increased. During 2003, we estimated that anglers creeled 710 walleye. In 2006, the WDFW estimated 7,855 walleye were kept (Petersen et al. 2007). An 11-fold increase in harvest may have begun to shape the walleye population in Moses Lake. Length frequency data in 2005 indicate the presence of a size class of walleye between 300 mm and 450 mm, whereas during 2006 the relative abundance is considerably less within the same size class. Historical data also confirm the presence of walleye in the 300-450 mm range.

There are several possibilities that may account for the apparent reduction of walleye within the 300-450 mm size range. The walleye within this size range may have been subjected to elevated levels of natural mortality, greatly reducing their abundance. Walleye mortality may also have been associated with angler harvest. In the past, walleye between 300 and 450 mm were protected, as they were not of harvestable size. Before the implementation of the new liberal bag limit, anglers frequently informed us that smaller walleye were readily caught, though they could not be kept. Once the size limit of walleye went from 18 in to 12 in, previously protected walleye entered the fishery at a much smaller size. The retention of smaller walleye was also indicated by the creel data collected during 2006. The estimated mean size of walleye kept in 2006 was 421 mm, and as small as 386 mm in June and July 2006 (Petersen and Schmuck 2007). During 2003, the mean size of walleye kept was 500 mm with the smallest mean size of walleye kept during of July (489 mm). As a result of the regulation change, the mean size of walleye kept has decreased by 79 mm.

Although the harvest of smaller walleye appears to be the trend on Moses Lake, it is unknown if an annual harvest of ~7,780 walleye will impact the population or the fish community. In lakes where elevated intraspecific food competition exists because of high densities, there are often various population signatures such as low growth rates in younger fish and decreased fecundity, which can be reversed with increased exploitation (Baccante and Reid 1988). The increased harvest of walleye from Moses Lake may elicit a community response, no response may be detected, or a response may be time delayed and may not be detected immediately (Johnson 1977). Although walleye populations have remained relatively static over the past 4 years with respect to sampling CPUE, anecdotal angling success has varied considerably. Although angling catchability has been found not to be density dependent (Newby et al 2000) there are other parameters such as prey availability and angler experience that may account for an increase in harvest.

The new walleye regulation was designed to not only manage for a good walleye fishery but also minimize the impact to other desirable game fishes. Ideally the WDFW would like to see a reduction in the cyclical fisheries within Moses Lake associated with what we assume is related to predator-prey interactions. Continued FWIN sampling on Moses Lake will allow managers to monitor and detect changes within the fish community. Analyzing species composition, CPUE, and relative weights will be necessary in order to detect fish community changes.

2. Task 1.2 - Quantify Walleye Production.

a. Introduction.

Little is known regarding the early life history of walleye in Moses Lake. We assume that the primary location where Moses Lake walleye spawn is within Crab Creek above Alder Street within the City of Moses Lake. Literature suggests that spawning occurs through the month of April, and in Moses Lake, this coincides with the initiation of the irrigation season, and the preferred spawning water temperatures of 3.3-6.7 °C (Wydoski and Whitney 2003). Incubation times vary based on temperatures, and upon hatching, walleye are believed to emigrate from Crab Creek to Moses Lake. It is believed that spawning occurs elsewhere in Moses Lake although this has never been documented. The objective of this task was to determine emergence timing and abundance of larval walleye from Crab Creek.

b. Methods.

Sampling was dependent on water operations, water temperature, and the presence of adult walleye. To determine when walleye were present, we conducted our sampling concurrently with the WDFW's adult walleye capture program. Once adult walleye were detected, we began sampling for larval walleye using a modified macroplankton sampler similar to that in Bryan et al (1989). Moses Lake is a very productive system with an abundance of plankton that can clog tow nets and reduce net efficiency. Consequently, we elected to use a smaller net to increase our sampling time. Our larval fish sampler consisted of a 30 cm x 30 cm, 563 μ net attached to a vertical rigid steel post located off the bow of the boat (Figure 6). We used two of these nets, one on each side of the boat. Each arm's sampling depth could be adjusted from 0 m to 1.2 m and was attached across the front of our sampling vessel via a 3.05 m galvanized tube. The long horizontal bar placed our sampling nets far enough away from the vessel that the hydraulic component associated with boat operations did not interfere with fish capture. To reduce the likelihood of sample loss, we elected to pull our nets while underway. In order to accomplish this, we developed a quick release system that consisted of a straight post (Figure 7) held in place by a cotter pin (Figure 8). The straight pin was connected to the net and a rope that was secured to the boat. Once the cotter pin was pulled, an operator in the boat simply pulled the net straight up while the net on the other side of the boat continued to fish.

Figure 6. Larval fish sampler used on Moses Lake, Washington.

Figure 7. Straight post of quick release system used to sample larval fishes on Moses Lake, Washington.

Figure 8. Cotter pin of quick release system used to sample larval fishes on Moses Lake, Washington.

The plankton sampler was deployed and the velocity of water moving through the sampler was measured. The velocity was used to calculate the volume of water that passed through the sampler using the following formula:

$$\text{Sampled volume} = [\text{Time (s)}] \times [\text{Velocity (m/s)}] \times [\text{Area of sampler } (m^2)].$$

We then calculated the number of walleye captured for a given amount of water sampled, and in turn extrapolated the total number of young of year (yoy) walleye produced from Crab Creek over time.

A post hoc analysis was added to compliment the larval fish tow efforts, which required us to examine the October 2005 and 2006 FWIN data in order to confirm whether yoy walleye were present within Moses Lake. Catch per unit electrofishing data from October 2005 were used to estimate walleye fingerling density using the following equation (Serns 1982):

$$Y=0.234(X),$$

where: Y = walleye fingerling density,
X = N/D, and X is fingerling catch per mile of shoreline,
N = the number of fingerlings caught during the sampling time, and
D = the distance in miles sampled.

$$\text{Lake Fingerling density} = (A)(Y),$$

where: A = is the area of the lake in acres, and
Y = is the number of walleye fingerlings per acre.

It should be noted that results from this method are a rough estimate and the design was developed in Northern Wisconsin Lakes.

c. Results.

Larval fish tows began on April 6, 2006, five days after the start of the irrigation season, when the amount of water that flows into Moses Lake increased, and the water temperature was 7.1 °C. Sampling was conducted on eight different occasions until May 30, 2006, when the water temperature reached 17.3 °C (Figure 9). During sampling, we captured 761 larval fish from Moses Lake, all of which were caught on May 23 and 30, 2006. Of the fish that were caught, 678 were identified as carp (*Cyprinus carpio*) and no walleye were captured (Table 6). Boat speed during May 23 and 30 averaged 4.295 f/s (2.93 mph). Despite our inability to catch newly hatched walleye within Moses Lake, our results from FWIN from 2005 and 2006 indicated yoy walleye were present during the fall sampling efforts (Figure 10).

Post hoc analysis of October 2005 electrofishing data to determine walleye fingerling density, estimated 59,268 fingerlings in Moses Lake. During the 2005 survey, we electrofished for 14,427 seconds at an estimated average speed of 1.4 k/h (3.49 m/s). Therefore, the total distance traveled during electrofishing was 3.49 miles, with an estimated 38.39 fingerlings caught per mile, and 8.98 per acre. The number per acre was then multiplied by 6,600 acres, which yielded an estimate of 59,268 fingerlings within Moses Lake during the October 2005 electrofishing survey.

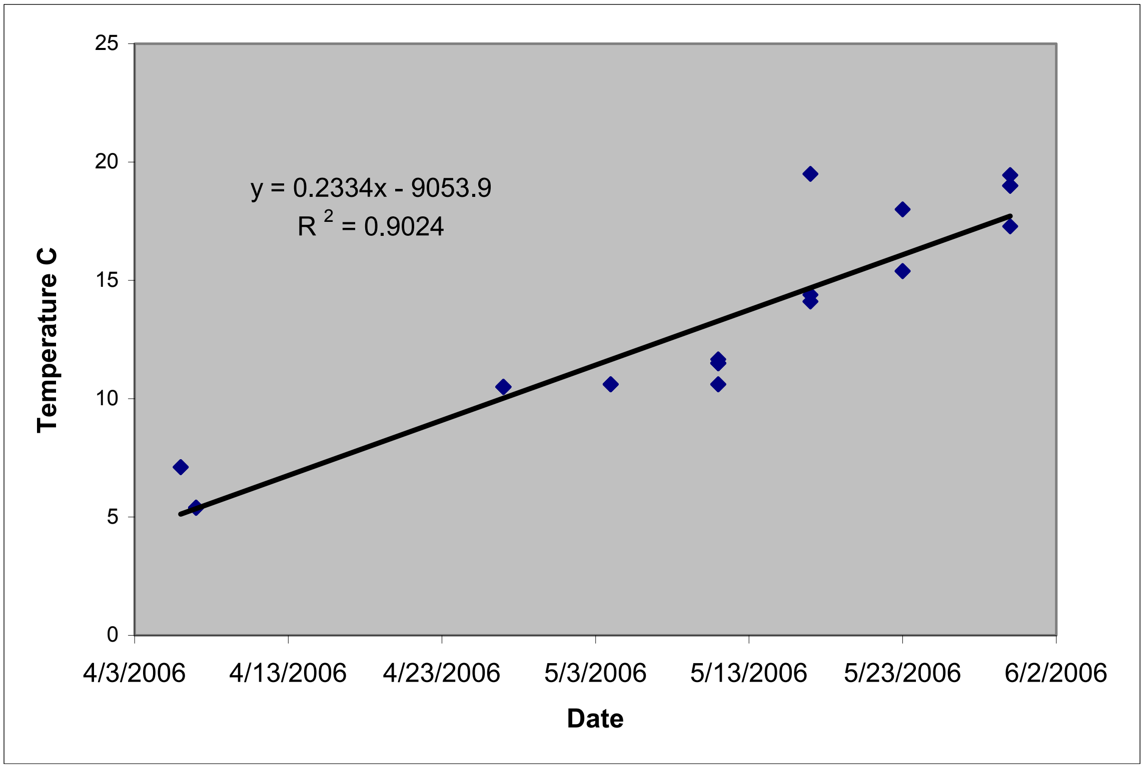

Figure 9. Water temperature during larval fish sampling on Moses Lake, Washington.

Table 6. Species composition by number from larval fish tows collected from April 2006-June 2006 in Moses Lake, Washington.

