ABUNDANCE AND DIET OF SMALLMOUTH BASS AT THE DALLES, JOHN DAY AND MCNARY DAMS, MAY THROUGH AUGUST 2012.

ANNUAL PROGRESS REPORT

MAY 2012 – AUGUST 2012

Prepared By:

Eric Tinus, Leif E. Rinearson
Erick S. Van Dyke and Christine Mallette

Oregon Department of Fish and Wildlife
Ocean Salmon and Columbia River Program

Clackamas, OR, USA

Prepared For:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife

Portland, Oregon, USA

Project Number 2008-718-00
Contract Number 53099

September 2013

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Here we report on the results from year two of an investigation examining predation by smallmouth bass *Micropterus dolomieu* on out-migrating juvenile salmon and steelhead in the access-restricted portions of the forebays and tailraces of The Dalles, John Day, and McNary dams. In 2011, Oregon Department of Fish and Wildlife (ODFW) sampled smallmouth bass by angling with hook and line from the three dams (McHugh et al. 2012); the same strategy was applied in 2012.

Background

Much effort has been devoted to understanding and managing predation by fish and birds on threatened and endangered juvenile salmon and steelhead *Oncorhynchus* spp. in the Columbia River Basin in recent decades. Northern pikeminnow *Ptychocheilus oregonensis* have been the focus of a long-term removal fishery (Beamesderfer et al. 1996) due to their ability to consume a substantial fraction of the out-migrant juvenile salmon population in the mainstem Columbia River (e.g., John Day Pool, Rieman et al. 1991). Similarly, management actions have been taken to reduce avian predation, including active hazing and the installation of structural deterrents at dams, and the translocation - to presumed lower impact areas - of entire bird colonies in the Columbia River estuary (Roby et al. 2002).

Although studies have documented smallmouth bass predation on juvenile salmon in the mainstem Columbia River (Rieman et al. 1991; Ward and Zimmerman 1999; Zimmerman 1999), their potential impact on salmon and steelhead abundance and productivity was not viewed as significant relative to predation by northern pikeminnow. However, concern over potential impacts has been highlighted recently (Halton 2008, Sanderson et al. 2009, Carey et al. 2011) due to a number of factors. While predation by smallmouth bass in Columbia River tributaries has not been identified as a conservation issue for protection and recovery of salmon and steelhead in the Willamette and John Day rivers (T. Shrader, ODFW, personal communication), some studies indicate that local impacts of smallmouth bass predation in the Yakima River can be severe (Fritts and Pearsons, 2004 and 2006). Additionally, recognition continues to grow that the distribution and effects of smallmouth bass, as well as other aquatic organisms, in Pacific Northwest river systems likely vary with a changing climate (Carey et al. 2011). Recent anecdotal accounts of large aggregations of smallmouth bass in areas immediately adjacent John Day Dam (B. Cordie and J. Randall, USACE, personal communication) suggest the predators could have greater impacts at some locations in the Columbia River than thought previously. These observations, combined with the recent call for non-native predator management actions in NMFS's 2008 Biological Opinion on the Operation of the Federal Columbia River Power System, substantiate the need for a more rigorous assessment of current smallmouth bass predation in the Columbia River.

The goal of this research was to characterize population demographics and quantify feeding by smallmouth bass within the immediate vicinity of The Dalles, John Day and McNary dams during the main period of juvenile salmon and steelhead outmigration (May-August) to identify potential 'hotspots' of smallmouth bass predation. For the purposes of this investigation, hotspots are defined as areas where smallmouth bass impose a level of predatory impact (a function of prey consumption and predator abundance) greater than has typically been observed in previous mainstem predation studies (e.g., Zimmerman 1999). Specific study objectives were to: (1) describe and compare relative densities of smallmouth bass in and between forebay sites perceived to be 'hot spots' and other nearby tailrace sites at the three dams, using hook-and-line sampling as the primary means for fish capture and (2) characterize the diet of these smallmouth bass, with a specific emphasis on quantifying predation on juvenile salmon.

METHODS

Study Area

We conducted hook-and-line sampling at The Dalles (TDA), John Day (JDA), and McNary dams (MCN). Sampling was carried-out at both the forebay (i.e., upstream) and tailrace (i.e., downstream) sides of each dam in areas inaccessible to the public. Specific locations were selected based on a number of considerations, including past observations made by U.S. Army Corps of Engineers (USACE) and Northern Pikeminnow Management Program (NPMP) staff, accessibility, safety, and putative habitat suitability. Surveyed sites at or near each of the three dams were limited to those areas that, while restricted to public access, were deemed safe to be accessed by the sampling anglers, as per USACE issued permit. These sites are collectively defined here as "angling accessible" zones surrounding each dam and included forebay powerhouse decks to ensure that areas where smallmouth bass were observed foraging during previous summers were included in sampling activities. By focusing angling effort on shore or dam areas, we were effectively able to sample different habitat types at the dams, including rip rap shores, bedrock shoals, vertical concrete structures (e.g., forebay walls), spillway footings, floating structures (e.g., docks and debris rafts), vegetated flats, gravel pits, and various combinations thereof. Many of these habitats have unique water velocities, flow rates and orientation to juvenile and adult fish passage routes. Sampled areas ranged from two to up to 20 m (forebay powerhouse walls) in depth. Given its unique structure and configuration, The Dalles Dam has greater diversity of angling-accessible habitats, whereas John Day and McNary dam sites – both structured similarly – represent lower accessible habitat diversity. Figures 1-3 show areas sampled during 2012 at The Dalles, John Day and McNary dams.

Field Sampling

The 2012 field sampling crew consisted typically of a team of three experienced bass anglers and a project biologist. The primary responsibilities of the project biologist were to lead the team, randomly select the sample sites for each daily session, process fish, and record data. To maximize angling effort, the biologist fished when time allowed and up to two other experienced samplers joined the team to bolster effort intermittently throughout the season. Sampling occurred Monday–Thursday, beginning May 7 and ending August 30, 2012. On average, angling began at 06:00 (Range; 05:30–07:30) and ended 14:00 (Range; 10:45–15:30). The total duration that each angler actively fished was composed of three two-hour periods each sampling day (Range 1–4 periods and 1.0–2.0 hours). Alterations to this general approach occurred due to unforeseen circumstances, differing site distances from the duty station or time-related access restrictions.

Prior to the beginning of the season, sampling dates were assigned at random to each of the three dams (electronic number generator) such that effort was allocated in a balanced manner (e.g., two sides of a dam for one day and one dam for two consecutive days) over 17 four-day temporal sample strata. Each day was treated as a unique event. Upon arriving at a site, the order in which the two sides were to be sampled was also randomized (coin toss) to ensure both forebay and tailrace were sampled during each event and to minimize the introduction of temporal bias. On each sample day, a random number generator was used to determine the sequence in which specific areas were sampled and which angler(s) were to sample them. Occasionally, not all sample sites could be included in the random draw because of access constraints due to maintenance activities, high winds, or prior commitments by Washington Department of Fish and Wildlife (WDFW) to angle for and remove northern pikeminnow at a sample site as part of the NPMP.

Sampling gear and techniques

The angling crew used a selection of lightweight spinning rods equipped with spinning reels and either 13.6-kg test Power Pro™ braided line or 4.5-6.3-kg test monofilament (Maxima™ or Berkley™). Heavy-duty casting rods equipped with level-wind casting reels and braided line (13.6-kg test) were also used, particularly while fishing in extremely deep and/or turbulent water. Terminal tackle selection included soft-plastic baits (tubes, grubs, worms, lizards, crayfish, and swim baits) in a variety of sizes and colors, crank baits (Rattle Trap™, Bill Dance Fat-Free Shad™, Bomber™, Storm Wiggle Wart™, etc.) and spinner/buzz baits (Appendix A). Soft plastics were fished in a variety of different ways, incorporating jig heads, worm hooks, bait hooks, and sliding egg weights. Jig heads weighed 4-11 g and hooks were typically 2/0 size; however, smaller and larger hooks occasionally were used to accommodate soft plastics of differing size.

Depending on conditions, tackle was fished by back bouncing, vertical jigging, drift/swing, cast/retrieve, and still fishing (on the bottom or under a bobber). Back bouncing was used commonly to angle from the tailrace powerhouse decks. Still fishing and vertical jigging techniques were used on elevated surfaces. Casting and retrieving approaches were used in areas close to water level, whereas drift methods were used in areas with faster moving water. To maintain consistency, anglers were supplied with a standard gear selection and were required to communicate throughout the day, relaying information about the efficacy of various tackle and fishing techniques. In general, lure selection was made based on angling location, conditions, and recent success.

Biological sampling

Species, time, location, tackle used, and angler details were recorded for all landed fish. To facilitate further data collection, smallmouth bass were placed immediately in a bucket, and transported to a centrally located live well filled with aerated water at ambient temperature. Subsequently, all captured smallmouth bass were: (*i*) scanned for the presence of a passive integrated transponder (PIT) tag, (*ii*) measured (fork length, nearest mm) and weighed (nearest 5 g), and (*iii*) for first-time captures, implanted with a PIT tag (injected into abdominal cavity) and given a secondary fin clip (anal fin) to assess PIT-tag retention. Smallmouth bass with a secondary mark and no PIT tag detection were given a new PIT tag. Lastly, diet samples were taken from individual smallmouth bass using non-lethal means. To this end, a modified Seaburg sampler (Seaburg 1957) was used to flush contents from the foregut into a sieve. From the sieve, individual diet samples were rinsed into sample bags, placed on ice in the field and frozen thereafter until later laboratory analysis. Following this process, all fish were allowed sufficient time for recovery after which they were released back into the area of original capture.

Laboratory Sample Processing

Smallmouth bass diet samples were processed using the methods developed for the biological evaluation of the NPMP (e.g., Porter 2012). In the laboratory, items in thawed diet samples were sorted into coarse prey categories (fish, crayfish, other invertebrates, and miscellaneous items such as unidentified organic matter, fishing lures, rocks, etc.) in trays and weighed (wet weight, nearest 0.01 g) according to prey type. Diet samples containing fish were then subjected to a soft-tissue digestion procedure to isolate diagnostic bones, allowing for finer taxonomic identification. Chemical digestion consisted of a two-stage process: first, the samples were immersed in a pancreatin (2% wet weight), sodium sulfide nonahydrate (1% wet weight), and tap water solution and held at 48°C for 24 h. A sodium hydroxide (3% wet weight) solution was then added to each sample to dissolve remaining fats. Remaining bones were rinsed in a sieve (425 µm), transferred to a Petri dish, and examined under a dissecting microscope for identification. We used a combination of bone keys (Hansel et al. 1988, Frost 2000, and Parrish et al. 2006) to identify prey fish to the lowest practical taxonomic level (typically genus). We determined the minimum number of juvenile salmon and steelhead in stomach content samples by counting the paired bones diagnostic of the taxon (e.g., left and right salmon or steelhead dentary bones). When only salmon or steelhead vertebrae were present, we assigned a one to the minimum count of salmon prey per individual smallmouth bass.

