
AVIAN PREDATION AT JOHN DAY AND THE DALLES DAMS 2011:
ESTIMATED FISH CONSUMPTION USING DIRECT OBSERVATION



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EXECUTIVE SUMMARY

Avian predators are a highly visible source of juvenile salmonid mortality at hydropower dams. The Federal Columbia River Power System 2008 Biological Opinion (NOAA 2008) and amendments requires monitoring of avian predation and implementation and improvement of avian deterrents as needed. In 2011, the third and final year of this study, we determined the impact of avian predators on fish passing downstream of John Day and The Dalles dams. Our objectives were to: 1) Determine species composition, distribution, and number of piscivorous birds; 2) Estimate fish consumption and attack location by the dominant avian predator, gulls (*Larus spp.*); and 3) Compare fish consumption by gulls between years and between dams.

To quantify avian consumption of fish, observers used binoculars to count the number of gulls, determine the rate of attacks (dives), and determine if an attack was successful (fish in bill) during the smolt outmigration period from 11 April to 28 July 2011. Unlike previous years we were not issued a permit to collect gulls for diet analysis. Therefore, in 2011 we estimate fish consumption rather than the more specific smolt consumption.

California gulls (*Larus californicus*) were the dominant foraging avian piscivore at both dams followed by western grebes (*Aechmophorus occidentalis*), American white pelicans (*Pelecanus erythrorhychos*), double crested cormorants (*Phalacrocorax auritus*), and others. The daily abundance of gulls at John Day Dam ranged from zero on 15 April and 28 July to a high of 30 on 29 April with a seasonal mean of 5.7 gulls. At The Dalles Dam the daily abundance ranged from zero on 28 July to a high of 63 on 23 May with a seasonal mean of 14.7 gulls.

At John Day Dam our estimate of fish consumption, which includes additive and compensatory sources of mortality, was 6,000 (95% CI 4,000 – 8,000) or 0.02% of the estimated 31.3 million smolt passing this dam. This is a reduction of 32,000 (84%) from 2010 when an estimated 38,000 fish were consumed and a reduction of 102,000 (94%) from 2009 when an estimated 108,000 fish were consumed. We developed geospatial maps of gull attack points which show hot spots just downstream of the avian deterrent lines, primarily on the spillway side of the river.

At The Dalles Dam our estimate of fish consumption, which includes additive and compensatory sources of mortality, was 16,000 (95% CI 13,000-20,000). This is a reduction of 70,000 (81%) from 2010 when an estimated 86,000 fish were consumed. Here also, gulls attacks were focused just downstream of the avian lines, primarily on the spillway side of the river. The avian deterrent line grid covering the spillway was expanded prior to the 2011 fish passage season.

Avian line arrays and hazing from boats was successful in protecting covered areas in 2011 as in 2010. As the deterrent effort was similar in both years, we attribute the decreases in fish consumption to natural variation in the number of foraging gulls, not level of deterrent effort. Regardless, the management objective of reducing avian predation was achieved in both years.

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INTRODUCTION

BACKGROUND

Predation on juvenile Pacific lamprey and salmonids by avian predators is well documented at Columbia River hydroelectric dams (Merrell 1959, Ruggerone 1986, Wiese et al. 2008) and other structures that concentrate and disorient out-migrants (Major III et al. 2005). Previous research at Bonneville, The Dalles, and John Day dams estimated gull abundance and predation immediately downstream of these facilities (Jones et al. 1998, 1999, Jonas et al. 2008). During 2006 - 2008 project biologists at The Dalles and John Day documented an increase in the number of gulls feeding at both of these projects (Figure 1). In an attempt to reduce the impact these predators have on emigrating smolts, a variety of methods have been employed including avian line deterrent arrays covering tailrace areas of the dams as well as active hazing methods such as pyrotechnics, high power water sprinklers, and propane cannons. In addition to this, lethal take has been used sporadically to reinforce non-lethal hazing. These efforts to reduce gull predation on fish passing The Dalles and John Day dams may be hampered by the presence of a nearby breeding colony of California (*Larus californicus*) and ring-billed (*Larus delawarensis*) gulls on Miller Island Rocks (Roby et al. 2011).