Species	Number	%
Black Crappie	2	0.26
Sculpin	35	4.59
Carp	678	89.09
Unknown	46	6.04

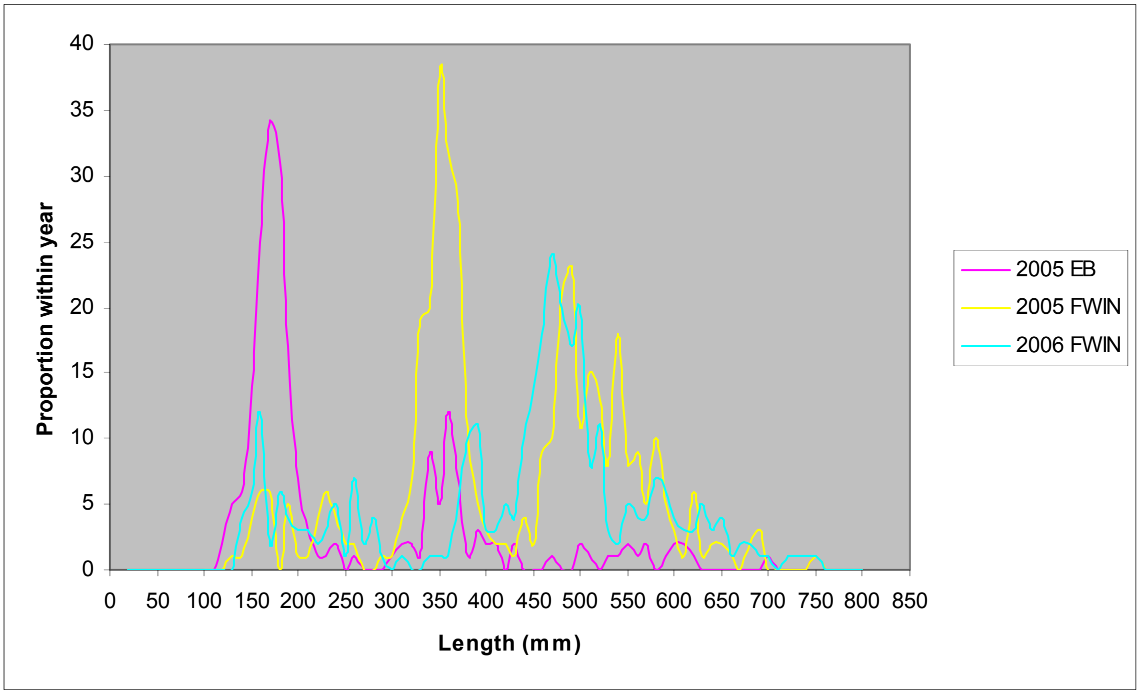

Figure 10. Length distribution of walleye captured during fall 2005 electrofishing (EB) and gillnetting (FWIN), and fall 2006 gillnetting (FWIN).

d. Discussion.

Unfortunately, we were unable to capture newly emerged walleye during the spring plankton tows. A variety of factors may have contributed to our unsuccessful attempts to capture larval walleye.

It is unknown how far walleye from Moses Lake migrate into Crab Creek to spawn. Ideally, we would have liked to locate spawning aggregations and set up nets directly below to capture newly hatched larval fish. The shoreline adjacent to Crab Creek above state highway 17 is private, and gaining permission to cross this land in order to survey walleye spawning distribution is highly unlikely. Therefore, we had to rely on our abilities to capture walleye a considerable distance from where we believe walleye were spawning. This sampling method was conducted under the assumption that once hatched, walleye immediately headed downstream and into Moses Lake. A study by Harvey (1987) suggested that fish greater than 10 mm were not as susceptible to downstream displacement associated with flooding events as fish that were < 10mm. It is possible that newly hatched walleye remained within Crab Creek in slow sections above Rocky

Coulee wasteway. The water that enters Moses Lake via Crab Creek and Rocky Coulee wasteway originates from Billy Clapp and Banks Lakes. During a one-year entrainment study in the outflow canal from Banks Lake, a tremendous amount of zooplankton were entrained. Consequently, the water in Rocky Coulee wasteway, and ultimately Crab Creek above Moses Lake, may carry a large food source for newly hatched fishes such as walleye.

If walleye did not reside in Crab Creek after hatching, it is possible they may have avoided our nets as we towed them through the water (Franzin and Harbicht 1992). However, larval fish have been captured in rivers using smaller drift nets (Franzin and Harbickt 1992) as well as from stationary boats (Gale and Mohr 1978). Noble (1972) found that the number of walleye caught in a low-speed (2 mph) tow was lower than the number of fish caught in a high-speed (8 mph) larval fish tow. Although our average speed was 2.94 mph, we did reach speeds of 3.64 mph while towing and overall we captured larval fish at a rate of $0.23/1m^3$.

It is also possible that we did not sample long enough and walleye may not have hatched. However, this is unlikely, as water temperatures during April and May would have resulting in an incubation time of 7-21 days (Wydoski and Whitney 2003). Consequently, newly emerged fish would not have had the ability to avoid our sampling gear during the times we sampled if they were susceptible to downstream flows. If walleye were not susceptible to downstream flows and moved into Moses Lake later, we may have missed them. It is also possible that walleye production in Crab Creek is not as great as assumed, and that the majority of production takes place in Moses Lake proper or walleye are entrained into Moses Lake at a larger size.

The assumption that walleye production primarily occurs in Crab Creek has never been confirmed. The WDFW hatcheries division targets adult walleye for brood stock in Moses Lake below the Crab Creek confluence. In addition, anglers target large adult walleye in Crab Creek during April, as this is the time walleye are believed to be spawning or migrating to spawn. In general, walleye are very abundant in Crab Creek during the month of April, although walleye production has never been documented. Even though we were unable to quantify walleye production during the spring, we have always been able to capture yoy walleye during our FWIN surveys. During the 2003, 2005, and 2006 FWIN surveys, the number of walleye <190 walleye / net was 1.5, 2.1, and 3.4, respectively. In 2003 and 2005, we conducted a boat electrofishing survey concurrently with the FWIN survey and caught a walleye every 600 and 108 seconds, respectively. Consequently, yoy walleye are present in Moses Lake during fall surveys but we do not know where they originate. It is possible that shoreline spawning occurs in portions of Moses Lake in Section 1 and 4, as large ripe walleye have been previously caught in these areas during spawning season.

In conclusion, we know that yoy walleye do occur in Moses Lake but we do not know the specifics of production. We know that in April, large numbers of walleye can be found in Crab Creek and during the same time, adult walleye can also be found within Moses Lake. Therefore, two types of spawning populations comprised of a river and lake component may exist within Moses Lake. A study by Jennings et al. (1996) found that offspring of river-spawning walleye were more frequently captured within their natal stream rather than in the connected lake. If there are lake and river spawning populations of walleye within Moses Lake, it is possible that offspring remain in Crab Creek after hatching. Once irrigation water flowing into Moses Lake is greatly decreased at the end of May and temperatures begin to increase, the habitat in Crab Creek may become suboptimal and force fish out of Crab Creek into Moses Lake. In order to better understand the production of walleye in Moses Lake we would suggest a more intense and increased duration sampling effort as well as attempt to work with local landowners in order to access Crab Creek. Further work may also include genetic analysis to determine if there is a discernable variation between walleye signatures, possibly indicating there are multiple life history types that exist sympatrically within Moses Lake. However, because BPA will no longer be funding the Moses Lake project, future data collections and analyses will fall to the WDFW.

C. Objective 2. Quantify Winter Losses.

1. Task 2.1 - Quantify Entrainment Losses.

In lieu of a report for this task, we have elected to submit a peer reviewed journal article summarizing all the entrainment data that have been collected during the tenure of the Moses Lake Project. However, we have included a summary table to demonstrate the level of entrainment that occurs from Moses Lake (Table 7).

Table 7. Summary of entrainment sampling on Moses Lake, Washington from 2005-2006.

Month and Location[1]	# of fish caught	Mean # fish / m^3
November (MLID)	222	0.0272
November (BOR)	376	0.1377
December (MLID)	274	0.0622

[1]MLID- Moses Lake Irrigation District outlets and BOR-United States Bureau of Reclamation Dam.

2. Task 2.2 - Quantify Rates of Fish Predation.

a. Introduction.

Previous results suggest that predation of walleye on the gamefishes of Moses Lake can be significant (Burgess et al. 2007). However, in the past, we did not obtain large winter samples and results were not definitive. In order to improve the level of analysis regarding walleye predation in Moses Lake, we increased our sampling efforts and focused on capturing walleye during times with smaller sample sizes. Walleye predation was estimated around two time periods. The first was fall and winter and the second was during rainbow trout releases to quantify the level of acute predation on net pen raised rainbow trout. In order to remain consistent, we followed the methodologies similar to those we had completed in the past (Burgess et al. 2007).

b. Methods.

i. Diet Composition.

Walleye were captured during FWIN sampling (Task 1.1), winter, and the net pen trout releases via boat electrofishing and gillnetting. The experimental gillnets used were 61 m long (200 feet) with 8 panels of mesh; 25 mm (1”), 38 mm (1.5”), 51 mm (2.0”) 64 mm (2.5”), 76 mm (3.0”), 102 mm (4.0”), 127 mm (5.0”), and 152 mm (6.0”). Net setting was consistent with FWIN protocol (Morgan 2002) and nets were set perpendicular from shore during sampling. Boat electrofishing was conducted along the shoreline at random locations within each of the four sections with a Smith-Root SR-18 boat using methods from previous surveys (Burgess et al. 2007).

Stomach contents were collected from both live and recent walleye mortalities. Live fish had their stomach contents removed via gastric lavage, whereas entire stomachs were taken from fish that were dead. The gastric lavage pump was constructed from a handheld sprayer with a modified elongated nozzle. The sprayer was filled with water and pressurized. To obtain stomach contents, the nozzle was inserted into the oral cavity, past the pyloric sphincter, and into the stomach, forcing water into the stomach and causing regurgitation. To minimize the amount of alcohol that we used and decrease the likelihood of samples degrading, we did not add any additional water to the bags where we stored the contents. During stomach evacuations we held walleye above a longitudinally cut 4" PVC pipe with a 356 μ mesh screen on one end which permitted water to flow through the mesh but captured all possible food items on the screen. Stomach contents where then removed from the screen and/or flushed using a squirt bottle filled with 95% alcohol as the lavage pipe was held at a 45 degree angle to allow contents to flow into a Whirl Pak. Sample contents were preserved in 95% ethanol.

Stomach items were identified to the lowest practical taxon using Leica 0.8-3.5 x dissecting scopes, enumerated, measured, and weighed to the nearest 0.0001 g. For zooplankton identification, we used Pennak (1989) and for insect identification, we used Merritt and Cummins (1996). For fish identification, we used Hansel et al. (1988), Wydoski and Whitney (2003), WDFW internal diagnostic bone keys, and some collected voucher specimens to increase our level of confidence when bones were collected from the stomachs. We calculated diet composition by weight and number for the various predators.

ii. Bioenergetics Modeling.

The advent of bioenergetics modeling has enabled researchers to measure effects of predators on prey items (Hansen et al. 1993). Food habits studies primarily examine an instantaneous measure of diets, while bioenergetics modeling enables prediction of the total amount of energy required for a particular individual or a population over a given amount of time (Brandt and Hartman 1993). The bioenergetics model uses six parameters: water temperature, predator diet, prey energy density, predator abundance, predator age distribution, and predator mortality, and works on the generalized and intuitive formula:

Energy consumed = Respiration + Waste + Growth.

This can be further broken down into a more specific mass balance equation (Hanson et al. 1997):

Consumption (C) = (respiration [R] + active metabolism [A] + specific dynamic action [S]) + (egestion [F] + excretion [U]) + (somatic growth [ΔB] + gonad production [G]).

Using the proportion of the diets for the walleye, we used the Fish Bioenergetics 3.0 model to estimate prey consumption. To calculate the consumption rates of walleye we needed six parameters: water temperature, predator diet, prey energy density, predator abundance, predator age distribution, and predator mortality. Water temperature data consisted of the mean daily temperature recorded continuously in Moses Lake from all depths and sections of the lake. Predator diets were collected and entered into the model as proportions by weight of stomach contents. The prey energy density is the amount of energy contained in a unit of weight and entered as joules per gram of wet body weight (Hanson et al. 1997). Units of energy for prey items were obtained from Cummins and Wuycheck (1971) and applied to the bioenergetics model. Walleye abundance was estimated by multiplying the mean number of walleye per net that were >300mm by the lake size in hectares (Nigel Lester, personal communication, 2005). All parameters were related to the Julian date in which the data were collected.

To calculate walleye ages we used two different methods. During the WDFW FWIN surveys conducted every fall, we collected otoliths and scales that were aged at our aging lab in Olympia, Washington. We also enlisted the help of Dr. Kirk Steinhorst from the University of Idaho to apply our data to the R-Mix model, which statistically analyzes the distribution of length-frequency data.