River Environment

We compiled river environmental data that could conceivably affect the predatory behavior and population dynamics of smallmouth bass, as well as behavior and susceptibility of juvenile salmon prey during the 2012 study. Average daily water temperature (^{o}C) and river flow (discharge, $m^3 \cdot s^{-1}$) were taken from the U.S. Geological Survey (USGS) and USACE water quality monitoring stations upstream and downstream of the dams. An indicator of juvenile salmon and steelhead out-migration timing was based on the Fish Passage Center's smolt passage index (www.fpc.org) as reported for John Day and McNary dams. A passage index is not currently estimable for The Dalles Dam. For context, 2012 flow and temperature conditions were compared to historical values. We used the period extending from 1973 through 2010 for a flow baseline, as this period best approximates the modern seasonal flow regime of the Columbia River (i.e., the last major storage dam was closed in that year). For temperature, we used the measurements for USGS site 14105700 beginning with the first year available (1997) through 2010. While we collected instantaneous water temperature data at many of our sites during sampling events, measurements were periodic throughout the season, because safe access was limited (e.g., angling from concrete walls high above the water or near very turbulent water). Therefore, we used the average daily temperatures logged at the USGS and USACE water quality monitoring sites to calculate smallmouth bass' juvenile salmon consumption indices (see below).

Data Analyses

To identify any potential localized areas of intense predation by smallmouth bass on juvenile salmon (i.e., "hotspots") described by 2012 data, we repeated the same three-part analysis conducted in 2011 to characterize patterns in abundance, consumption of juvenile salmon prey, and potential predatory impact (a function of abundance and consumption) across sites (McHugh et al. 2012). First, we calculated catch per unit of effort (CPUE) during each sampling event of smallmouth bass PIT-tagged during 2012 at each dam and side of dam, as well as the average for the 2012 sampling season. We then compared annual (2012) CPUE to mark-recapture (m-r) estimates of population abundance at angler accessible areas of each dam's tailrace and forebay to assess the ability of CPUE estimates to reflect population-level variability among dams and the sides of each dam. We calculated an index of juvenile salmon consumption (*CI*) for each sample of smallmouth bass per dam and side for each m-r recapture event. To approximate potential site-specific predatory impact (*PI*) during 2012, we first converted *CI* values into daily consumption rates (*CR*) using published relationships (i.e., Ward and Zimmerman 1999). Daily *CR* values were then multiplied by the 2012 season-wide population abundance estimate and these products were summed throughout the sampling season to arrive at a potential total predatory burden at a given dam-site area. For days when no sampling occurred, *CR* values were estimated by linear interpolation. Because size of individual predators affects rates of prey consumption (Zimmerman 1999), we also characterized the distribution of sizes (fork length in mm) of the dam- and side-specific populations. Lastly, a series of linear models– considering main (dam and side) and interaction (dam-side) effects were fit to the data to test for spatial difference in CPUE, *CI* and mean fork length.

Abundance metrics

To index relative abundance, CPUE (bass·angler h^{-1}) was calculated as

$$CPUE_{ij} = \frac{\sum landed\ bass_{ij}}{\sum angler\ hours_{ij}},$$

where CPUE was evaluated at each area (i) by sampling period (j) stratum. To evaluate temporal trends, CPUE was calculated for periods coinciding with the m-r intervals (see below). Further, to evaluate spatial trends in relative abundance, CPUE was also recalculated as the overall catch for the season divided by the sum of angler hours for the entire season at each dam-side combination.

Because CPUE can reflect factors other than population abundance (e.g., gear efficiency) and to allow for an approximation of predatory impact, we estimated population abundance ($\widehat{N}$) of smallmouth bass in the angler-accessible areas of each dam-side combination in 2012. We used a Schnabel population estimator (Schnabel 1938), adjusted by Chapman (1952, 1954), based on the number of PIT-tags applied and recaptured in 2012. The Schnabel estimate was calculated as

$$\widehat{N} = \frac{\sum_{t=1}^{n}(C_t M_t)}{\left(\sum_{t=1}^{n-1} R_t\right)+1},$$

where n = the number of sampling periods, M_t = total number of marked fish at the start of the t^{th} sampling period (t = 1,..., n), C_t = total samples taken in period t, R_t = number of recaptures in the sample C_t, and R = total recaptures during the experiment (sum of R_t; Ricker 1975). The total number of marked fish at the start of a given period was adjusted to account for removals (i.e., mortalities during sampling. The m-r intervals for 2012 at each dam-side are defined as sampling efforts at a dam separated by periods of sampling at a different dam (consequently, sampling at the end of a workweek and again at the beginning of the next workweek at the same dam is treated as a single recapture event). Confidence intervals (± 95% confidence limits [C.L.]) were calculated based on the distribution of a Poisson random variable (i.e., R_t) as

$$lower\ C.L. = \frac{\sum C_t M_t}{Poisson(\lambda)_{lower}} \text{ and } upper\ C.L. = \frac{\sum C_t M_t}{Poisson(\lambda)_{upper}},$$

where $Poisson(\lambda)_{lower}$ and $Poisson(\lambda)_{upper}$ are the lower and upper confidence limits for $\sum R_t$ distributed in a Poisson frequency distribution, respectively. Confidence limits for $R_t < 26$ were taken from Appendix II in Ricker (1975). Otherwise, limits were calculated as $Poisson(\lambda)_{lower} = R_t + 1.92 - 1.96\sqrt{(R_t + 1)}$ and $Poisson(\lambda)_{upper} = R_t + 1.92 + 1.96\sqrt{(R_t + 1)}$. In estimating absolute abundance, it is important to acknowledge the limitations of this approach relative to our data. Given our sampling gear, our realm of inference extends only to the 'population' within the hook-and-line accessible region surrounding each forebay or tailrace study site; one or more assumptions required for unbiased estimation of abundance using the Schnabel estimator (i.e., population closure, perfect mark retention and identification, equal capture probability, no effect of handling on recapture probability) is likely violated to a minor but unknown extent.

Diet evaluation

We characterized the diet patterns of smallmouth bass based on three metrics. First, we estimated the composition of diets based on the percent wet mass of coarse prey categories as a proxy for the importance of fish (all species) to the energy budget of smallmouth bass. We then estimated the frequency of occurrence (i.e., number of guts with prey$_i$ / total sample size), with a particular emphasis on salmonids. To quantify predation on salmonids, we applied a model developed by Ward and Zimmerman (1999) to calculate a daily consumption index (CI) for each dam-site combination. We calculated CI for all sampling episodes where n smallmouth bass > 5 as

$$CI = 0.0407 \cdot e^{0.15T} \cdot W^{0.23} \cdot (S \cdot GW^{-0.29}),$$

where T is mean water temperature (^{o}C) for the period and location (forebay or tailrace, at each dam), W is mean predator weight (g), S is the mean number of salmonids per predator, GW is the mean gut weight (g) per predator, and constants are smallmouth bass-specific allometric parameters (Ward and Zimmerman 1999). Consumption rates (salmonids·d^{-1}) were then approximated based on the empirical relation between *CI* and *CR* (Ward and Zimmerman 1999) for *CI* > 0 as follows:

$$CR = -0.003 + 1.969 \cdot CI.$$

When *CI* = 0, *CR* was assigned a value of zero. We estimated all 2012 diet-related parameters according to m-r intervals.

Predatory impact assessment

We repeated the approach of McHugh et al. (2012) to assess potential predatory impact on juvenile salmonids. The impact of these predators on juvenile salmon could vary from site to site depending on the numbers of predators present and the rates of consumption on juvenile salmon. For example, a high number of predators at one site consuming few juvenile salmon prey may have a smaller impact than a lower number of predators consuming many prey. To understand the significance of documented predation in the context of salmon conservation, McHugh et al. (2012) developed a means to address the question "how many juvenile salmon might smallmouth bass have eaten during the annual juvenile salmon and steelhead outmigration?" We applied a similar method to 2012 data, integrating estimated rates of juvenile salmon consumption and abundance of smallmouth bass predators at the three dams' forebays and tailraces. Total consumption of juvenile salmon in the tailrace and forebay of each dam was approximated as the product of smallmouth bass abundance (season-wide estimate of population size) and the daily per capita consumption rates (*CR*, juvenile salmon·d^{-1}) for each area *i*, summed over the *j* days in the study period as follows:

$$Total\ consumption_i = \sum_{i=1}^{1} \sum_{j=1}^{n} N_i CR_j.$$

Given uncertainty in abundance estimates, the potential season total consumption was estimated at the point estimate of abundance, as well as the upper and lower 95% confidence bounds, for each dam-side combination. Further, estimated total consumption is reported in coarse measures (i.e., 1,000s of fish consumed).

Statistical analyses

To test for spatial differences in CPUE, *CI* and average fork length (FL) across dams (TDA, JDA, MCN) and sides of dams (forebay, tailrace), we fit a series of linear models to data considering main (dam and side) and interaction (dam-side) effects. Statistical analyses were conducted in the R programing environment. All tests were considered significant at $\alpha = 0.05$.

Catch-per-unit-effort

We adopted a stepwise approach to test for spatial differences in catch-per-unit-effort while accounting for the serial nature of our data collection. First, an ordinary least-squares (OLS) model was fit to the data. Given our data effectively represent a time-series for each dam-side location, we then examined autocorrelation functions (ACF) and partial autocorrelation functions (PACF) of residuals from the OLS model to assess the presence of temporal autocorrelation and help elucidate the potential structure of error processes. We used the 'auto.arima' function in the R package 'forecast' with the external regressors dam and side to help further characterize error structure. Based on information obtained from the AFCs, PAFCs and 'auto.arima' selection function, we then specified a series of candidate auto-regressive and auto-regressive moving average models. Candidate models were applied to the data using the 'arima' function in the R package 'stat', again including the external regressors dam and side. A final correlation structure was selected by comparing Akaike information criterion (AIC) values among candidate models. Time-series diagnostics were then conducted for the selected correlation structure using 'tsdiag' in the R package 'stats' to ensure the efficacy of the final model in dealing with autocorrelation. To assess spatial differences in CPUE, we applied a generalized least-squares (GLS; 'gls' in package 'nlme') model to the combined dataset where correlation in residual error was modeled using an auto-regressive moving average function (ARMA; order, p = 1, q=2) selected during the process described previously. Output from the initial GLS analysis revealed no significant interaction; thus a second, additive, GLS model was fit to assess the significance of main effects. Finally, we conducted *post hoc* pairwise comparisons using least-squares means ('lsmeans' in the R package 'lsmeans') with a Tukey adjustment.