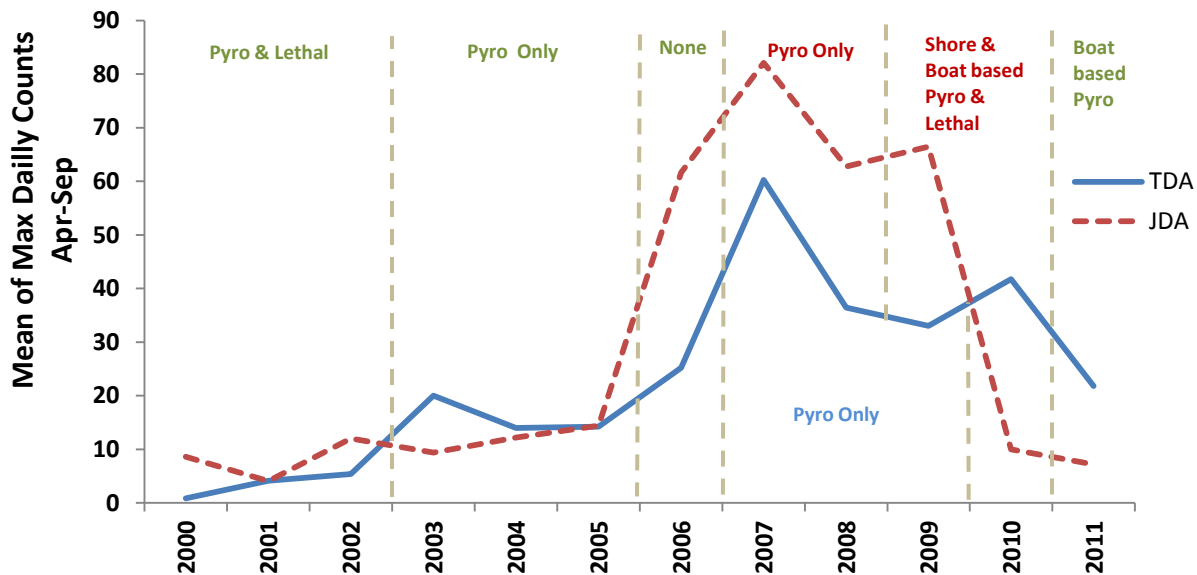


Figure 1. Mean yearly gull counts from maximum daily counts provided by the project biologists from April to September during fishway inspections. TDA is The Dalles and JDA is John Day.

Gulls from Miller Island Rocks and other outlying areas make use of multiple food sources including juvenile fish, insects on agricultural land, and garbage from landfills. In addition to the hydroelectric facilities in the area, there are a variety of agricultural lands and landfills for gulls to exploit. Two landfills are nearby, a large landfill at Columbia Ridge at Arlington, OR upstream of John Day Dam and a smaller Wasco County Landfill near The Dalles, OR. This variety of food sources gives gulls the option to change their feeding habits as circumstances dictate. Human intervention such as hazing may merely move the gulls from one food source to another. From a fish management perspective this can be problematic if hazing merely moves the gulls to another dam and does not result in a system wide benefit to smolt survival. For example, in 2010 the successful combination of avian lines and boat hazing at John Day Dam may have displaced some gulls downriver to The Dalles Dam or upriver to McNary Dam.

Quantifying avian caused mortality at U.S. Army Corps facilities provides resource managers information required to implement various deterrent strategies when necessary. However, this task is not easily completed as researchers have not developed methods of determining whether fish consumed in the tailrace of the dams are moribund (compensatory mortality) or healthy (additive mortality). Ruggerone (1986) also recognized this limitation in his early work with avian predation. Because of our inability to differentiate between additive and compensatory mortality we use the term consumption rather than predation throughout this report.