Before calculating survival we had to determine which method of collection would best produce a sample that was unbiased relative to size. However, as stated in the literature there is no one sampling technique that captures all species or sizes of fish in equal proportions, hence the need for multiple gear types (Everhart and Youngs 1981). Because of the size selectivity and the inability to combine CPUE of our sampling gears, we elected to calculate survival of fishes 0-3 years old from our electrofishing and fish 4 years and older from our gillnetting events (Appendix 2). Length frequency data suggested these methods were less selective for these sizes (ages) of walleye.

To estimate annual mortality, we first determined annual survival using the Chapman-Robson estimator (Everhart and Youngs 1981):

$$\hat{S} = \frac{T}{n + T - 1}$$

where: $\hat{S}$ = annual survival,

$T = \sum_{x=0}^{k} x f_x$ = the sum of the coded age times its frequency,

x = the coded ages,

f_x = the frequencies, and

$n = \sum_{x=0}^{k} f_x$ = the sum of the frequencies.

Finally, assuming annual survival is the compliment of annual mortality, we calculated mortality using:

$$A = 1 - S$$

where: A = annual mortality.

$$A = 1\text{-}S.$$

c. Results.

i. Diet Composition.

Of the 311 walleye that were sampled between October 17, 2005 and May 12, 2006, only 1% of their diets by weight represented invertebrates and the remainder was attributed to fish prey items (Figure 11). The most abundant fish consumed by walleye during our sampling period were from the family Centrarchidae, of which black crappie represented 92% of the centrarchids by weight (Figure 12). Centrarchids were an important component of age 1 walleye diets (Figure 13). By age 2, centrarchids only represented 16 percent of a walleye diet while yellow perch represented 75% (Figure 14). Although the diets from walleye age 3+ contained centrarchids, their abundance decreased as walleye aged and rainbow trout increased as a prey item (Figures 15, 16, and 17).

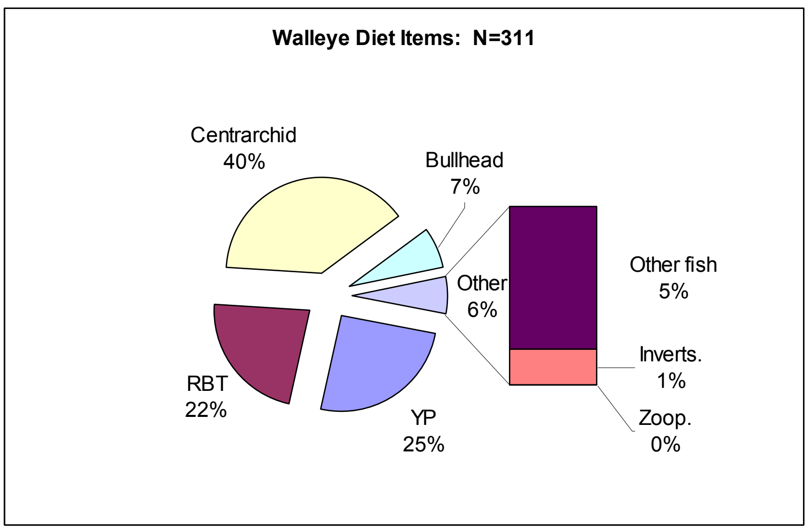

Figure 11. Diet composition of walleye from October 2005-May 2006 in Moses Lake, Washington.

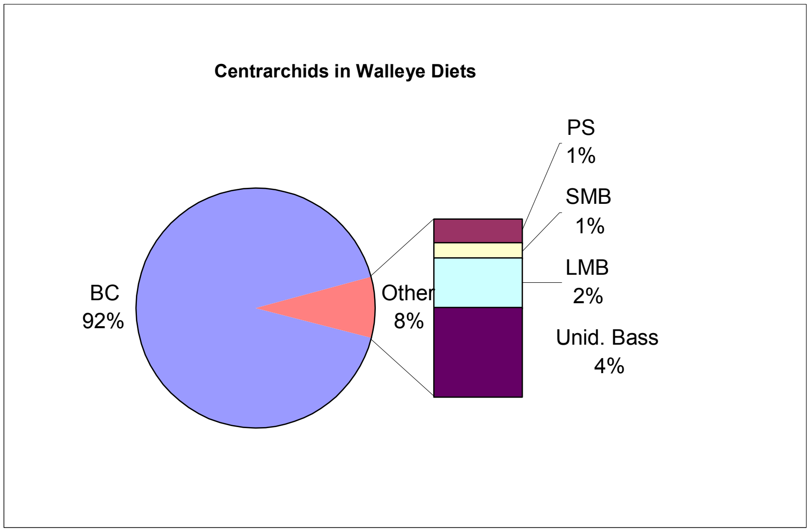

Figure 12. Composition of centrarchids within walleye diets from October 2005-May 2006 in Moses Lake, Washington.

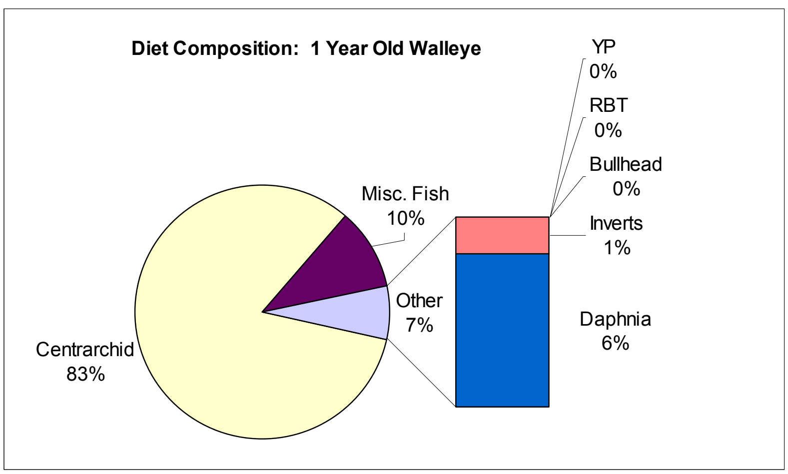

Figure 13. Diet composition of age 1 walleye from October 2005-May 2006 in Moses Lake, Washington.

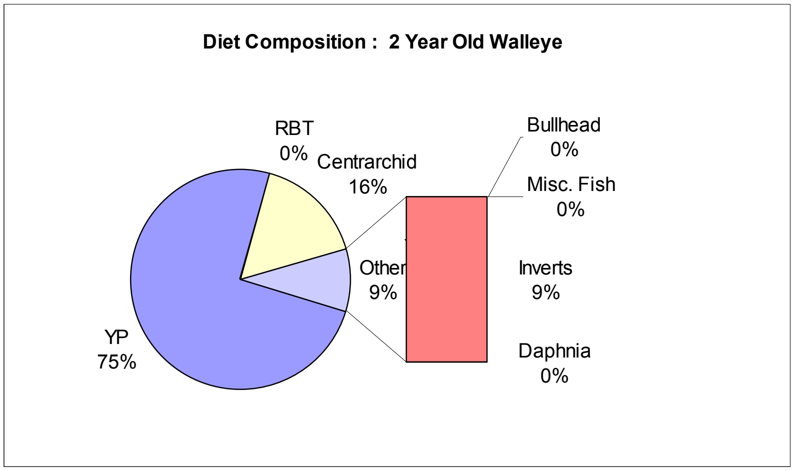

Figure 14. Diet composition of age 2 walleye from October 2005-May 2006 in Moses Lake, Washington.

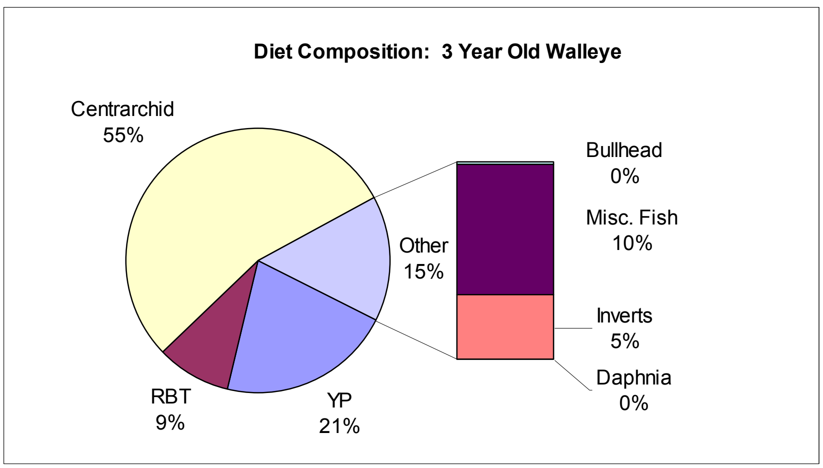

Figure 15. Diet composition of age 3 walleye from October 2005-May 2006 in Moses Lake, Washington.

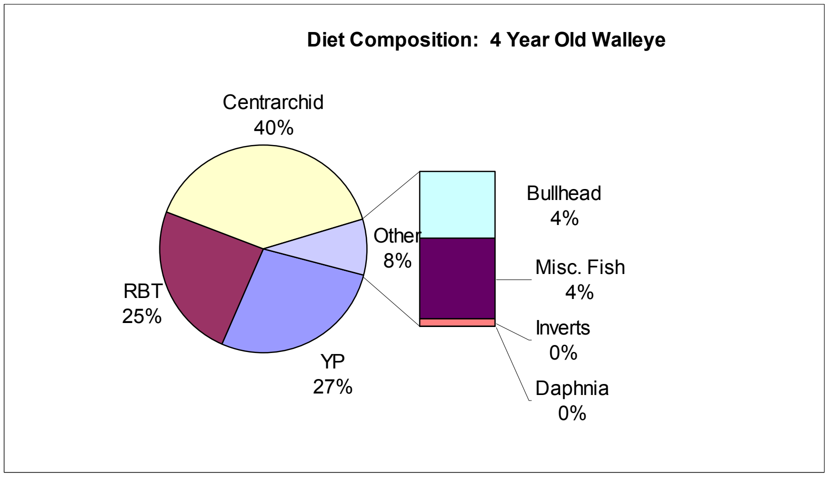

Figure 16. Diet composition of age 4 walleye from October 2005-May 2006 in Moses Lake, Washington.

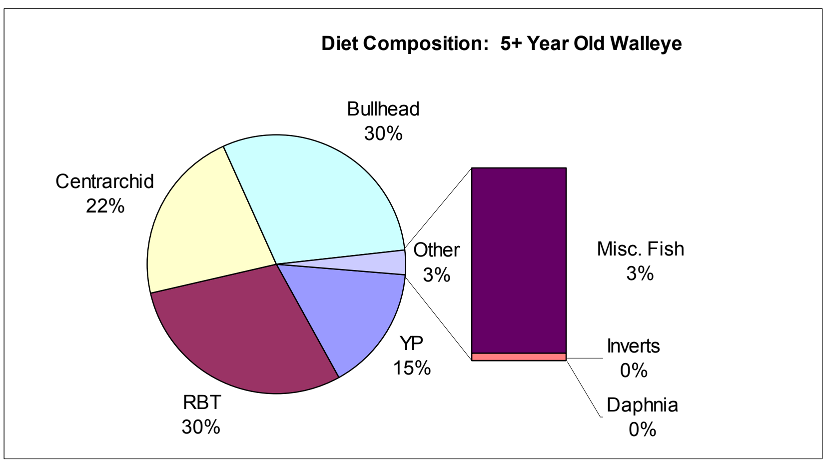

Figure 17. Diet composition of age 5 walleye from October 2005-May 2006 in Moses Lake, Washington.

ii. Bioenergetics Modeling.