Consumption index

The same step-wise process used to select a correlation structure for CPUE time-series' was applied to *CI* data. However, for the *CI* response variable, the final model represented an ARMA process with a second order auto-regressive component (p=1) and a fourth-order moving average component (q=4). As for CPUE, *CI* values did not vary significantly among different combinations of dam and side (i.e., interaction), and therefore an additive GLS model was fit to evaluate the significance of main effects. Lastly, pairwise comparisons were conducted to assess difference among levels of the main effects.

Fork length

To evaluate difference in fork length among levels of main and interaction effects, initially, we fit an OLS model to untransformed data. Model assumptions were assessed using the 'lm.ModelAssumptions' function in the R package 'lmSupport'. Because these diagnostics indicated slightly heteroscedastic and non-normal errors, a second OLS model was fit after log-transforming the response variable. A reassessment of model assumptions indicated transformation effectively stabilized the variance and helped normalize residuals; thus, multiple pair-wise comparisons were conducted using the 'TukeyHSD' function of the R package 'stats'.

RESULTS

Environmental Conditions and Passage Timing

Angling at the dams began on 7 May and concluded on 30 August 2012. Like 2011, extreme river conditions were encountered at all dams during portions of this sampling season. River flow was above average throughout the sampling season with the exception of a few days beginning in June (Figure 4). These high flows translated into elevated spill levels, averaging 216 and 120 kcfs in June and July, and associated turbulence in the tailrace-sampling

environment. Spill levels during 2012 exceeded dams' hydraulic capacity less frequently than in 2011. As was observed in 2011, water temperatures during 2012 were generally outside of the range observed in recent years (1997 onward), with daily average temperatures often remaining *ca.* 2 ºC below average until the sampling season was nearly finished (Figure 4).
Based on available smolt passage data, our sampling spanned most of the sub-yearling Chinook outmigration at McNary and John Day dams (Figure 4). Our sampling began after 50% of the yearling Chinook and juvenile steelhead had out-migrated. Although passage index data are not available, we assume that the juvenile outmigration window was similarly captured at The Dalles Dam, given its proximity to the upstream smolt monitoring site (*ca*. 40 km downstream).

Effort and Catch

Angling effort

We fished for an average of 13.3 angler hours (lines in water) at each side of each dam per sample day, totaling 1,253 hours across sites for the season (Table 1). We fished for 413, 423, and 418 hours at The Dalles, John Day, and McNary dams, respectively. While somewhat variable, effort was generally distributed evenly across the sample season (Figure 5). We averaged 48 hours of effort per month at the forebay sides and 56 hours at the tailraces.

Catch patterns

In total, the dam angling team landed 1,380 smallmouth bass over the course of the season. Over half of these were captured at John Day Dam, and the remaining (44% of total) was divided approximately evenly between The Dalles and McNary dams (Table 2). On an aggregate basis, 277 (20%) of the landed smallmouth bass were caught previously (i.e., tagged recaptures) during either 2011 or 2012. Observed hooking-related mortality (3.0%) and PIT tag loss (inferred from secondary marks, 3.6%) were relatively low. Hook-and-line encounters of non-target fish were also modest, totaling 112 individual fish for the season. Non-target encounters consisted primarily of a mix of walleye *Sander vitreum* (37), northern pikeminnow (29), and common carp *Cyprinus carpio* (16; Table 3). No mortality of non-target catch was observed and walleye were captured only at McNary Dam.

Smallmouth bass catches varied through time and across the three dams (Figure 5). The lowest monthly catches occurred during May in the forebays of all three dams, and in the forebays of McNary Dam during June and The Dalles Dam in July. Catches generally increased in the forebays of John Day and McNary dams, and decreased in the John Day tailrace through the course of the season. Monthly catches at The Dalles Dam remained relatively constant throughout the sampling season. Our highest daily catch occurred mid-May (47 smallmouth bass) in the John Day tailrace.

Of the numerous types of gear fished, soft plastic lures were by far the most productive style of lure. Nearly identical to 2011, 89.1% of smallmouth bass landings during 2012 were captured using soft plastics. Smoke-colored tubes with copper glitter were the most effective style of soft plastic, followed by a combination of several other smoke-colored variants of tubes and grubs with other glitter combinations. The smoke-colored plastics yielded 40% of the total smallmouth bass catch during 2012. Soft plastics featuring clear, white or silver accounted for 29% of our catch, whereas soft plastics with darker dominant colors of green, black, or brown were associated with 19% of our catch. Approximately 11% of all landed smallmouth bass were caught on lures, primarily Rattle Traps^{TM}. Examples of the array of terminal gear used are presented in Appendix A.

Catch-per-unit-effort

Given the relative consistency in sampling effort across the season, smallmouth bass CPUE varied in a manner similar to the seasonal and project-to-project catch patterns described previously. CPUE for the entire season was lowest at McNary Dam (0.68 smallmouth bass per angler hour), intermediate at The Dalles Dam (0.77), and was highest at John Day Dam at a rate of 1.84 smallmouth bass per angler hour (Table 4; Figure 5). Seasonally, CPUE increased from May through August of 2012 in the forebays of John Day and McNary dams and decreased in the tailraces of The Dalles and John Day dams. In terms of a statistical test of the “hotspots” hypothesis, our analysis revealed a statistically significant effect of dam only on CPUE ($F_{2,90}$=7.7, P = 0.0008; Table 5, Figure 6); neither the ‘side of dam’ (i.e., forebay, tailrace) nor the side-dam interaction effect was statistically significant (p =0.8266 and p=0.6346, respectively). In terms of specific dam-to-dam differences, CPUE at John Day was found to be significantly higher than at both McNary and The Dalles dams (p=0.0030 and p=0.0017, respectively). McNary and The Dalles CPUE values were not significantly different (t = 0.19, df = 90, p = 0.9811). In sum, relative abundance, as indexed by anglers’ CPUE, differed between the three projects but not systematically between the forebay and tailrace environments of all three dams.

Population abundance

Based on release–recapture patterns for smallmouth bass during the sample season, we estimated the total size of populations within the angling-accessible forebay or tailrace zone at each dam (Table 6, Figure 6). Site-to-site differences in population estimates generally mirrored those observed for CPUE, with the strength of association between these two parameters estimated at R = 0.85 (Pearson’s correlation, t = 3.27, df=4, p=0.031). Population estimates for tailraces of The Dalles and McNary dams and McNary Dam forebay ranged 100-500, whereas those for the forebays of John Day and McNary dams and McNary Dam tailrace ranged from approximately 700 to 1,700. Additionally, estimates suggest a trend towards larger ‘angling-accessible’ populations in tailrace compared to forebay areas at The Dalles and John Day dams (i.e., based on confidence intervals), but no difference at McNary Dam.

Fork length analysis

We caught smallmouth bass that ranged 85-520 mm and averaged 269 mm FL over all sites and sample days. Statistical results indicate that dam ($F_{2,1371}$=73.39, p<0.0001), side-of-dam ($F_{1,1371}$=82.06, p<0.0001), and the dam*side interaction effects ($F_{2,1371}$=33.43, p<0.0001) each accounted for a significant component of overall FL variation (Table 5). The largest average FLs of smallmouth bass occurred at The Dalles forebay (327 mm), The Dalles tailrace (300 mm), and McNary tailrace (295 mm; Figure 7). The lowest average FL among the study sites occurred at the forebays of John Day and McNary dams (236 and 246 mm, respectively) and the John Day tailrace (272 mm). With the exception of average FL being greater at The Dalles tailrace than at McNary tailrace, these results are the same as observed for 2011 (McHugh et al. 2012). McHugh et al. (2012) reported the smallmouth bass size distribution focusing on those fish between 150 and 300 mm due to the putative ability of this size class to impose a disproportionate predatory impact. During 2012, the proportion of smallmouth bass catches within this size range for all study areas combined was 73%. For each dam-side sampling area, ordered from downstream to upstream on the Columbia River, proportions in this size range were: 52% and 41% (The Dalles Dam), 80% and 87% (John Day Dam), and 54% and 83% (McNary Dam). The proportion of catch in this size range was highest in the forebay of John Day Dam during both 2011 and 2012.

Diet and consumption metrics

Based on an examination of more than 1,000 samples collected throughout the season, we observed that the average smallmouth bass diet consisted approximately of a 35:65 mix of fish and invertebrate (crayfish, other crustaceans, insects, mollusks, etc.) biomass across the three dams. Proportions of fish biomass in the diet were greater at both John Day (34% forebay, 52% tailrace) and McNary dams (44% forebay, 31% tailrace) compared to The Dalles Dam (21% forebay, 25% tailrace). Diets also varied seasonally across the study sites. The contribution of fish to the diets of smallmouth bass increased between May and August from 16% to 60% at the McNary Dam forebay and decreased at the forebays of The Dalles and John Day dams and in McNary tailrace. At the tailraces of The Dalles and John Day dams, the proportion of fish in the diet was lowest during August. Within John Day forebay, the proportion of invertebrates other than crayfish increased from 10% in May to 41% in August, which is similar to the pattern observed by McHugh et al. (2012) during 2011.

In terms of presence of individual prey fish in diet samples identified through analysis of bones, fish were found in 22-44% of the smallmouth bass gut samples collected from each dam-side study site (mean = 28%; Table 7). Of the fish taxa encountered, sculpins *Cottus* spp. and juvenile salmon and steelhead occurred most frequently (10 and 11% of all diet samples, respectively). The presence of juvenile salmon prey was more than five times greater than sculpins at the forebays of John Day and McNary dams. In McNary Dam forebay, the frequency of occurrence for both sculpin and minnow species native to the Columbia River was 3.6%. In The Dalles forebay, native minnow species and exotic sunfish species occurred at the same frequency as juvenile salmon and steelhead (2.3%). Less than 1% of the observed prey fish from all gut samples combined was nonnative species (centrarchids, American shad, ictalurid catfish, and yellow perch). Of all prey fish, suckers, minnows, sticklebacks *Gasterosteus* spp., and juvenile lampreys occurred in 2.5% of all gut content samples.

Indices of salmonid consumption by smallmouth bass (*CI*), and corresponding consumption rates, varied markedly across the sample sites and the study period. Daily *CI* estimates averaged 0.20 (corresponding CR = 0.40 salmonids · day^{-1}) overall, and site-specific season-wide averages ranged from 0.04 in The Dalles forebay (CR = 0.08) to 0.40 (CR = 0.80 salmonids · day^{-1}) in the forebays of John Day and McNary dams. Our statistical evaluation of *CI* patterns demonstrated a significant effect of dam and side of dam with no significant interaction (Table 5). Seasonally, *CI*s remained consistent through early July, at which time they increased at all sites except The Dalles tailrace (Figure 8). The highest CI values occurred during the first week of August in McNary Dam forebay (1.00) and during the second week of August at John Day Dam forebay (0.89). Consumption index values at John Day tailrace were also highest during the second half of the sampling season, but began to decrease during the first part of August.