OBJECTIVES

U.S. Army Corps of Engineers (USACE) project biologists raised concerns over the five year trend of increasing numbers of gulls foraging in the tailrace at John Day Dam (Figure 1). The Portland District's Fisheries Field Unit (FFU) was tasked with evaluating the effectiveness of hazing from a boat and avian deterrent line arrays at John Day and The Dalles dams by determining the impact of avian predators on juvenile salmonids, some of which are federally listed as threatened or endangered.

We had three objectives:

- 1) Determine species composition, distribution, and number of piscivorous birds.
- 2) Estimate fish consumption and attack location by gulls (*Larus spp.*).
- 3) Compare fish consumption by gulls between years and between dams.

JOHN DAY DAM SITE DESCRIPTION

John Day Dam is located at river mile 216 and spans the Columbia River in a north-south line starting with the navigation lock, spillway, and then powerhouse (Figure 2). The powerhouse is equipped with screens that divert juvenile fish away from the turbines to the juvenile fish bypass system on the south shore. In 2011 between 10 April and 31 August, spill was to be regulated between 30% or 40% night and day with top spillway weirs (TSW's) affixed to the front of bays 18 and 19 to increase volitional surface passage. Unusually high spring flows reaching 500 kcfs resulted in spill exceeding these percentages during May and June. Discharge through the TSW's was fixed at 20 kcfs; the percentage of spill discharge through the TSW's varied as the spill volumes fluctuated throughout the season. Due to the higher flows water covered most of the downstream islands where birds rest making them unusable for birds during most of the fish passage season.

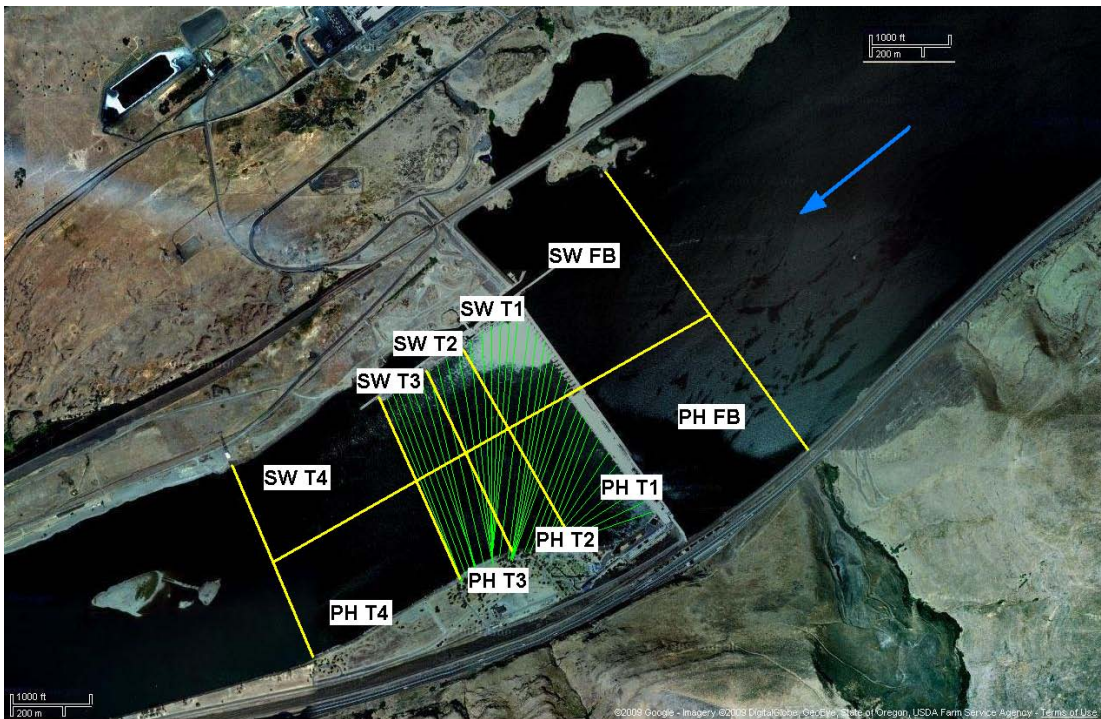


Figure 2. Image of John Day Dam at Columbia River mile 216 (©Google Images 2009). Flow is from right to left with the 2010 avian array represented by thin green lines and the observation zones demarked by thicker yellow lines.