Modeling of walleye captured between October 17, 2005 and May 12, 2006 was conducted for 1,000 individuals. Age distribution for the Bioenergetics model was estimated using the 2005 FWIN survey data. During the course of the study, walleye exhibited a strong correlation between temperature and prey consumption (r^2=0.98; Figure 18). Even though rainbow trout represented a large portion of the walleye diet (Figure 11), walleye only targeted rainbow for ~9 days once they were released from the net pens. However, during this short period, the least abundant walleye 3 years and older from the 1,000 individuals modeled were estimated to consume 116,441.6 grams of rainbow trout (Table 8). Walleye appeared to alter their predation habits temporally as they shifted between prey items (Figure 19). The largest group of fish estimated to be consumed by walleye was centrarchids at 572,886.5 grams.

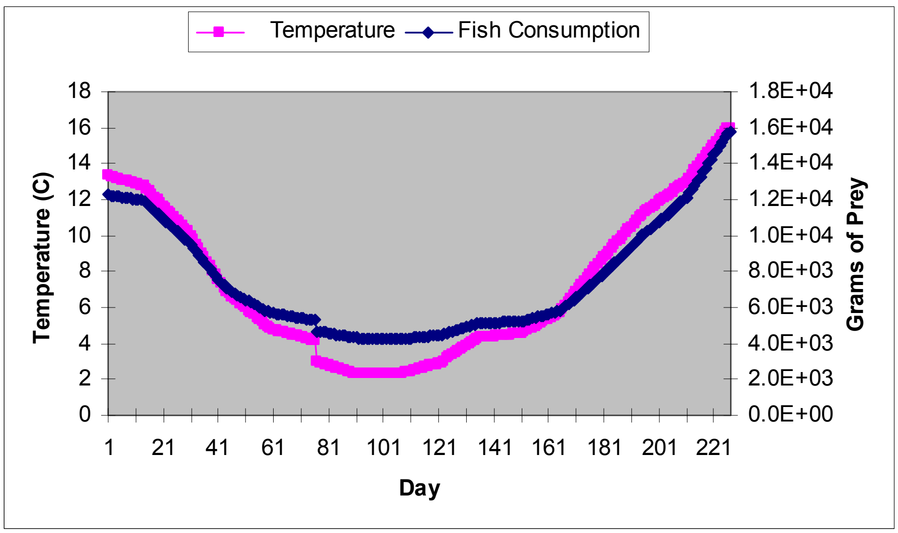

Figure 18. Daily consumption of prey fishes by 1,000 walleye in Moses Lake, Washington from 10/17/05-5/31/05 relative to temperature.

Table 8. Estimated consumption rates of most common prey items[1] by Moses Lake, Washington walleye between October 17, 2005 and May 12, 2006. Modeling was conducted for a population of 1,000 walleye.

Age	**Cent.**	**Other Fishes**	**YP**	**Daph**	**Inverts**	**BH**	**RBT**
1	87.2	3,233.8	0.0	4,751.8	6,553.5	0.0	0.0
2	7,030.5	15,408.0	7,091.4	0.0	20,047.1	0.0	0.0
3	121,633.1	36,900.3	82,749.6	1.0	135,257.5	174.3	4,669.6
4	374,635.3	178,446.0	304,128.4	7.7	55,920.4	90,927.4	106,167.6
5+	69,500.4	9,812.8	20,529.3	0.1	301.1	47,895.6	5,604.3
Total (g)	572,886.5	243,800.9	414,498.8	4,760.6	218,079.5	138,997.2	116,441.6

[1]Cent.-Centrarchids, YP-Yellow Perch, Daph-*Daphnia*, Inverts-Miscellaneous Invertebrates, BH-Bullhead spp., and RBT-Rainbow Trout.

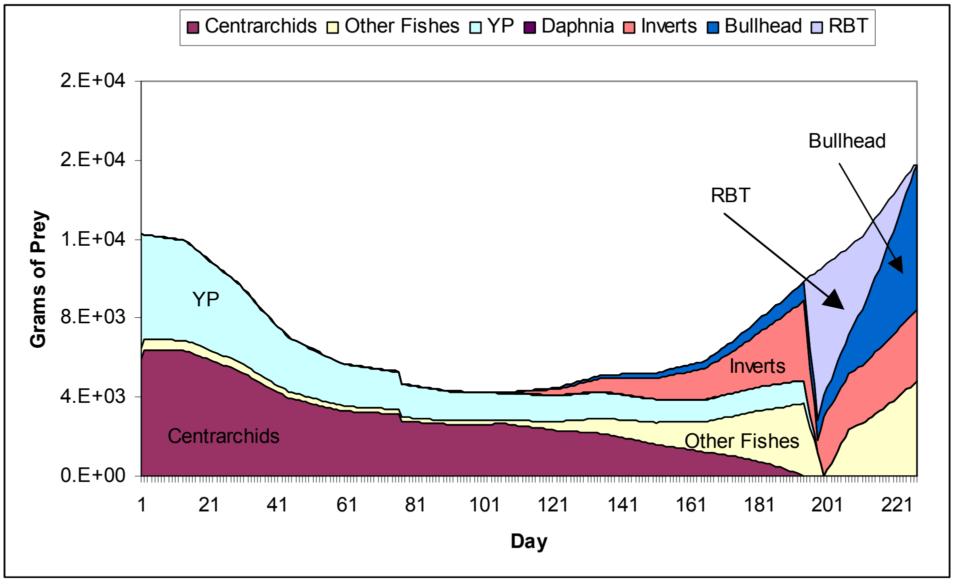

Figure 19. Prey selection (g) by 1,000 walleye in Moses Lake, Washington from 10/17/05-5/31/05.

d. Discussion.

Few studies regarding the predation impacts of walleye on resident fish within the Upper Columbia Basin have been conducted (Baldwin et al 2003; Burgess et al 2007; Polacek et al 2007). In Moses Lake, we have estimated that the walleye consume a considerable amount of prey fishes on an annual basis (Burgess et al. 2007). The goal of this task was to better establish a consumption estimate during the winter, which is traditionally thought to be the non-growing season due to cold temperatures. Temperature can be one of the parameters that dictates consumption rates in the fish community (Koenst and Smith 1976), and in Moses Lake as the temperature decreased so did the rate of prey consumption. However, even when Moses Lake reached temperatures as low as 2.4 °C, we estimated that 1,000 walleye still consumed 4,000+ grams of prey items daily. If these consumption rates were the same during 2003 when we conducted our abundance estimate, the population of walleye in Moses Lake would have consumed ~520,000 grams of prey items a day.

The abundance of walleye and their impacts on prey populations have been a concern for fisheries managers (Hartman and Margraf 1992). Walleye in the Columbia Basin are not a co-evolved species and the amount of investigations has been limited.

Consequently, the impacts of walleye on resident fishes are not yet understood. Our data suggested that walleye are opportunistic feeder and target species that are generally abundant during the fall and winter months such as black crappie and yellow perch. The diet preference of walleye shifted dramatically during the spring when pen raised rainbow trout were released, as walleye immediately began to target these fish. The prey preference by walleye of soft-rayed fishes versus spiny-rayed fishes has been documented (Knight et al. 1984). Once the pen-reared rainbow trout were released and made available as a prey item, it is not surprising that walleye would have targeted them. A similar predator-prey relationship has also been documented on Lake Roosevelt where walleye exhibited an immediate response to newly release pen-reared salmonids (Baldwin et al 2003). It can be expected that the impacts of walleye on stocked salmonids would be greater in Moses Lake compared to FDR as fewer salmonids are stocked in Moses Lake and the density of walleye is considerably higher (FWIN results: FDR - 1.3 walleye per net, Moses Lake - 35 walleye per net.

We have previously documented the impacts that walleye have on the prey fish population in Moses Lake (Burgess et al. 2007 a and b). In short, the walleye population of Moses Lake can potentially consume a tremendous amount of prey fish. If this population should continue to grow, the impending impacts to the standing prey fish population will be negative. Consequently, we recommended that the walleye regulation be changed in order to increase exploitation, decrease walleye abundance, and in turn, decrease consumption of prey fishes by walleye.

D. Objective 3. Reporting and Proposal Writing.

1. Task 3.1 - Reporting to BPA and WDFW.

Due to the scope of the Moses Lake Project, many of the submitted annual reports have been progress reports. In order to fulfill our contractual obligations regarding BPA technical report requirements we are in the progress of finalizing 2002-2004 Completion Report as well as a paper that will summarize all the entrainment work that was completed during the tenure of the Moses Lake Project. All other status reporting and quarterly reports were completed in a timely manner.

2. Task 3.2 - Proposal Submission.

The development and submission of a proposal to continue work on Moses Lake consumed a substantial amount of time and resources. As we have explored virtually every factor that could influence the fishery within Moses Lake, the next logical step was to develop a proposal that investigated the final parameter that may be acting on the fishery in Moses Lake. The impacts of avian predators on the Moses Lake fishery are unknown. What is known is during certain times of the year WDFW waterfowl counts indicated there is often an abundance of avian predators that utilize Moses Lake. As well as impacting the fishery within Moses Lake, a portion of these predators, namely common mergansers, may seasonally laterally migrate between Moses Lake and systems that contain anadromous fishes or sensitive species. Although Dr. Daniel Roby of Oregon State University expressed interest that our proposal project was funded, the second ISRP review of our proposal resulted in a 'do not fund' designation. Consequently, the Moses Lake project is to be terminated at the end of March 2007. During this time, staff will be finishing up reports and papers associated with the Moses Lake project.

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IV. Appendices.

A. Appendix 1 – WDFW/U.S. Fish and Wildlife Service Waterfowl Counts.

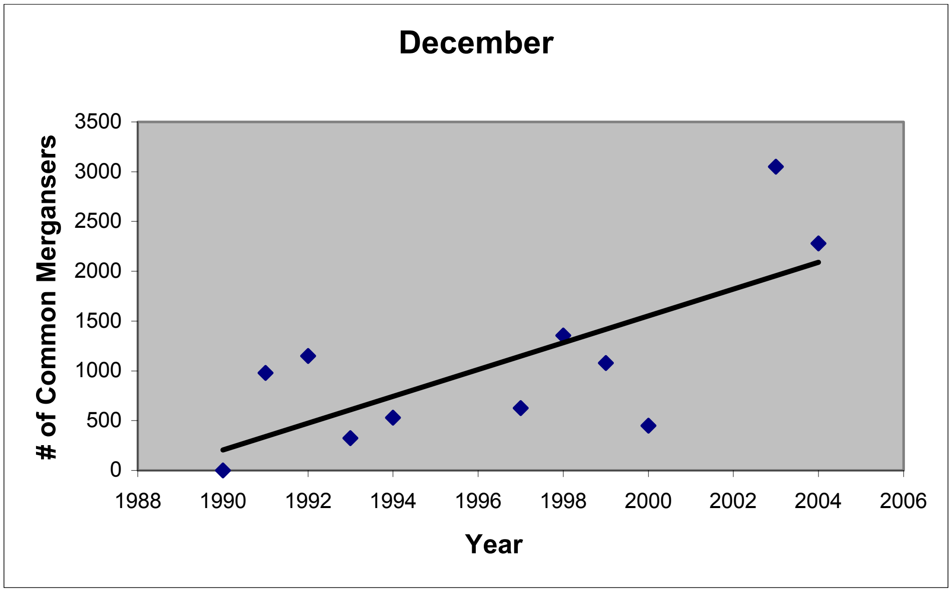

Figure 1. Number of common mergansers found during WDFW and U.S. Fish and Wildlife Service waterfowl counts conducted on Moses Lake, Washington in December from 1990-2004.