Following the routine described by McHugh et al. (2012), we estimate that approximately 214,000 (149,000-322,000) juvenile salmon (presumably mostly subyearling Chinook, given the seasonality of consumption rate patterns reported above) were consumed within forebay and tailrace areas at the three dams in total during the sample season. The vast majority of this total is attributed to the forebay and tailrace areas of John Day Dam (47% and 28%) and McNary forebay (20%; Figure 9). Consumption by smallmouth bass at The Dalles Dam accounted for about 3% of the total predatory impact, and the remainder (~8,000 fish) was attributed to predation in the tailrace of McNary Dam.

DISCUSSION

The second year of study to investigate the predatory behavior and population dynamics of smallmouth bass at the tailraces and forebays of three Columbia River dams, corroborates the conclusions of McHugh et al. (2012). We found that local predation by smallmouth bass on juvenile salmon and steelhead - coincident with a large outmigration of juvenile salmon - can be intense in some areas and during specific times of year.

Plans to replicate the investigation over multiple years provided an opportunity to observe smallmouth bass predatory impacts under different annual environmental conditions. Yet, conditions among the two years were comprable; Columbia Basin water run off conditions during 2011 and 2012 were outside of the norm (McHugh et al. 2012), with marginally cooler temperatures and higher flows during 2012. Consequently, results from the two years might help understand the predatory impacts of smallmouth bass on out-migrating salmon only under particular river conditions. The main contrast between these two years was that the period of peak flows and uncontrolled spill was more extensive in 2011 compared to 2012. For both 2011 and 2012, relative potential for predatory impacts by smallmouth bass to populations of salmon and steelhead juveniles was greatest in the forebays of McNary and John Day dams. Predation in the forebay and tailrace of The Dalles Dam was substantially lower. During 2012, the point estimates of "predatory impact" were higher in the forebays of John Day and McNary dams than during 2011, coinciding with spill volumes at the dams being lower during most of 2012 than during 2011.

Further evaluations of information collected during both 2011 and 2012 should include investigation of the patterns of mark recoveries. With two years of study and some 2,000 PIT-tagged smallmouth bass at large, more information on distribution patterns to determine how well assumptions required to estimate population abundance are met could be available through analyses of both years' data combined, a review of any PIT tag detections at the fixed-site detectors at salmon and steelhead passage facilities, and through other studies. Aggregating two years of recoveries of marked fish might result in higher precision of estimates of abundance used to approximate relative rates of potential predation impacts to salmon and steelhead populations, and presents the opportunity to employ alternative estimators. Further, anglers' site-specific collections might be used to quantify relative predatory impacts that are specific to the unique configurations of each dam. Repeating these field investigations during a Columbia Basin water year closer to average (lower than the extremes during 2011-2012) could help to understand if predatory impacts were likely to differ, particularly with warmer water temperatures.

LITERATURE CITED

Beamesderfer, R. C., D. L. Ward, and A. A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898–2908.

Carey, M.P., B.L. Sanderson, T.A. Friesen, K.A. Barnas, and J.D. Olden. 2011. Smallmouth bass in the Pacific Northwest: A threat to native species; a benefit to anglers. Reviews in Fisheries Science. 19:305-315.

Chapman, D.G. 1952. Inverse multiple and sequential sample censuses. Biometrics 8:286-306.

Chapman, D.G. 1954. The estimation of biological populations. Ann. Mathemat. Stat. 25:1-15.

Fritts, A. L., and T. N. Pearsons. 2004. Smallmouth bass predation on hatchery and wild salmonids in the Yakima River, Washington. Transactions of the American Fisheries Society 133:880-895.

Fritts, A. L. and T. N. Pearsons. 2006. Effects of predation by nonnative smallmouth bass on native salmonid prey: the role of predator and prey body size. Transactions of the American Fisheries Society. 135:853-860.

Frost, C. N. 2000. A key for identifying prey fish in the Columbia River based on diagnostic bones. U.S. Geological Survey Western fisheries Research Center, Cook WA. USA 50p.

Halton, E. 2008. Predation Workshop: review, evaluate, and develop strategies to reduce non-native piscivorous predation on juvenile salmonids. Proceedings of a workshop sponsored by the Bonneville Power Administration and the Columbia Basin Fish and Wildlife Authority, Portland, Oregon.

Hansel, H. C., S. D. Duke, P. T. Lofy, and G. A. Gray. 1988. Use of diagnostic bones to identify and estimate original lengths of prey species. Transactions of the American Fisheries Society 117:55–62.

McHugh, P.A., C. Mallette, L.E. Rinearson, E.S. Van Dyke, and M.H. Weaver. 2012. Smallmouth bass abundance and dietary habits at three mainstem Columbia River dams: Are forebay and tailrace environments 'hotspots' of salmonid predation? Annual Progress Report to Bonneville Power Administration, Portland, Oregon.

Parrish, J.K., K. Haapa-aho, W. Walker, M. Stratton, J. Walsh, H. Ziel. 2006. Small-bodied and juvenile fishes of the Mid-Columbia Region including keys to diagnostic otoliths and cranial bones. Draft Version, March 2006. University of Washington, Seattle WA. USA 137p.

Porter, R. 2012. Report of the predation index, predator control fisheries, and program evaluation for the Columbia River Basin experimental Northern Pikeminnow Management Program, 2011 Annual Report to Bonneville Power Administration, Portland, Oregon.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. No. 191, 382 p.

Rieman, B. E., R. C. Beamesderfer, S. Vigg, and T. P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448–458.

Roby, D. D., K. Collis, D. E. Lyons, D. P. Craig, J.Y. Adkins, A. M. Myers, and R. M. Suryan. 2002. Effects of colony relocation on diet and productivity of Caspian terns. The Journal of Wildlife Management 66:662-673.

Sanderson, B. L., K. A. Barnas, and A. M. Wargo Rub. 2009. Nonindigenous species of the Pacific Northwest: an overlooked risk to endangered salmon? BioScience 59:245-256.

Schnabel, Z.E. 1938. The estimation of the total fish population of a lake. Am. Mathemat. Mon. 45:348-352.

Seaburg, K. G. 1957. A stomach sampler for live fish. Progressive fish-Culturist 19:137–139.

Ward, D. L., and M. P. Zimmerman. 1999. Response of smallmouth bass to sustained removals of northern pikeminnow in the lower Columbia and Snake Rivers. Transactions of the American Fisheries Society 128:1020–1035.

Zimmerman, M. P. 1999. Food habits of smallmouth bass, walleyes, and northern pikeminnow in the lower Columbia River Basin during outmigration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:995–1007.

ACKNOWLEDGEMENTS

We thank all those (more numerous than acknowledged here) for their efforts to make the 2012 investigation a success. Anglers Kyle Bekley, Marikay Jester, Graham Kessler, and Bob Mauldin caught and helped sample the fish, often during extremes in weather and through occasional unanticipated river conditions. Emma Bell, Tim Blubaugh, Matt Gardner, Hayden Howell, Kristine Pierce, Kevin Rybacki, and Jordan Wheeler worked tirelessly in the laboratory to stage and analyze gut samples and prepare the electronic datasets for analysis. Many USACE personnel assisted to provide security clearance, to ensure safe working conditions, and to gain access to sampling sites including Paul Keller, Bob Cordie, Dietra Greene, Miro Zyndol, Carl Dugger, and Bobby Johnson. Eric Winther and Bill Fleenor (Washington Department of Fish and Wildlife) helped coordinate overlapping angling efforts of this bass study with angling for northern pikeminnow conducted through the Northern Pikeminnow Management Program. Adam Storch and Pete McHugh provided important assistance with statistical analyses, and along with Tucker Jones gave helpful comments to improve this report. We thank Karen Morrell, Ken Frisby, Lisa Chambers (all with ODFW), Russel Porter and Ashley Deits with Pacific States Marine Fisheries Commission, and John Skidmore (BPA) for administrative support.

TABLES

Table 1. Monthly and side-specific angling effort totals at The Dalles, John Day, and McNary dams during 2012.

Dam	Side	Total fishing effort (angler hours)				
		May	June	July	August	Total
The Dalles	Tailrace	56	52	78	68	254
	Forebay	49	38	32	40	159
	Total	105	90	110	108	413
John Day	Tailrace	50	54	42	66	212
	Forebay	45	58	48	60	211
	Total	95	112	90	126	423
McNary	Tailrace	32	53	66	60	210
	Forebay	46	54	60	48	208
	Total	78	107	126	108	418
	All sides	277	309	326	342	1,253

Table 2. Smallmouth bass catch, by disposition, for tailrace and forebay of each dam during 2012.

		First time captures			Recaptures [a]		
Dam	Side	Tagged and released	Hooking mortality	Released untagged	PIT tag present, released alive	Hooking mortality	Missing PIT tag, re-tagged and released
The Dalles	Tailrace	159	5	0	64	0	2
	Forebay	56	1	0	28	1	0
	Total	215	6	0	92	1	2
John Day	Tailrace	325	7	2	35	0	2
	Forebay	325	14	0	68	3	0
	Total	650	21	2	103	3	2
McNary	Tailrace	90	1	0	46	3	4
	Forebay	114	5	0	18	0	2
	Total	204	6	0	64	3	6
	All sides	1,069	33	2	259	7	10

[a] Includes fish tagged during 2011.

Table 3. Non-target fish encountered during May-August 2012 while sampling smallmouth bass by angling from dams.

Species	The Dalles Tailrace	The Dalles Forebay	John Day Tailrace	John Day Forebay	McNary Tailrace	McNary Forebay	All Areas
American shad (*Alosa sapidissima*)	2	0	0	0	0	0	2
Carp (*Cyprinus carpio*)	1	8	0	1	4	2	16
Largemouth bass (*Micropterus salmoides*)	0	0	0	0	0	3	3
Northern pikeminnow (*Ptychocheilus oregonensis*)	25	0	3	0	1	0	29
Peamouth (*Mylocheilus caurinus*)	1	0	0	0	0	0	1
Salmon adult (*Oncorhynchus* spp.)	1	0	0	0	0	0	1
Salmon juvenile (*Oncorhynchus* spp.)	2	0	0	0	3	0	5
Sculpin (*Cottus* spp.)	1	0	3	0	0	2	6
Sockeye adult (*O. nerka*)	0	0	3	0	0	0	3
Steelhead (*O. mykiss*)	0	1	0	2	2	1	6
Sucker (*Catostomus* spp.)	0	0	0	0	1	0	1
Walleye (*Sander vitreus*)	0	0	0	0	29	8	37
White sturgeon (*Acipenser transmontanus*)	1	0	0	0	0	0	1
Yellow perch (*Perca flavescens*)	0	0	1	0	0	0	1
All species	9	34	3	10	16	40	112

Table 4. Mean monthly catch per unit of effort (CPUE) of smallmouth bass by dam and side of dam during 2012.