Avian deterrents at John Day Dam included both a passive line array of 125 lines and active pyrotechnic hazing from a boat for two shifts from 0600 to 1800 hrs, seven days a week from 15 April to 15 July 2011. The avian line array was constructed in 2010 and designed to include 128 main lines plus lower ‘filler’ lines (Figure 2). By summer 2011, three of the lines had failed and

not yet been replaced. For a more detailed description of avian lines and observation zones see Zorich et al. 2011. The US Department of Agriculture Wildlife Services (USDA) hazers operated boats downstream of the boat restricted zone in the John Day tailrace. The USDA agents fired pyrotechnics (screamer and cracker rounds from a starter pistol and bottle rockets with report) from the boat to discourage gulls from feeding in the vicinity of the dam.

THE DALLES DAM SITE DESCRIPTION

The Dalles Dam is located at river mile 192 and spans the Columbia in a reverse “L” shaped pattern starting with the navigation lock on the north shore, the spillway perpendicular to the flow, and the powerhouse with a non-overflow monolith parallel to the flow (Figure 3). The powerhouse is not screened for juvenile fish. Instead, an ice-and-trash sluiceway is used to skim and guide juvenile fish from the surface and divert them away from the turbines to an outfall chute between the monolith and powerhouse (in zone PH T3).



Figure 3. Image of The Dalles Dam at Columbia River mile 192 (©Google Images 2009). Flow is from right to left with the 2011 avian array represented by thin green lines and the observation zones demarcated by yellow lines.

Avian deterrents at The Dalles Dam included a passive line array as well as two eight hour shifts of active boat based hazing by the USDA. The avian line array was expanded downstream of the spillway with seven additional lines prior to the 2011 fish passage season. The 2011 array consisted of 74 lines connected to poles on the Oregon shore or Lone Pine Island. Lines spanned the powerhouse tailrace to attachment points on the powerhouse hand rail and fencing downstream of the ice and trash sluiceway's outfall. Downstream of the spillway, lines spanned the river from a newly installed pole on an island near the Oregon shore to attachment points along the Washington shore (Figure 3). Active hazing was performed by the USDA from April through July operating a boat downstream of the US-197 bridge. Similar to John Day Dam, the USDA agents fired pyrotechnics from a boat to discourage gulls from feeding in the vicinity of the dam.

In 2011 spill was to be regulated to 40% night and day through bays 1-8. However, due to high spring runoff spill exceeded 40% from 17 May to 27 June. During this period spill also occurred south of the spill guide wall located between bays 8 and 9. This additional spill was mostly from bays 9 – 14. Flows in 2009 and 2010 were similar to the ten year average, but in 2011 the high flows changed the landscape around the facility such that it reduced available loafing areas, increased turbidity, and passed juveniles through the system faster (Figure 4).