B. Appendix 2 – Results of Electrofishing and Gillnetting for Walleye.

Results from the 2003 FWIN and concurrent electrofishing survey showed there was a significant difference in size selectivity between gillnetting and electrofishing sampling techniques (*t=11.59, P<0.05*). The mean and median lengths for fish captured using electrofishing were 448.1 mm and 488 mm, respectively, while fish captured via gillnets had mean and median lengths of 310.9 mm and 275 mm, respectively (Figures 1 and 2). These data are also apparent when combined (Figure 3).

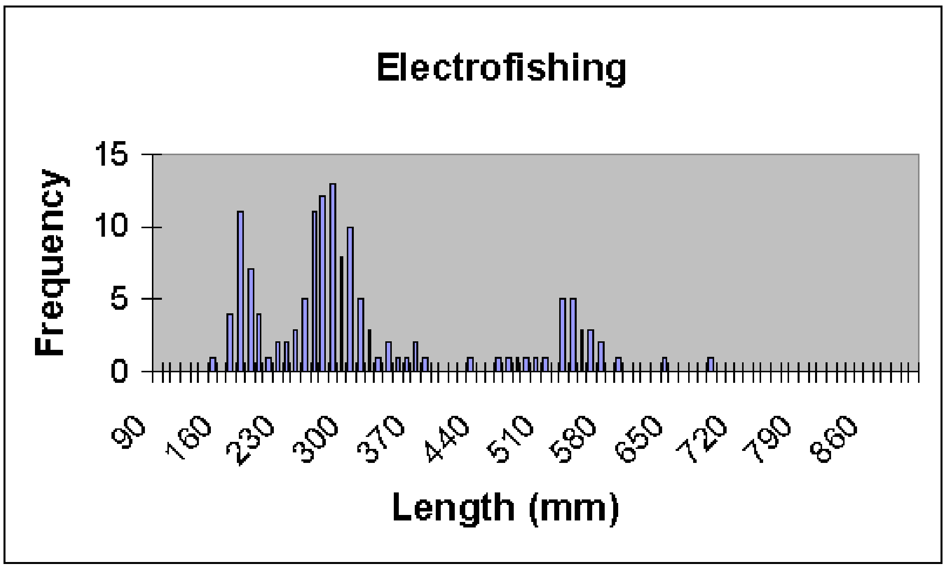

Figure 1. Length frequency of walleye captured via boat electrofishing during fall 2003 in Moses Lake, Washington.

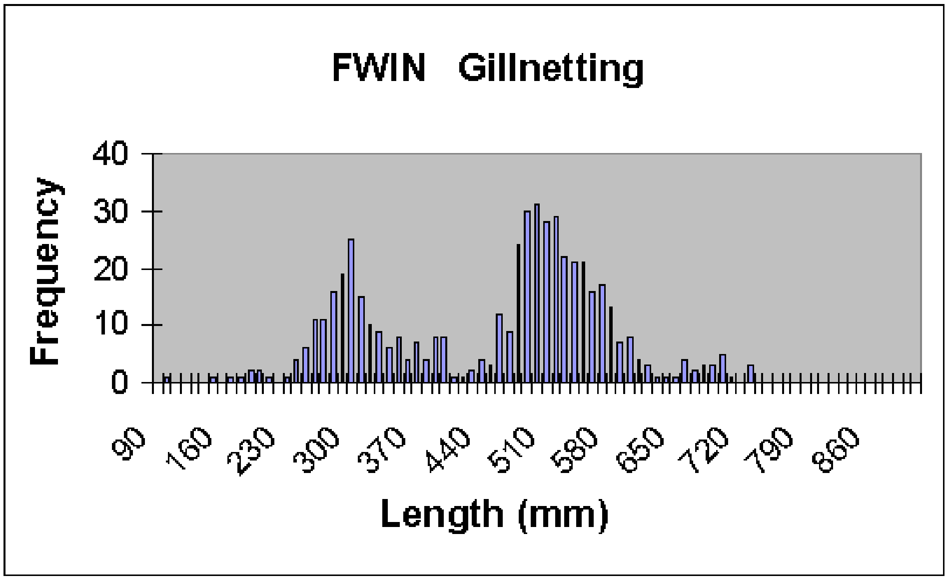

Figure 2. Length frequency of walleye captured in Moses Lake, Washington via gillnetting during fall 2003.

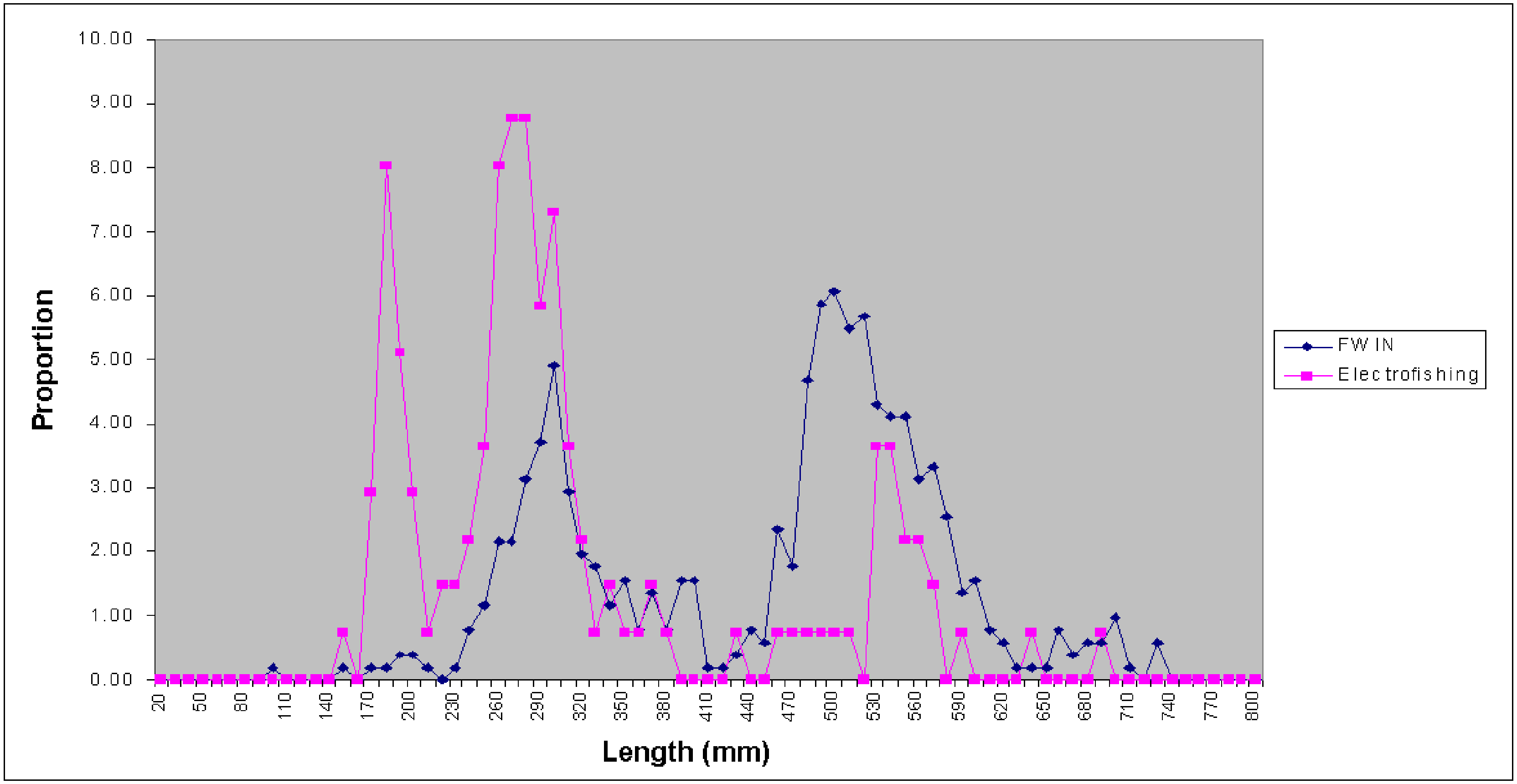

Figure 1. Proportion of walleye captured via electrofishing and FWIN gillnetting in Moses Lake, Washington during fall 2003.

C. Appendix 3 - Second Draft of the Moses Lake Project Proposal Addressing ISRP Comments.

Project ID: 199502800

Title: Piscivorous Avian Resource Utilization of Moses Lake and the Relationship to Other Systems

Response to ISRP Comments

Preface

This project has produced a considerable amount of data and results that has allowed managers to adjust regulations in an attempt to improve the resident fishery within Moses Lake. We have also learned that entrainment of fishes from Moses Lake is high which reduces not only the fish abundance within Moses Lake but potentially seeds waters below with non-native deleterious species with respect to salmonid fitness. Another possible limiting factor that we have detected in recent years is the high abundance of avian predators on Moses Lake. These birds may impact the Moses Lake fishery as well fisheries within the entire Basin including the Mainstem Columbia River. The continuation of this project is important not only as an off-site mitigation endeavor for resident fishes but also to investigate the impacts of avian predators on native ESU's within the Columbia River.

Below I have developed answers for each of the questions or comments the ISRP stated within their review of the project 199502800. Some changes were made to the existing proposal but in general I was able to address each of the questions using existing information within the proposal. It is also important to mention that this project has experienced a substantial amount of natural and anthropogenic circumstances that has caused us to approach our collections and analysis with an adaptive management approach. We have been willing to modify most of our tasks during the tenure of our project and we are of the understanding this will also need to be done in the future in order to be successful.

1. Because this work will be conducted on Moses Lake and fishery within this is not a new project. We have indirectly proposed this work within the original scope of work on page 10 in the section titled Uncertainties within the Moses Lake Fishery our 4th uncertainty was:

> *4. Interspecific interactions are affecting the survival of Moses Lake fishes. The fish community within Moses Lake is diverse and not co evolved. Consequently, interspecific interactions may be amplified. Investigations regarding diet overlap and habitat overlap between species are necessary to determine whether interspecific interactions negatively impact-panfish recruitment.*

This statement was meant to include interactions between all animals that use Moses Lake, not just fish versus fish interactions; case in point bird / fish interactions. The specifics of the work to be performed was not mentioned in the first proposal but is still related to the fishery.

2. Success of this project will be gauged by the answering the 4 uncertainties we have outlined on page 9 by following the work elements within Phase 1 of this proposal.

3. There is an inadequate match to Crab Creek Subbasin Objectives due to the fact the wildlife portion of the Subbasin plan was not completed and the entire plan has not yet been accepted. However, quantifying bird predation on salmonids is suggested in the Lower Columbia River Subbasin plan as well as other documents. The Draft Columbia River Basin Research Plan (2005) states, "The cumulative effects of predation must be evaluated including marine mammals, avian species such as terns, cormorants, mergansers, as well as piscivorous fish including northern pikeminnow, walleye and smallmouth bass." The regional monitoring framework within the same document has a Predator Status and Trend Monitoring component that poses the Management Question; "What is the impact of predators on juvenile salmonids within the Columbia River Basin?" Seated within the primary management question are several subordinate questions addressing avian colony sizes, distribution and consumption rates. Consequently, the NWPCC recognizes the potential impacts avian predators may have on fishes within the Columbia Basin.

The project we are proposing will initially look at the effects of avian predation on Moses Lake and how these predators may travel and utilize the resources of the mainstem Columbia River. Phase two will consist of the development and implementation of a control plan.