		Catch per unit of effort (fish / angler h)				
Dam	Side	May	June	July	August	Total
The Dalles	Tailrace	1.32	1.00	0.77	0.66	0.91
	Forebay	0.39	0.63	0.50	0.68	0.54
	Total	0.88	0.84	0.69	0.67	0.77
John Day	Tailrace	2.14	2.13	1.43	1.32	1.74
	Forebay	0.31	1.97	2.23	2.92	1.95
	Total	1.28	2.04	1.86	2.08	1.84
McNary	Tailrace	0.48	0.59	0.86	0.69	0.69
	Forebay	0.35	0.28	0.83	1.21	0.67
	Total	0.40	0.43	0.85	0.92	0.68
	All sides	0.88	1.14	1.07	1.27	1.10

Table 5. Linear model results for comparison of smallmouth bass catch per unit of effort (CPUE), consumption indices, and fork length across dams and sides of dams during 2012.

Response	Effect	df	F	*P* -value
CPUE	Dam	2	7.668	0.0008
	Side	1	0.048	0.8266
	Dam*Side	2	0.457	0.6346
Consumption Index	Dam	2	0.022	0.0219
	Side	1	0.012	0.0123
	Dam*Side	2	1.082	0.3452
Fork Length	Dam	2	73.393	<0.0001
	Side	1	82.064	<0.0001
	Dam*Side	2	33.431	<0.0001

Table 6. Abundance estimates for smallmouth bass within the angling-accessible zone of The Dalles, John Day, and McNary dams, 2012 (LCB = lower 95% confidence bound, UCB = upper 95% confidence bound).

Dam	Side	Abundance	LCB	UCB
The Dalles	Tailrace	455	318	649
	Forebay	109	67	185
John Day	Tailrace	1,741	1,231	2,453
	Forebay	1,193	894	1,589
McNary	Tailrace	271	173	447
	Forebay	667	368	1,334

Table 7. Number of smallmouth bass stomach content samples and frequency of occurrence (i.e., no. samples with taxon / total no. samples) of fish taxa in smallmouth bass diets during 2012 by dam and side of dam.

	The Dalles		John Day		McNary	
Category	Tailrace	Forebay	Tailrace	Forebay	Tailrace	Forebay
Total sample	229	86	367	410	144	137
Empty stomachs	64	15	112	63	36	20
	27.9%	17.4%	30.5%	15.4%	25.0%	14.6%
Stomachs containing fish	55	19	110	97	64	43
	24.0%	22.1%	30.0%	23.7%	44.4%	31.4%
Catostomidae (suckers)	0	1	1	0	1	0
	0.0%	1.2%	0.3%	0.0%	0.7%	0.0%
Centrarchidae (sunfish)	0	2	0	2	0	1
	0.0%	2.3%	0.0%	0.5%	0.0%	0.7%
Clupeidae (shad)	1	0	0	1	0	0
	0.4%	0.0%	0.0%	0.2%	0.0%	0.0%
Cottidae (sculpin)	30	7	55	12	39	5
	13.1%	8.1%	15.0%	2.9%	27.1%	3.6%
Cyprinidae (minnows)	3	2	2	0	0	5
	1.3%	2.3%	0.5%	0.0%	0.0%	3.6%
Gasterosteidae (stickleback)	0	0	0	3	0	1
	0.0%	0.0%	0.0%	0.7%	0.0%	0.7%
Ictaluridae (catfish)	0	0	0	0	0	0
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Petromyzontidae (lamprey)	2	0	6	8	0	0
	0.9%	0.0%	1.6%	2.0%	0.0%	0.0%
Percidae (perches)	0	0	2	0	0	0
	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%
Salmonidae (trout, salmon)	7	2	25	68	15	27
	3.1%	2.3%	6.8%	16.6%	10.4%	19.7%
Unidentified	14	6	23	12	12	10
	6.1%	7.0%	6.3%	2.9%	8.3%	7.3%

FIGURES

Figure 1. Aerial image of The Dalles Dam illustrating the smallmouth bass sampling areas in the downstream tailrace (lower left and right) and upstream forebay (upper left and upmost right) during 2012. Tailrace: 1. cul-de-sac to end of adult fishway foundation; 2. cul-de-sac along adult fishway foundation to Oregon powerhouse; 3. powerhouse; 4. riprap below ice/trash sluiceway; 5. First spillway, Oregon shore; and 6. navigation lock. Forebay: 1. Oregon shore to adult fishway exit; 2. adult fishway exit to powerhouse; 3. powerhouse; 4. powerhouse to spillway; 5. auxiliary water supply adjacent navigation lock.

Figure 2. Aerial image of John Day Dam illustrating the smallmouth bass sampling areas in the downstream tailrace (left of dam) and upstream forebay (right of dam) during 2012. Tailrace: 1. Auxillary water supply Oregon shore; 2. riprap below adult fishway; 3. powerhouse; 4. first spillway Washington shore; 5. navigation lock. Forebay: 1. Oregon shore riprap; 2. powerhouse; 3. riprap Washington shore.

Figure 3. Aerial image of McNary Dam illustrating the smallmouth bass sampling areas in the downstream tailrace (lower) and upstream forebay (upper) during 2012. Tailrace: 1. riprap Oregon shore downstream of adult fishway; 2. catwalk/island; 3. concrete wall adjacent adult fishway; and 4. concrete cavity, tailrace deck. Forebay: 1. Oregon shore riprap to adult fishway exit; 2. adult fishway exit to powerhouse; 3. powerhouse; and 4. auxiliary water supply and navigation lock.

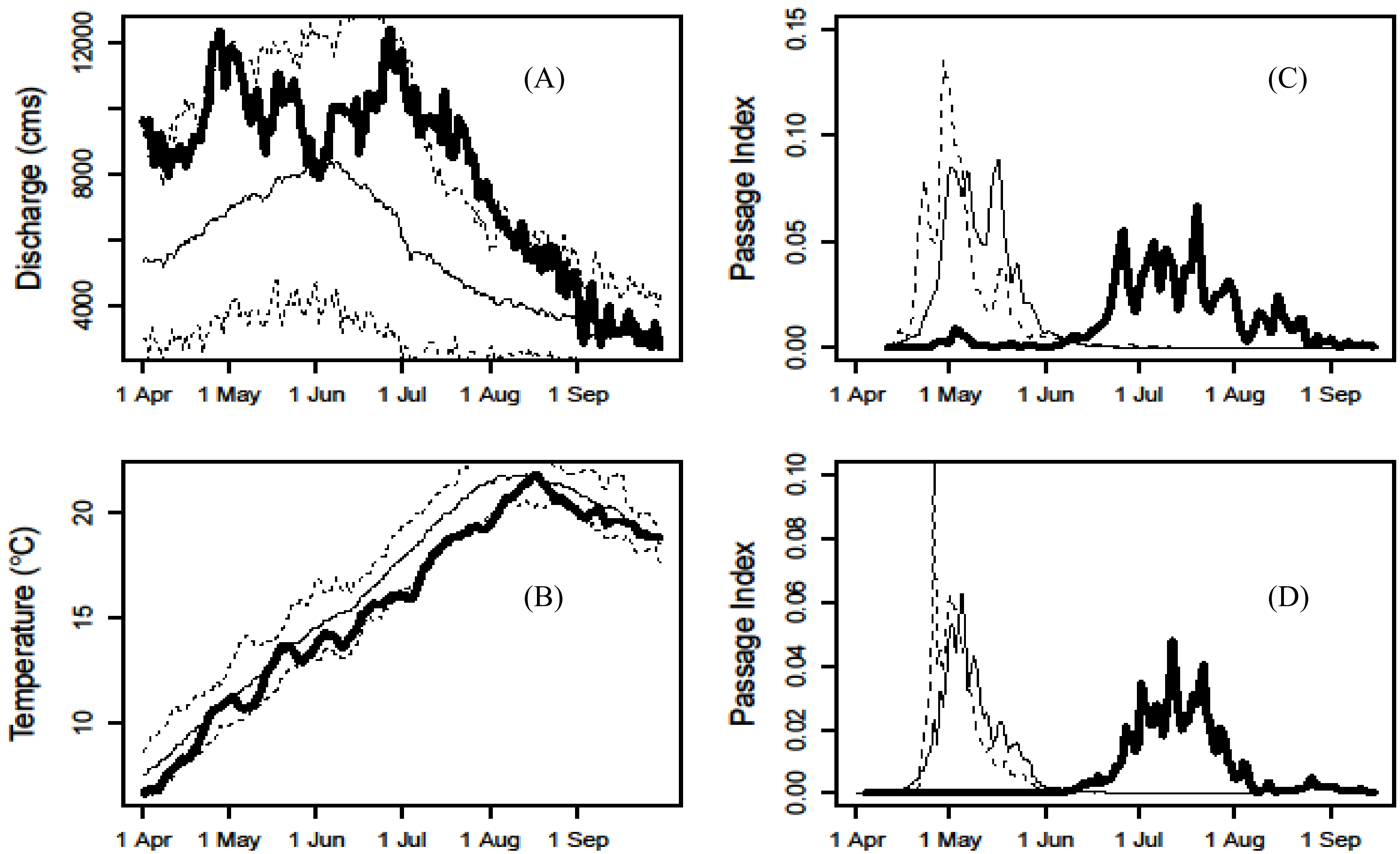


Figure 4. (A) Daily discharge (cubic meters per second) at The Dalles Dam (USGS station 14105700) during 2012 (thick solid line), and mean (+/- 95% quantiles, thin solid and dashed lines) values for the period extending from the end of major storage reservoir construction (Columbia Basin-wide) to 2010. (B) Daily temperature at The Dalles Dam USGS station relative to the mean and range (thin solid and dashed lines) for its historical record (1997-2010). Passage index values (scaled to species-dam totals) for steelhead. (thin dashed line), age-1 Chinook (thin solid line), and age-0 Chinook (thick solid line) for McNary (C) and John Day (D) dams.