4. Regarding the ISRP's statement that "the literature review is fairly restricted and does not make a convincing case for avian control". Phase 1 of this project is not suggesting avian control. Phase 2, which will be seeking funds after the 2007-2009 funding years indicates the possibility of avian control if needed (page 9). This spring the WDFW implemented a cormorant hazing program that involved the continual disturbing of cormorants on Moses Lake during the net pen trout releases in order to minimize predation (Jeff Korth 2006). Should a control program be warranted we will have the option of using lethal or non-lethal measures.

Unfortunately, I was unable to consult all studies relevant to our proposal. As suggested by the ISRP I have since read Antolos et al. (2005) and some of the methodologies are analogous to what we have proposed. We too are taking a 'bioenergetics approach' with respect to avian predation.

5. The ISRP lists only two 'important issues' which include: '(1) are too many fish being consumed, and (2) if so, what could be done that is effective and acceptable to the community." Regarding issue 1, we are concerned not with only the number of fish that are being consumed but also what are the origins of the fishes being eaten. Work elements 1.2 and 1.3 will address both the number and the general origin of the prey eaten. As for issue number 2 we will address this during the out years during Phase 2 if needed.

A. Abstract

The Moses Lake Project, funded by the Bonneville Power Administration (BPA), has already provided invaluable management information to enhance the fishery on one of Washington's historic premier fisheries. Data collected and analyzed has clearly demonstrated to managers that predation is one of the major forms of mortality to target fishes and consequently to enact recreational fishing regulation changes. The only limiting factor that we have not entirely assessed is the impact by avian predators on the fishes of Moses Lake. Monthly counts suggest substantial numbers of fish eating birds that inhabit Moses Lake during various times of the year. The same predatory birds may also be affecting ESA listed fishes within the Mainstem Columbia River as some evidence suggests that many of them migrate laterally between the bodies of water within the Columbia Basin. The fitness of many of the migratory birds may have increased with the increase in waters containing fishes within the basin has negated the need to migrate long distances in search of food. Consequently, many of the inland lakes and reservoirs, Moses Lake included, may act as a resource refuge for such predators as common mergansers (*Mergus serrator*) and double crested cormorants (*Phalcrocorax auritus*). We plan to use stable isotope signatures to ascertain the relative importance of juvenile salmon and other fishes in the diets of the avian predators utilizing Moses Lake. In addition, satellite telemetry technology will be used to track their movements. This will allow us to discover how large their foraging area may be and whether seasonal or localized events significantly affect bird movement patterns.

B. Technical and/or scientific background

Moses Lake was one of the premier resident panfish fisheries in the Northwest during the 50's and 60's but community structure has recently changed to a walleye (*Sander vitreus*) fishery. Although walleye are a heavily sought gamefish, the fishery is more specialized requiring a boat and a variety of expensive gear compared to a panfish fishery, which is relatively simplistic, and numerous angler "types" can participate. This change in the Moses Lake fishery prompted the pursuit of BPA funds in the mid-1990s as off-site mitigation to investigate the recreational fishery within Moses Lake with the initial objective of restoring the historical panfish fishery. The change in the Moses Lake fishery has been hypothetically linked to several possible factors such as overfishing, the eruption of Mt. Saint Helens and the subsequent ash deposition, the application of chemicals for mosquito control, carp, predation and entrainment. Our findings suggest that predation and entrainment are the two factors primarily contributing to the current decline of panfish within Moses Lake

Recent creel data and abundance estimates have confirmed that the fishery has shifted from a general panfish fishery to a more specialized walleye fishery (Burgess et al 2006). Top predators, such as walleye, can have a substantial impact on forage fish populations in many systems (Beamesderfer et al 1990; Rieman et al. 1991; Vigg et al.

1991; Zimmerman 1999). Furthermore, Carline has found an inverse relationship in biomass between percids and centrarchids in 71 Wisconsin lakes (1986), which corroborates our findings within the fish community of Moses Lake.

The depletion of fish prey is most common for introduced fish assemblages in reservoirs where drawdown increases vulnerability of prey fish (McMillan 1984; McMahon and Bennett 1996) and their entrainment (Winchell et al. 1997). Within Moses Lake, we have determined that centrarchids are the most entrained group of fishes, which are largely the panfish in decline in Moses Lake (Burgess et al 2006). Consequently the combination of entrainment and increased rates of predation associated with the annual drawdown negatively impact the fishery within Moses Lake.

Despite the change in the fish community, Moses Lake is still a premier warmwater mixed species fishery (NWPCC 2004 Crab Creek Subbasin Plan). However, the increase of avian predators such as double crested cormorants and common mergansers (WDFW unpublished waterfowl count data 1992-2005) and their impacts in basin lakes and the mainstem Columbia River have concerned managers and policy coordinators. Such concern prompted the Yakima Klickitat Fisheries Project (YKFP) to quantify avian predation on salmonid (*Oncorhynchus* spp.) smolts in the Yakima River Basin. In Minnesota's Leech Lake, the cormorant issue has become such a problem that the state and federal government has approved a depredation measure to remove a large percentage of the birds. More locally, poor trout harvest in some of the Columbia basin's smaller lowland lakes where cormorants have been observed for extended periods of time (Jeff Korth, a WDFW District Fish and Wildlife biologist 2005 Personal Communication).

The Columbia River Basin has a very large population of piscivorous birds (Roby et al. 1998). A recent study on the Columbia River in the McNary Pool found that Caspian Terns consumed as many as 382,000 to 825,000 smolts annually over a two-year period (Antolos et al. 2005). Avian predation is not limited to the Mainstem Columbia River. Within the Yakima Basin common mergansers in 2002 were one of the most abundant avian predators (Stephenson et al. 2003); common mergansers have been found to feed on salmonid fishes (Wood 1985). Although the YKFP study was informative with respect to avian predator counts and biomass consumption it examined the number of birds present during the spring and summer when smolts are most likely present. However, during the winter months when salmonid smolts are not present within the mainstem Columbia River large congregations of common mergansers are often spotted on Moses Lake. For example, in December 2004, 2,280 common mergansers were counted on Moses Lake and only 131 common mergansers were counted on the pools at the combined locations of Wanapum, Rock Island, Rocky Reach and Wells dams on the Columbia River (WDFW unpublished data winter waterfowl counts). However, In March 2005, 1,067 common mergansers were counted on Moses Lake but by May, June and July, the last month of the survey, no common mergansers were counted on Moses Lake. During this time between December 2004 and June 2005 the cormorant count went from zero to 222 individuals on Moses. It is believed that double crested cormorants migrate from the coastal regions in early spring to the inland lakes to breed, raise their fledglings and feed (Jim Tabor, personal communication 2005). The Moses Lake area is used during the winter by common mergansers and by double crested cormorants during the spring and summer. The presence of these species impacts the resident fishery within Moses Lake and potentially other listed species within the Columbia Basin waters.

C. Rationale and significance to regional programs

Originally, the Moses Lake Project was funded as an off site mitigation project as outlined in Section 10.1 of the 1994 NWPPC's Fish and Wildlife Program Resident Fish Goal which states, "The program goal for resident fish is to recover and preserve the health of native resident fish injured by the hydropower system, where feasible, and, where appropriate, to use resident fish to mitigate for anadromous fish losses in the system." In the same document it was also stated in Section 10.2A.1 of the Program provides priorities for Columbia River Basin resident fish, including a high priority to populations that support important fisheries. This priority applies to introduced as well as native species, including bass, perch and others. Within the 2000 NWPCC Fish and Wildlife Program Document off-site mitigation opportunities still exist as substitution for anadromous fish losses and it states: "Administer and increase opportunities for consumptive and non-consumptive resident fisheries for native, introduced, wild and hatchery reared stocks that are compatible with the continues persistence of native resident fish species and their restoration to near historic abundance (includes intensive fisheries within closed systems).

As it appears the new NWPCC document does not make the same references to non-native fish off-site mitigation efforts (2000) as in the previous document (NWPPC 1994). However, if it is recognized that off-site mitigation projects are directly related to mitigation projects within the hydropower system we believe that a strong justification exists to fund projects referred to as off-site mitigation. The currently funded off-site mitigation Moses Lake project collected data not only on fish but also with help from WDFW's Wildlife program, on migrating avian predators. Consequently, we understand the association between the basin lakes like Moses Lake and migrating waterfowl. The continuation of the Moses Lake Project will allow us to investigate interactions between avian predators and resident and native fishes throughout the Columbia River and potentially the Northwest region as waterfowl migrate great distances (Hochbaum 1955; Sojda 2002).

The Draft Columbia River Basin Research Plan (2005) states, "The cumulative effects of predation must be evaluated including marine mammals, avian species such as terns, cormorants, mergansers, as well as piscivorous fish including northern pikeminnow, walleye and smallmouth bass." The regional monitoring framework within the same document has a Predator Status and Trend Monitoring component that poses the Management Question; "What is the impact of predators on juvenile salmonids within the Columbia River Basin?" Seated within the primary management question are several subordinate questions addressing avian colony sizes, distribution and consumption rates. Consequently, the NWPCC recognizes the potential impacts avian predators may have on fishes within the Columbia Basin.

Other documents within the Columbia River Basin also cite avian predation as a concern including the Crab Creek Subbasin Plan (2004 page 47), the Lower Middle Columbia Mainstem Subbasin Plan (2004, page 38) and the Upper Middle Columbia Mainstem Columbia Subbasin Plan (2004, pages 173). Such concerns are also issued within the FCRPS Biological Opinon Remand where it states; “Avian predators are one the factors currently limiting Salmonid recovery in the Columbia River Basin” (2004, page 22) and further suggests, “actions may be warranted to reduce consumption of juvenile salmon”.

D. Relationships to other projects

The Moses Lake Project is directly related to the Lake Roosevelt Fisheries Evaluation Program (199404300) and the Banks Lake Fisheries Evaluation Project (200102800) in regards to their focus on resident fish. Moses Lake receives water and fish through entrainment from Lake Roosevelt and Banks Lake. The project is also related to the Joint Stock Assessment above Chief Joseph and Grand Coulee Dams Project (JSAP #199700400). The relationship between Moses Lake and fisheries above Chief Joeseph Dam is also stated within 29.2.1.4 Banks and Moses Lakes of the Upper Columbia River Subbasin Plan (NPCC 2006) where it states: “Although not part of the Upper Columbia Subbasin, the management of Banks and Moses Lakes are closely linked to the management of water included in the upper Columbia Subbasin, even though they are geographically distinct. In addition the Banks and Moses Lakes Projects are mitigation for the Upper Columbia Subbasin.”

Even though the Moses Lake Project has historically been a non-native resident fish project our results suggest possible connectivity with other projects. For example, our results have shown a large amount of fish entrainment occurs from Moses Lake via the dam outlets and into the Crab Creek channel. Consequently, species that negatively interact with native salmonids may be moving downstream through the system and ultimately ending up in the mainstem Columbia River and its tributaries. These fish may constitute a large component of the predator population, as physical habitat conditions in the mainstem are not favorable for recruitment (Dr. D.H. Bennett, 2005 Personal Communication). Thus, upstream reservoirs may be providing a major source of seeding for several fish predators. As well as the contribution of fish predators, the Moses Lake area may also be a seasonal refuge for two avian predators that commonly impact native salmonids (Roby et al. 1998, Stephenson et al 2003). Prior to the USBOR Columbia Basin Irrigation Project, little lacustrine water was located within the Basin. After the construction of the Potholes Channel in 1955 and the ensuing flooding of desert areas, considerably more watered habitat was created (USBOR 1998). South of Moses Lake, in the Potholes Reservoir the numbers of breeding cormorants went from 16 pairs in 1978 to 652 breeding pairs in 1997 (Finger and Tabor 1997). The altered habitat is ideal for migrating waterfowl including avian predators and the increase in abundance is reflected in the WDFW winter waterfowl counts (WDFW, Unpublished data) and in the literature (Carter, et al., 1995; Roby et al. 2003).