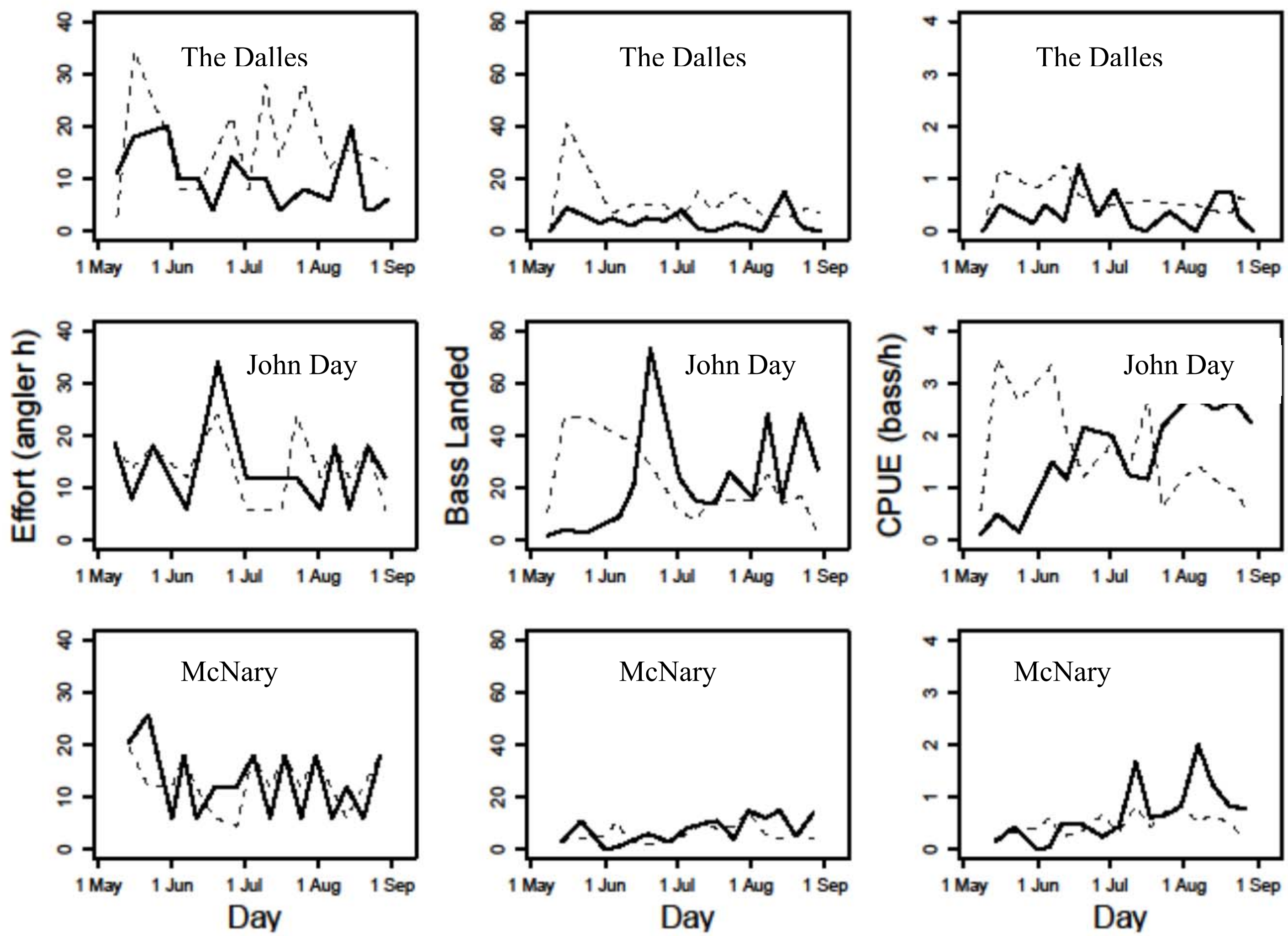


Figure 5. Effort (angler hours, left column), catch (middle column), and CPUE (SMB / angler hour, right column) by study site and sample day during 2012. Tailrace values appear as dashed lines and forebay values appear as solid lines.

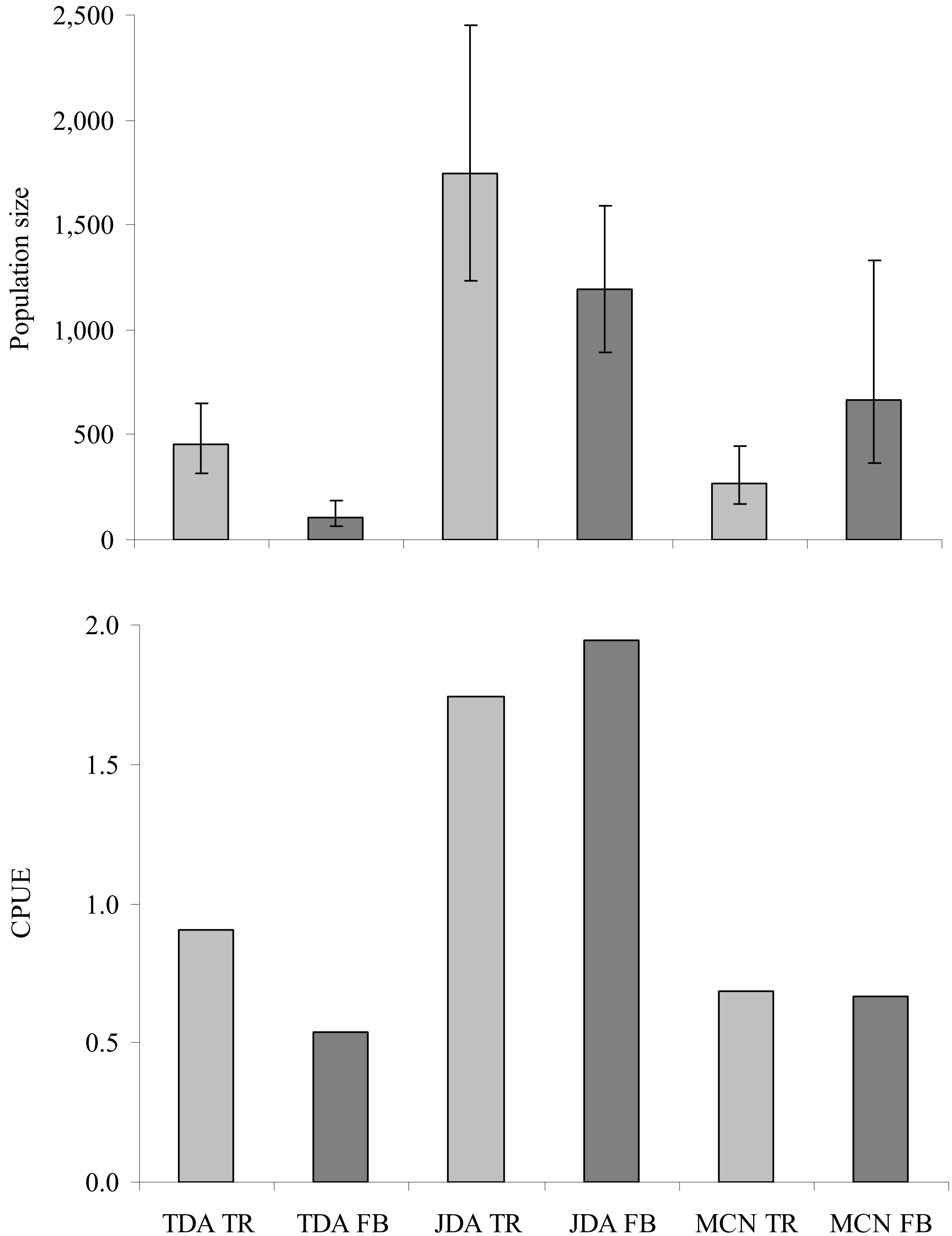


Figure 6. Bar chart of CPUE and population estimates by dam and side of dam during 2012. Displayed CPUE values are mean season-wide estimates; error bars around population estimates correspond to 95% upper and lower confidence bounds. Dams are TDA = The Dalles, JDA = John Day, MCN = McNary; TR = Tailrace, FB = Forebay

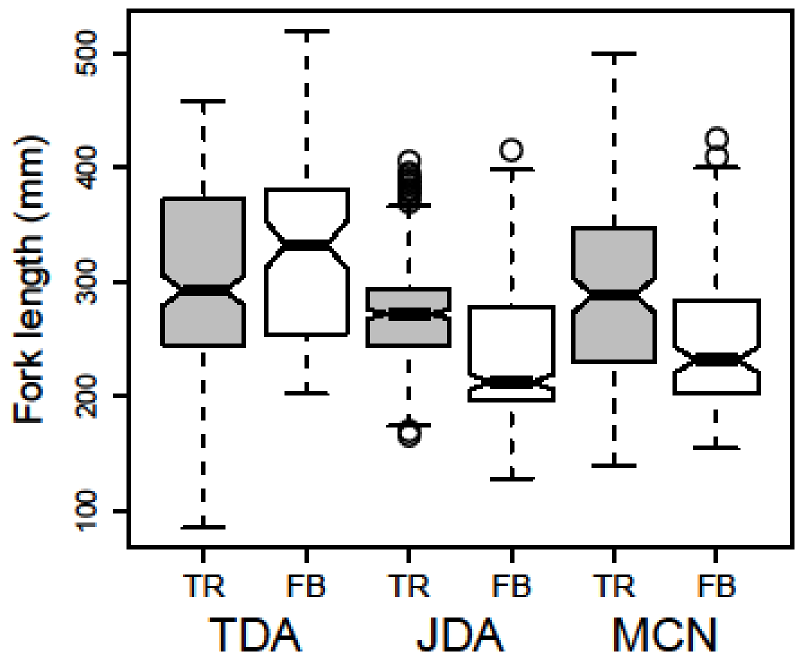


Figure 7. Box-and-whisker plots of fork length distributions for each site during 2012. Upper and lower box bound correspond to the first and third quartiles of the distributions, the center line corresponds to the median, the lower and upper whiskers are the 5th and 95th percentiles, and the circles are outliers. Note: the notch width (+/- 1.58 times inter-quartile range / n0.5) approximates a 95% CI around the median; a lack of notch overlap between boxes approximates a statistically significant difference in distributions.

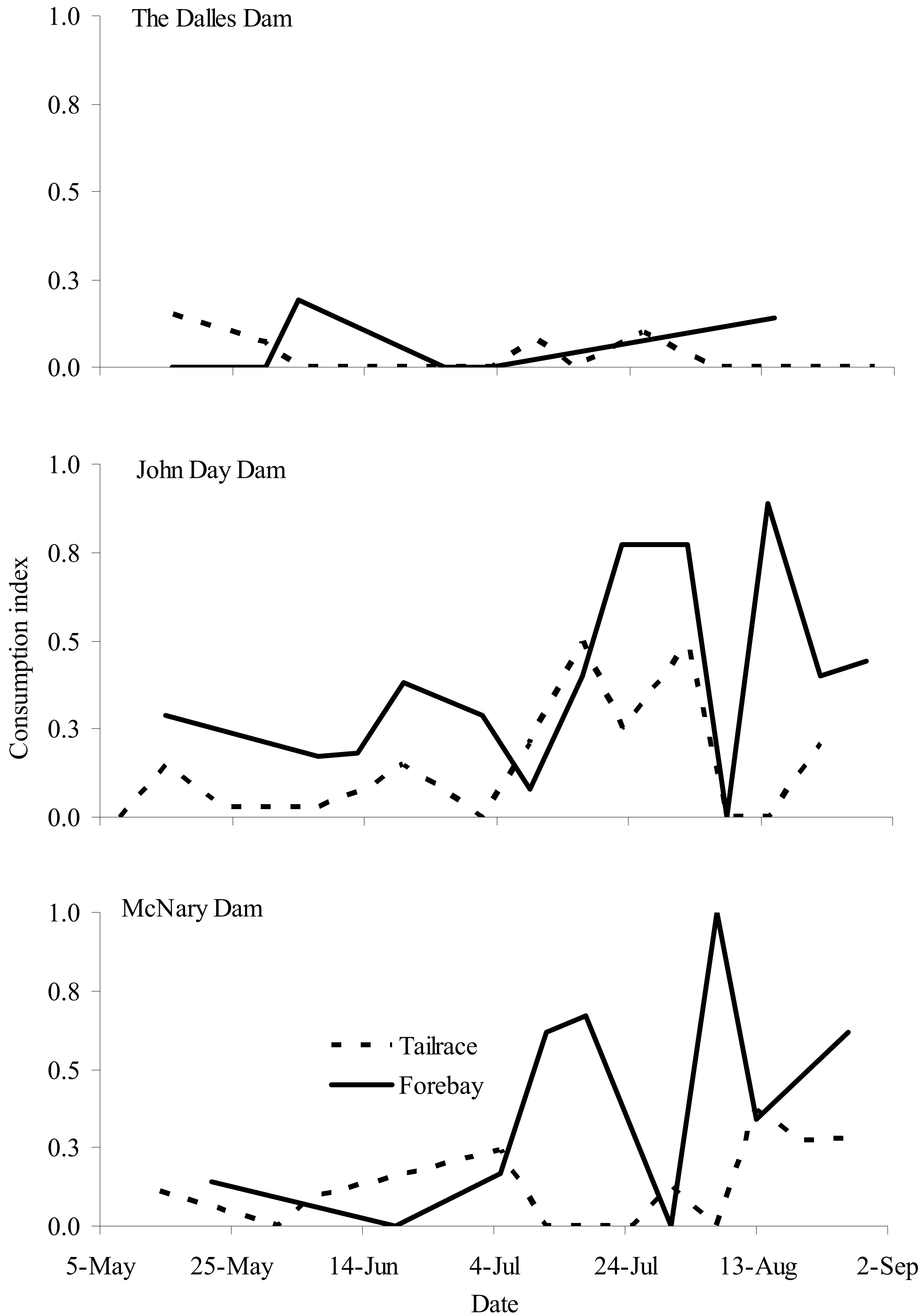


Figure 8. Consumption index values by dam and side for smallmouth bass sampled in 2012.

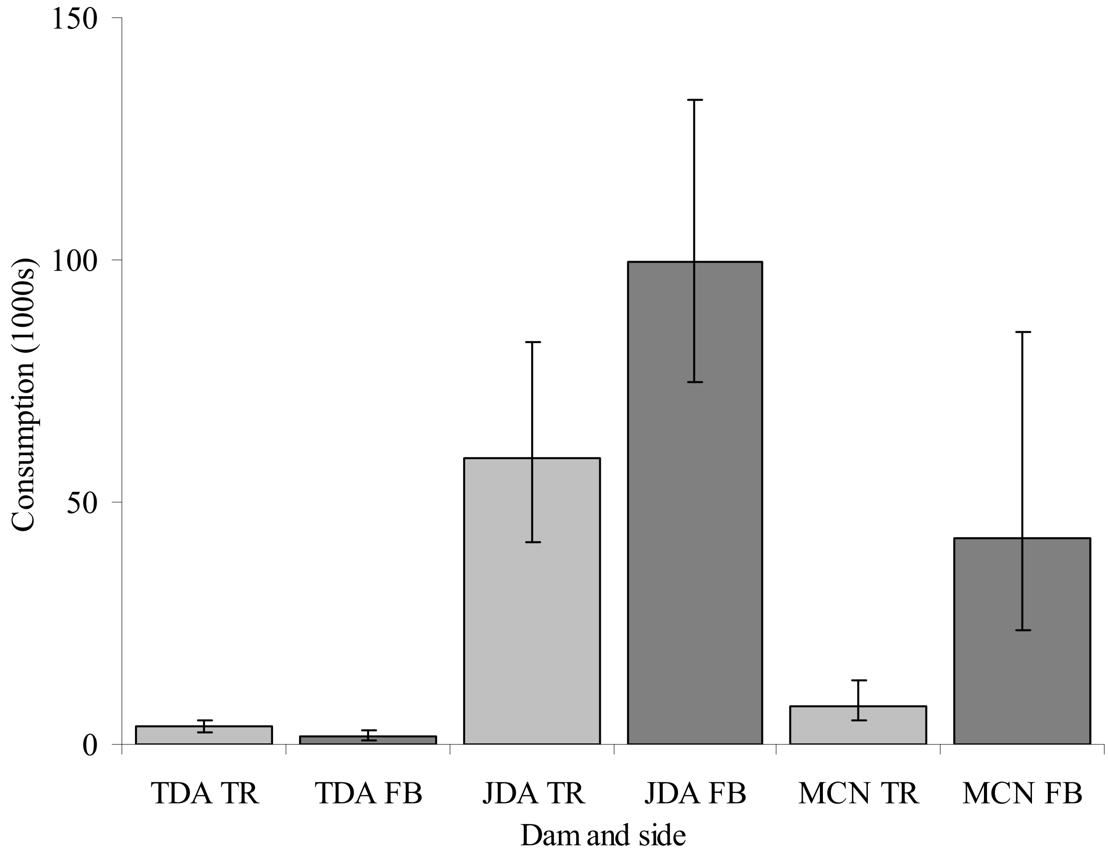


Figure 9. Estimated total consumption of juvenile salmon and steelhead per population of smallmouth bass within the angling-accessible area of tailraces and forebays of The Dalles, John Day. and McNary dams during 2012. Note: error bars around totals correspond to consumption calculated at the 95% upper and lower confidence bounds of population estimates.

APPENDIX

Descriptions of lures used during 2012

Following is a description of various lures used during 2012, commercially available to bass anglers. Use of these lures does not necessarily represent any endorsement of any particular lure manufacturer by ODFW. In an effort to standardize tackle descriptions, a new system was developed for 2012. Lures were divided into 15 different categories. Colors were consolidated into broader categories and manufacture given names were excluded from data sheets. Instead, a primary, secondary and accent color was recorded when applicable. Primary colors were those most dominant on the lure. Secondary colors are the second most prominent color on the lure. Accent colors are the colors of strips, dots or glitter on the lure. If a lure had more than two solid colors present only the two most prominent colors were recorded as the primary and secondary colors. The same is true of accent colors. Only the two most dominate were recorded. Below is a more in depth look at lures and descriptions.

In an effort to keep tackle descriptions more uniform, the tackle descriptions used are slightly vague. Some lures had more than two solid colors and more than two accent colors, these less prominent colors were purposely omitted from the tackle descriptions. Additionally colors have many variations that were not specifically described in the tackle descriptions. All variations of green, for example, were referred to as green (GRN) with no other description given, such as light green, forest green, moss green, etc.

Lure Selection- Each individual angler selected lures to be used based on location, conditions and personal preference. As a general rule the use of crank baits, top water lures, buzz/spinner baits and spinners was limited to locations within 3 meters of the water. Locations greater than 3 meters above the water could typically only be sampled effectively with some combination of soft plastic lure and weight. Soft plastic lures were by far utilized the most due to effectiveness and versatility.

Buzz Bait (BB) - Use very little, typically over submerged vegetation in shallow areas.

Examples: Booyah® Pond Magic™ Buzz**,** Strike King Pro Buzz**,** Lunker Lure Original Buzzbait**,** War Eagle Lures Buzzbaits, etc.

Chartreuse Buzz Bait (CHR BB)

White Buzz Bait (WHT BB)

Bladed Walleye Jig (BLD)- These lures were used at the recommendation of a local tackle shop for windy conditions and vertical jigging. Success rate was not high enough to generate much enthusiasm from anglers.

Examples: Reef Runner Cicadas**,** Cotton Cordell Gay Blade**,** Bitzer Creek Zip™ Lure**,** Heddon Sonar Lure**,** etc.

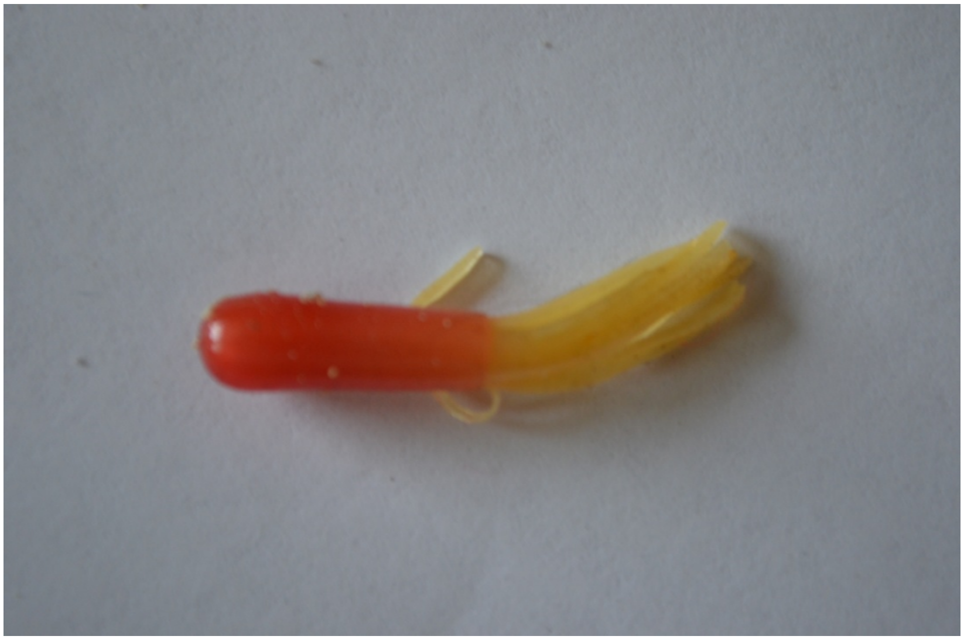
Bladed Walleye Jigs (BLD)

Yellow and Chartreuse Bladed Walleye Jig, (YLW & CHR BLD)

Crappie Jig (CRP)- Often used when light unaggressive bites were observed.

Examples: Southern Pro Original Lil Hustlers **,** Lindy Dancin' Crappie Tube**,** Southern Pro 1" MicroTube Bodies, etc.

Crappie Jigs (CRP)



Pink and White Crappie Jig (PNK & WHT CRP)

Deep Diving Crank Bait (DCB)- Used effectively from all but the highest sampling sites.

Examples: Rapala® Jointed Deep Husky Jerk®, Bomber Lures Suspending Fat Free Shad, Rapala® X-Rap® Deep Shad**,** Bandit Flat Maxx Deep Crankbait**,** etc.