Thus, the best available information strongly implicates Moses Lake avian and piscivorous predators in impacting aquatic communities throughout the Columbia River. As well as the relationship between the Banks Lake and FDR projects this project will also compliment efforts of Dr. Daniel D. Roby’s project; Avian Predation on Juvenile Salmonids in the Lower Columbia River (Project # 199702400) and the proposed Mid-Columbia Trophic Dynamics Project (200703600). In general, the continuation of the

Moses Lake project will be related to various anadromous fish supplementation and recovery efforts in the Columbia River system and the WDFW lowland trout Program.

E. Project history

During the funding of the Moses Lake Project much has been learned about the fish community within the lake (Burgess et al 2006). These findings have guided managers to initiate regulation changes. Additionally, we have found the following:

What is known about the Moses Lake Fishery

1. Primary and secondary production is not limiting fish production within Moses Lake;

Community density peaked in both July and September although the peak in September contained nearly twice as many individuals as in July. The peak in community density during September contained greater than 2,200 /L (Figure 1). Macrozooplankton densities in October and November were lower than in June. Historical studies and the abundance of secondary production negated the need to quantify primary production.

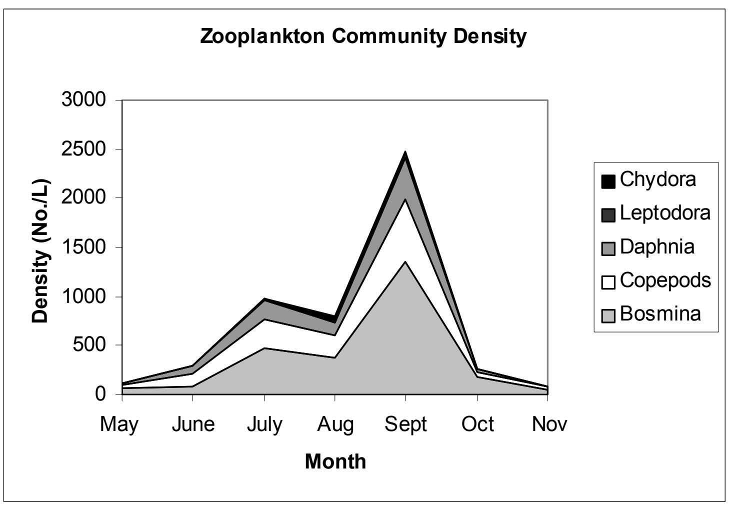

Figure 1. Zooplankton species composition by number from May-November,2002.

2. Carp are not impacting gamefish production;

One of the concerns with carp is they can directly impact spawning fishes or suspend solids reducing production. However, this was not the case as there was no indication of production deficiencies and during fall surveys young of year fishes were abundant indicating spawning was successful (Table 1).

Table 1. Number of fish collected from the four sections of Moses Lake during fall 2002 (122 seine hauls) and spring 2003 (135 seine hauls) beach seining and popnetting surveys.

		Section 1		Section 2		Section 3		Section 4	
Gear Type	**Species**	**Fall 2002**	**Spring 2003**	**Fall 2002**	**Spring 2003**	**Fall 2002**	**Spring 2003**	**Fall 2002**	**Spring 2003**
Beach Seine	**Black crappie**	921	52	125	29	43	215	114	0
Beach Seine	**Bluegill**	501	8	417	4	143	0	365	0
Beach Seine	**Largemouth bass**	560	3	705	10	134	43	112	1
Beach Seine	**Smallmouth bass**	368	7	66	0	10	3	20	6
Beach Seine	**Walleye**	36	10	8	23	1	45	4	0
Beach Seine	**Yellow perch**	22,505	7,109	18,333	16,812	4,225	42,102	961	652
Popnet	**Black crappie**	0	0	0	0	0	0	0	0
Popnet	**Bluegill**	26	0	45	0	9	0	20	0
Popnet	**Largemouth bass**	23	0	11	0	8	0	1	0
Popnet	**Smallmouth bass**	0	0	0	0	0	0	0	0
Popnet	**Walleye**	0	0	0	0	0	0	0	0
Popnet	**Yellow perch**	27	2	0	9	0	1	0	1

3. Water quality is not limiting gamefish production;

There were areas of sub-optimal water quality conditions such as dissolved oxygen within Moses Lake, However, such conditions did not persist and were localized

4. Predation rates by walleye on the prey fishes are high;

According to SIA adult walleye and rainbow trout are top-level predators, both obtaining the most energy from pelagic sources. Furthermore, the population of walleye >400mm was estimated to be 55,000. Applying the fish bioenergetics 3.0 model we estimated the population of walleye consumed ~400,000 kg of prey fish a year.

***5. Many fish are entrained from Moses Lake throughout the year;**

Entrainment sampling was conducted at the Moses Lake Irrigation District Outlet in 2003 and 2004. Our estimates of fish loss from Moses Lake were generally higher than those estimated by Winchell et al. (1997) for 43 sites around the U.S. Our highest losses in November were with black crappie and those exceeded 41 per million cubic feet. Winchell et al. (1997) identified black crappie as a Moderate-High species with their qualitative rating system. Their mean estimates for black crappie were 0.584 per million cubic feet in the fall and 0.0798 black crappie per million cubic feet in the winter. Our estimates for the winter exceeded 100 black crappie per million cubic feet of water. Yellow perch were also entrained from Moses Lake although in the fall, our estimates were 0.422 and 130 per million cubic feet compared to 2.51 and 0.318 per million cubic feet for fall and winter, respectively by Winchell et al. (1997). Overall, our estimated loss from Moses Lake was higher which suggests that some management efforts should be directed towards reducing entrainment.

Additional entrainment surveys have and are being conducted on both the Moses Lake Irrigation District Outlet as well as the larger USBOR outlet. We also anticipate trapping larval fish during the spring 2006 to better estimate walleye production in Moses Lake. The Banks Lake Fishery Evaluation (200102800).

***6. During various times of the year avian predators utilize Moses Lake.**

Waterfowl counts have enumerated over 2,000 common mergansers on Moses Lake on a given day during the winter and over 200 cormorants utilizing Moses Lake during the spring and summer months. Anecdotal we have counted over 1,000 cormorants actively feeding on Moses Lake during the spring months.

7. Angler exploitation (<2%) of walleye on Moses Lake is low;

The walleye anglers exhibit a 'catch and release' mentality on Moses Lake. Subsequent harvest is low and preliminary Fisheries Assessment Simmulation Tools (FAST) modeling suggests exploitation could be increased 500% with a negligible impact to the fishery (Burgess et al 2006).

8. A bottleneck exists in prey survival between the winter to early spring months associated with predation and entrainment;

Data from beach seining suggest winter mortality is high (table 1). This assumption is corroborated with our bioenergetics modeling results and entrainment results.

The Remaining Uncertainties

1. How do avian predators impact the Moses Lake fish community?

2. Do avian predators laterally migrate between Moses Lake and the Columbia River?

3. Do avian predators feeding on fishes in Moses Lake also actively feed within the Mainstem of the Columbia River?

4. Is the fish community within Moses Lake changing as a result of the regulation changes?

Purpose

The goal for the continuation of the Moses Lake Project is to assess the impacts of avian predators on the resident fishery within Moses Lake and the possible connectivity to other systems where native ESUs may potentially be impacted. In a collaborative effort the WDFW will take over many of the previous Work Element Titles that had been conducted by Moses Lake Project staff. Consequently, there are two components to this proposed project:

1. Avian predator investigations. (BPA funded)

- *Phase 1. Inventory and assessment of avian predators. Funding 2007-2009.*
- *Phase 2. Application of collected data and analysis. This phase will be implemented should avian predators appear to be deleteriously impacting resident and anadromous fishes. Out year funding if required.*

2. The fish community component. (WDFW sponsored)

The BPA funded Moses Lake project has provided information to WDFW to initiate necessary regulation changes within the resident fishery of Moses Lake. To further monitor this fishery and assess the fish community response to the regulation change is now the responsibility of the WDFW. The Moses Lake staff will offer assistance in the form of technical support as we have the expertise base to do so and the data will be needed to perform Objective 1 with respect to prey selectivity and electivity. However, the collection, synthesis, analysis and reporting of data will be the responsibility of the WDFW staff.

F. Proposal biological objectives, Work Element Titles and methods

Phase 1: Inventory and assessment of avian predators

<u>Objective 1. Quantify impacts of avian predators</u>

Hypothesis: Avian predators are adversely affecting survival of resident and anadromous fishes in the Mainstem Columbia River.

Work Element Title 1.1. Enumerate significant avian predators utilizing Moses Lake

Work Element Name: Collect/Generate/Validate Field and Lab Data (157)

Monthly, low level (< 500’) aerial waterfowl counts will be conducted on Moses Lake during 2006. Aerial surveys will be performed by one member of the Moses Lake project as well as an experienced WDFW waterfowl biologist to accurately count the total number of birds occupying Moses Lake. WDFW personnel will conduct counts for the months of October through the end of January and as part of this research project we shall make counts for the remaining 8 months. Knowing the total number species of avian predators that may inhabit Moses Lake at a given time will allow us to estimate the total potential consumption rates of such predators (Work Element Title 1.2).

Work Element Title 1.2 Quantify stomach contents and consumption rates of avian predators

Work Element Name: Collect/Generate/Validate Field and Lab Data (157)

We currently have a permit to collect 30 double crested cormorants (Permit # MB105866-0) for stomach content and stable isotope analysis (SIA Work Element Title 1.3). Common mergansers are not included within the permit but can be collected at a rate of seven per day using conventional hunting methods and licenses. Live birds will also be sampled using a Coda Enterprises Net Gun to increase sample sizes and reduce the possibility of negative public sentiment towards the WDFW and the project. Upon bird collection, pertinent biological data such as harvest data, location, species, sex, body weight and wing length will be recorded. Stomach and esophagus contents will then be emptied into a whirl pack and preserved similar to the methods in Roby and Craig (1998. Samples will be identified to species for fish using Whydoski and Whitney (2003) and remaining items will either be classified as invertebrate, amphibian or other. Fish parts will be identified using established bone keys (Hansel et al. 1988). These data will provide the proportion of fish consumed by avian predators on Moses Lake.

Similar to Hunt et al. (2003) we will also determine the energy demand and consumption rates (grams) of the avian predators utilizing Moses Lake. To calculate the energy demand of avian predators utilizing Moses Lake will we use the equation taken from Brit-Friesen et al (1989):

$$\text{Log } Y = 3.24 + 0.727 \log M$$

Where M is the mass in kg of the species in question and Y is the estimated daily energy requirement in kJ. The Canadian Council of Ministers of the Environment has developed daily food ingestion rates of avian species relative to body weights (CCME 1998). Using the monthly enumerations of avian predators (Work Element Title 1.1) and the mean species body mass (kg) associated with the estimated daily food ingestion rates, we will estimate their monthly consumption rates. For example it is stated that a female common merganser has a daily food consumption equaling 27% its body weight a day. If the average weight of a female merganser is 1.232 kg , its daily food consumption is 0.332 kg/day. The cumulative monthly impact will be calculated for each species and sex using the following equation.

$$Mc = Dc * d * N$$

Where Mc is the estimated monthly cumulative consumption (kg), Dc is the calculated daily consumption (kg), d is the number of days within a given month and N is the number of individuals per sex and species. We will also calculate the season consumption of avian predators by using the mean number of predators for the three months and total number of days per season and compare to the cumulative monthly estimates.