Deep Diving Crank Bait (DCB)

Silver and Blue Deep Diving Crank Bait (SIL & BLU DCB)

Lipless Crank Baits (RT)- Very effective for use at sampling sites close to water level and when dealing with aggressive fish.

Examples: Bill Lewis® Rat-L-Trap®, Bass Pro Shops® Tourney Rattle Bait, Rattlin Rapala® Lure, XCalibur® One Knocker Rattle Bait**,** etc.

Lipless Crank Baits (RT)

White and Blue with Yellow Lipless Crank Bait (WHT & BLU W/YLW RT)

Shallow Diving Crank Bait (SCB) – Used effectively from sampling sites close to water level.

Examples: Strike King® Square Bill®, Storm® Thunder Stick®, Rapala® Husky Jerk®, Bass Pro Shops® Tourney Minnow, etc

Shallow Diving Crank Bait (SCB)

Yellow and Chartreuse with Black Shallow Diving Crank Bait
(YLW & CHR w/BLK SCB)

Soft Plastic Crayfish (CRF)- At times very effective when conditions allowed bottom to be fished.

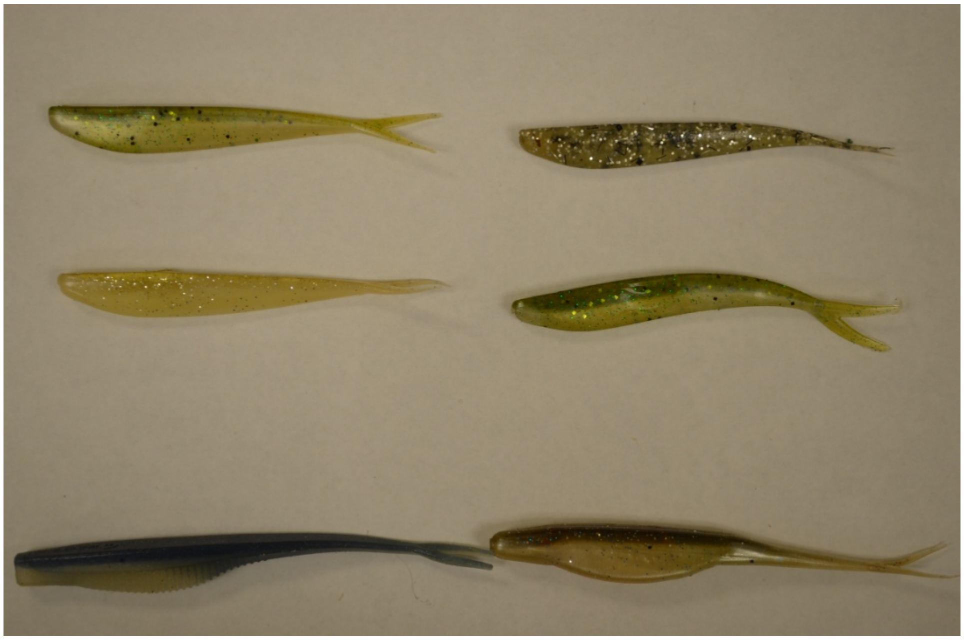
Examples: YUM® F2 Crawbug, Berkley® PowerBait® Chigger Craw, Gary Yamamoto Fat Baby Craw, Zoom Lil Critter Craw, etc.

Soft Plastic Crayfish (CRF)

Green with Red and Black Soft Plastic Crayfish (GRN w/RED/BLK CRF)

Soft plastic Fluke (FLK)- Very effective when used to site fish to SMB actively pursuing baitfish.

Examples: Zoom® Super-Salty Fluke, Berkley® Gulp!® Minnow, Zoom Super Fluke Jr., Trigger X Aggression Minnow, etc.



Soft plastic Fluke (FLK)

Soft Plastic Grub (GRUB)- One of the most effective and versatile lures used. Can be vertically jigged off tall structure, fished along the bottom or cast and retrieved.

Examples: Kalin's® Lunker Grub**,** Berkley® Power Grub**,** Mister Twister Curly Tail Grub **,** Strike King Rage Tail™ Grub**,** Trigger X® Aggression Swimming Grub**,** etc.

Soft Plastic Grub (GRUB)

TOP: Smoke with Copper Grub (SMK w/CPR GRUB)
Bottom: Clear with Silver Grub (CLR w/SIL GRUB)

Soft Plastic Lizard (LZRD)- Worked slowly along the bottom would often produce fish when fishing was slow and other lures did not produce fish.

Examples: Zoom 6" Super Salty Lizard, Berkley® PowerBait® Lizard, Wave Tiki-Moko Lizard, etc.

Soft Plastic Lizard (LZRD)

Brown with Green and Black Soft Plastic Lizard (BRN w/GRN/BLK LZRD)

Soft Plastic Minnow (MIN)- Effective in many of the same situations as grubs and tubes. Examples: Storm WildEye® Swim Shad**,** Tsunami™ Holographic Split-Tail Minnow**,** BanjoMinnow®**,** Storm® Wildeye® Swimbaits, etc.

Soft Plastic Minnows (MIN)

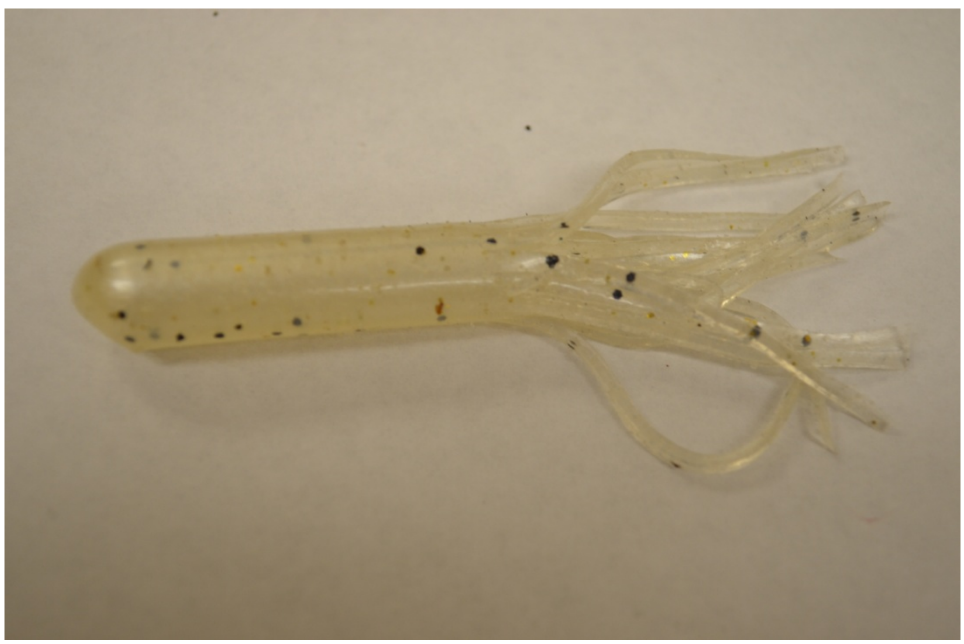
White and Blue with Yellow Soft Plastic Minnow (WHT & BLU w/YLW MIN)

Soft Plastic Tube (TUBE)- By far produced the most fish.
Examples: Yamamoto 3-1/2" Tube, Venom 3" Finesse Salt Tubes, YUM® F2 Tube, etc.

Soft Plastic Tubes (TUBE)

TOP: Smoke with Red & Black Tube (SMK w/RED/BLK TUBE)
BOTTOM: Smoke with Copper Tube (SMK w/CPR TUBE)

Soft Plastic Tubes (TUBE)



White with Black Soft Plastic Tube (WHT w/BLK TUBE)

Soft Plastic Worm (WORM)- A consistent producer when fishing was slower.
Examples: YUM® F2 Ribbontail™ Worm**,** Berkley® PowerBait® Worms, Cabela's Fisherman Series Go-To Ribbon Tail Worm**,** etc.

Soft Plastic Worms (WORM)

Purple with Blue Soft Plastic Worm (PPL w/BLU WORM)

Spinner Bait (SB)- Used fairly infrequently.
Examples: Mann's Hank Parker "The Classic" Spinnerbait**,** Terminator™ S-1 Super Stainless Spinnerbait**,** Booyah® Pond Magic™ Spinnerbait, etc.

White and Blue with Orange Spinner Bait (WHT & BLU w/ORG SB)

Green & Chartreuse with Orange Spinner Bait (GRN & CHR w/ORG SB)

Spinner (SPN)- Very popular with one member of 2011 team, used very infrequently during 2012 season.
Examples: Blue Fox® Super Vibrax® Spinners**,** Worden's Lures Original Rooster Tails**,** Panther Martin Original Spinners**,** etc.

In-line Spinners (SPN)

Chartreuse & Orange with Black In-line Spinner (CHR & ORG w/BLK SPN)

Top Water Hard Baits (TW)- Very effective when fished over submerged vegitaion and when fish are aggressive.
Examples: Bass Pro Shops® XPS® Slim Dog Hardbait, Rapala® Skitter Pop®, Rebel® Pop-R, etc.


Top Water Hard Baits (TW)

White & Blue with Yellow Top Water Hard Bait (WHT & BLU w/YLW TW)

Hooks and Jig Heads- A wide variety of styles, brands and sizes were used based on each individual angler’s personal preference and fishing conditions.

Lure Codes	Lure Description	Examples
RT	Rattle Traps or similar lipless crank baits	Rattle Trap
SCB	Shallow diving crank bait, small lips designed to dive less than 8'	Original Rapala
DCB	Crank baits with large lips designed to dive 8' or deeper	Wiggle Wart, Fat Free Shad, Bomber, Boss Hawg
TW	Top Water Lures	baby torpedo
SB	Spinner Baits	
BB	Buzz Bait	
SPN	Spinners	Blue Fox, Rooster Tail
Tube	Soft plastic tubes 2"-5" inches	
Grub	Soft plastic grubs 2"-5" inches	
Worm	Soft plastic Worms 2"-9" inches	
Lzrd	Soft plastic lizards	
CRF	Soft plastic crayfish	
MIN	Soft plastic minnows	
FLK	Soft plastic fluke	slug-go
BLD	Walleye bladed jig	
CRP Jig	Soft plastic tubes less than 2"	

Code	Color	**Primary Color**
AMB	Amber	Most dominate color
BLK	Black	on the lure
BLU	Blue	
BRN	Brown	**Secondary Color**
CHR	Chartreuse	Second most prominent
CLR	Clear	color on the lure
CPP	Copper	
GRY	Gray	**Accent Color**
GLD	Gold	The color of stripes,
GRN	Green	dots or glitter
ORN	Orange	
PNK	Pink	
PPL	Purple	
PRL	Pearl	
RED	Red	
SIL	Silver	
SMK	Smoke	
YLW	Yellow	
WHT	White	