Using the total kg of food consumed a month and the proportion of prey items we will be able to estimate the total consumption of specific food items for the avian predators utilizing Moses Lake. The total number of prey items taken will be calculated using weight / length relationships from previously collected resident fish data from Moses Lake and statewide WDFW data for anadromous fishes.

Work Element Title 1.3. Conduct stable isotope analysis of avian predators
Work Element Name: Analyze/Interpret Data (162)

Using traditional methods and a collection permit, common mergansers and cormorants will be collected (Work Element Title 1.1). Tissue samples will be collected and immediately placed on ice. Sample preparation may be conducted by a consulting laboratory (e.g. UC-Davis, Univ. of Idaho) or conducted internally. Processing entails drying the sample for 12 hours in a 65 °C oven, and grinding it to a flour consistency with a mortar and pestle. Approximately 1 mg of the dried sample will be packaged in a tin cup and analyzed for ^{13}C and ^{15}N signatures. Analyses are made using a mass spectrometer with a CE Instrument's NC 2500 elemental analyzer. Output from the mass spectrometer is δ values, per mil (‰) deviations from standards (atmospheric nitrogen or Pee Dee Belemnite carbon), where:

$$\delta^{15}N \text{ or } \delta^{13}C = [(R_{SAMPLE} - R_{STANDARD})/R_{STANDARD}] \times 1000$$

R_{SAMPLE} = the isotopic ratio of the sample and,
$R_{STANDARD}$ = the isotopic ratio of the standard.

SIA output will allow us to determine the signature of the avian predators and compare those signatures to the established Moses Lake and Banks Lake, and Mid-Columbia food web (proposed Mid-Columbia Trophic Dyamics Project #200703600). Signature will also permit us to determine the origin of the prey items and the trophic ranking of the avian predators on Moses Lake. To differentiate among fish we will use stable isotope signatures from previously collected Moses fish and signatures of Columbia River fishes collected during the proposed Mid-Columbia Trophic Dynamics Project (200703600).

Work Element Title 1.4. Use satellite telemetry to track avian predators
Work Element Name: Collect/Generate/Validate Field and Lab Data (157)

There are several problems associated with telemetry studies. One of the problems with conventional radio and sonic telemetry is locating the specimen of concern as we discovered during our previous works tracking carp (Burgess et al. 2003). Furthermore, cost, time and often safety issues associated with tracking personnel under unfavorable field conditions. We feel we can increase our efficiency and more importantly our accuracy using satellite technology. Habit Research has developed a satellite transmitter, the 503 PTT Certified Argos transmitters that can send a location signal directly to a computer site (Habit Research Web Site www.habitresearch.com). Using this technology, which has been tested on water fowl (Green et al 2002) we will track 10 double crested cormorants and 10 common mergansers. Birds will be captured by net from a blind, a moving boat or at points of interception where they regularly fly. It will be important to minimize the stress and the future survival of the tagged animals. Consequently, we will utilize skilled WDFW waterfowl biologist when handling live birds.

Telemetry data will be used to locate daily and seasonal congregations of birds, possible colonies and determine if there is a link between birds utilizing Moses Lake and the Columbia River. These data will be entered into a GIS package to provide a spatial reference of avian predators movements.

Work Element Title 1.5. Compare stable isotope data (predicted) to the stomach contents of avian predators.

Work Element Name: Analyze/Interpret Data (162)

Diet partitioning will be estimated using the linear mass balancing mixing model ISOCONC 1.01 supplied by Philips and Koch (2002). Methods similar to those in Clarke et al. (2005) will require us to determine the top three prey items of each of the predators and calculate their mixture carbon and nitrogen signatures. These data will allow us to compare the validity of diet analysis to the predicted stable isotope levels.

The ISOCONC model is designed to account for three food sources. Although avian predators on the Columbia have been shown to be very specialized with respect to prey selection (Roby et al 1998), this may not be the case with the diets of birds utilizing Moses Lake due to the variability in potential prey items. If this appears to be a problem we will pool prey items if statistical analysis does not indicate a significant difference in isotopic signature (Clarke et al 2005).

Objective 2. Reporting and Administration

Work Element Title 2.1. Pices reporting

Work Element Name: Produce Status Report (141)

Complete and enter status reports into BPA's data base Pisces, regarding project schedules and contractual obligations being met.

Work Element Title 2.2. Quarterly reporting

Work Element Name: Produce Status Report (141)

Quarterly reporting to BPA regarding the status of the project. These reports will also include data and analysis when applicable.

Work Element Title 2.3. Annual Reports

Work Element Name: Produce Annual Report (132)

Annual reports will be completed every year at the end of the contract period to present results and inform BPA of project status. Annual reports will also present data, analysis and recommendations should they be required. This will also be the appropriate time to request budget modifications or changes within the work plan.

Work Element Title 2.4. Stakeholder presentations

Work Element Name: Outreach and Education (99)

As a state agency receiving federal monies it is our obligation to not only inform WDFW and BPA of our results but also the many concerned stakeholders that have personal and professional interests in our project. Consequently, some time will be spent presenting our information in public forums. These presentations will include the data and results contained within our annual reports.

Work Element Title 2.5. Additional administrative duties.

Work Element Name: Manage and Administer Projects (119)

This task will include the day-to-day operations associated with project personnel, agency policy, purchases, additional inter- and intra-agency exercises and budget monitoring.

Work Element Title 2.6. Obtain necessary sampling and collection permits.

Work Element Name: Environmental Compliance/Produce Environmental Compliance Documentation (165)

We currently have a migratory bird permit to collect 30 double crested cormorants. We will renew this permit and apply for additional permits to conduct the sampling we have proposed.

Objective 3. Monitor Resident Fishery within Moses Lake

Note: Work Element Titles 3.1, 3.2, 3.3 will be paid for and conducted by the WDFW's Region 2 Warmwater Team. We will use their data to monitor changes in the fishery and the abundance of prey items relative to the selectivity of prey items by avian predators. Methodologies are outlined within the appendices.

Work Element Title 3.1. Fall sampling (WDFW sponsored)
Work Element Title 3.2. Creel Survey (WDFW sponsored)
Work Element Title 3.3. Perform standardized indices analysis including aging (WDFW sponsored)
Work Element Title 3.4. Model rates of predation

Phase 2. Application of collected data and analysis. This phase will be implemented should avian predators appear to be deleteriously impacting resident and anadromous fishes.

Objective 4. Management implementation and monitoring and evaluation

Hypothesis: Impacts of avian predators on resident and anadromous fishes can be reduced.

Work Element Title 4.1 Conduct feasibility study and implement avian predator exclusion zones.

If double crested cormorants are in fact negatively impacting the anadromous and resident fish community lethal measures cannot be employed. Although depredation permits are often granted to Midwestern and Southern States, the state of Washington has no such provision. However, measures can be taken to haze and possibly reduce the fitness of cormorants. In areas of foraging propane cannons similar to those used in orchards could be deployed to reduce areas for prey consumption, creating more intraspecific competition and possibly decreasing population size. Such implementation could be used not only on Moses Lake but throughout the Columbia Basin where substantial numbers exist.

Work Element Title 4.2 Promote the harvest of common mergansers
Work Element Name:

Common mergansers can be harvested during the waterfowl hunting season within Washington State. However, they are not a sought after species but some sportsmen often shoot mergansers as they are considered a nuisance species. Should we find that common mergansers appear to be negatively impacting the resident fishery of Moses Lake and potentially the Columbia River we could promote the harvest of common mergansers in areas of concern.

Work Element Title 4.3 Continue to enumerate significant avian predators utilizing Moses Lake. Identical protocol to phase 1, objective 1, Work Element Title 1.
Work Element Name:

To determine if exclusion and removal programs are working waterfowl counts will be conducted on a monthly basis on Moses Lake and throughout the Basin (during the months of October – January). The WDFW will be responsible for the months of October through the end of January and we will be responsible for the remaining 8 months. Low level (< 500') aerial surveys will be performed by one member of the Moses Lake project as well as an experienced WDFW waterfowl biologist to accurately count the total number of birds occupying Moses Lake. Knowing the total number species of avian predators that may inhabit Moses Lake at a given time will allow us to estimate the total potential consumption rates of such predators (Work Element Title 1.2).

Work Element Title 4.4 Expand efforts of tracking and locating areas of importance for avian predators within the Columbia Basin.
Work Element Name:

An expansion in efforts will only be necessary if data from objectives 1 and 2 warrant it. For example if the satellite telemetry and stable isotope analysis indicate negative interactions are occurring outside the study area.

G. Facilities and equipment

We currently have much of the equipment and facilities to perform the Work Element Titles within the proposed project. Including an 18' electrofishing boat and a gas pickup truck. However, due to the inhospitable conditions that can occur on the Columbia River as well as the size of the sample area we will also need to purchase an additional 22' electrofishing boat to be used concurrently with the smaller 18' electrofishing boat. To tow the additional boat and transport personnel we will also require a crew cab pickup truck, preferably diesel. We have also picked up a 22' Boston Whaler off of state surplus to be used as a general work boat as well as a pelagic netting boat that will need two 150 HP outboard motors. We currently have a field office in Ellensburg where we store gear and boats and in the past we have had an agreement with Central Washington University to use lab space and facilities.

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I. Key personnel

WDFW Large Lakes Research Team (LLRT)

Dave Burgess (writing team)
Matt Polacek (writing team)
Katrina Simmons (writing team)

Associated Staff

Dr. David Bennett- Professor Emeritus, University of Idaho. Project Consultant.
Dr. Steve Schroder- WDFW Research Scientist. Project Advisor

Dave S. Burgess

1621 Brook Lane
Ellensburg Washington 98926

Education

Central Washington University, 2002 M.S. Biology
Central Washington University, 1991-1995, B.S. Biology
Wenatchee Valley Community College, 1989-1991, A.A.S. Management

Employment History

August 2002-Present
WDFW Moses Lake Project (199502800) Lead Biologist III.
Responsibilities (including below): Project management and day-to-day operations. Interactions with multiple state and federal agencies. Writing and completing past reports writing proposals. Managing contracts, protocol design and analysis including Fisheries Assessment and Simulation Tools, Bioenergetics Modeling, Stable Isotope Analysis and modeling. Obtain federal permits for migratory bird collections.

Oct 1999-August 2002
Washington Department of Fish and Wildlife, Moses Lake Fisheries Restoration Project, Biologist I.
Responsibilities: Analysis of historical biological data. Collection of warmwater fishes using boat and electrofishing techniques. Identification of warmwater fish and record pertinent biological information such as length and weight. Collect and age determination of scales. Analysis of data using a variety statistical methods. Design draft protocol for sampling zooplankton, diets of Moses Lake fishes, creel survey, and population estimation. Pursued and developed contract with Washington Department of Ecology to monitor water quality on Moses Lake.

1. June 1999 to October 1999
DB Environmental Consultants, Sub-contractor for Cascade Aquatics contracting for Washington Department of Fish and Wildlife.
2. June 1998 to September 1998
Washington Department of Fish and Wildlife, Scientific Technician II
3. June 1997- June 1998
Bureau of Reclamation/Central Washington University Coop. Research Assistant.
4. May 1997 to October 1997
Washington Department of Fish and Wildlife, Scientific technician II.
5. May 1995 to October 1995
Washington Department of Fish and Wildlife, Scientific technician I

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