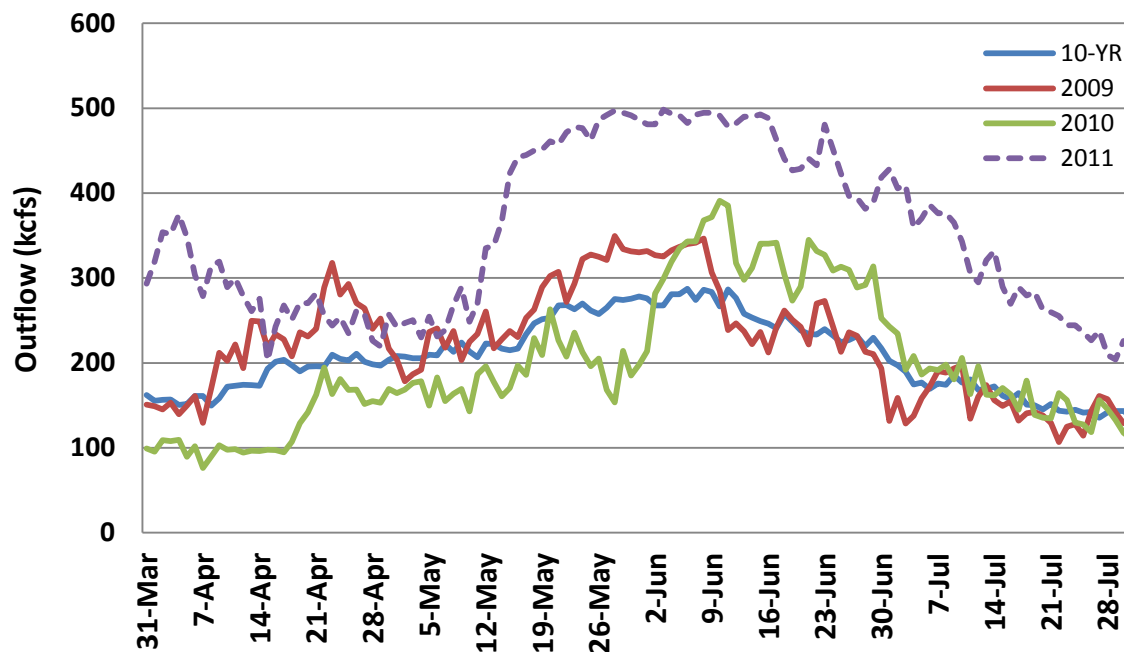


Figure 4. Total discharge (kcfs) through The Dalles Dam 2009 – 2011 including the 10-year average (Columbia River DART webpage- Jan 17 2012).

METHODS

COMMON TO BOTH DAMS

We collected counts by behavior (foraging, loafing, or fly by), attack rate, and location data on California gulls. Secondly, we collected counts of western grebes (*Aechmophorus occidentalis*), American white pelicans (*Pelecanus erythrorhynchos*), great blue heron (*Ardea herodias*), double-crested cormorants (*Phalacrocorax auritus*), Caspian terns (*Hydroprogne caspia*), osprey (*Pandion haliaetus*), and common merganser (*Mergus merganser*) when they were in the area. Two observers worked morning shifts and two worked evening shifts. All daylight hours were covered, Monday through Friday and occasional weekends during the April through July juvenile salmonid outmigration. The study areas at both dams were too large to be seen by one person so they were divided into observation zones.

Visual foragers, such as piscivorous birds, require a certain amount of light to effectively locate and then attack fish. Sun light intensity was measured to help evaluate when birds began foraging at the projects, and the variability of predation activity throughout the day. These measurements were taken using a Simpson® Illumination Level Meter Model 408-2 at The Dalles Dam on eight separate days while rotating through all zones (n=51). This instrument reports in Foot-Candles and these were converted to lux using a 10.75 multiplier.

OBSERVATIONS

One observation session consisted of one observer watching one zone for one hour. First the observer counted the number of each species in the zone. Next they scanned the entire zone counting the number of gull attacks (beak hitting the water) occurring within 30 minutes, followed by 30 minutes of attack evaluation. That is, using binoculars (Leupold¹ 10 x 50 with 5° field of view) to focus on any diving individual, the observer evaluated the success of that attack (modified focal individual approach). There were three possible outcomes of attack evaluation: successful, unsuccessful, or unknown. An attack was considered successful if a fish was seen in the bill or the bird made an obvious swallowing motion by lifting its head skyward. An attack was unsuccessful if a bird emerged from the water with no obvious prey in its bill. If the observer could not be certain of the outcome it was classified unknown, for example if the bird was flying away from the observer or the observer's view was obstructed by waves as the bird emerged. The observation session ended with another count of each species in the zone and then the observer moved to the next zone.

¹ Use of brand name does not imply endorsement by the USACE.

BIRD ABUNDANCE AND FISH CONSUMPTION

Bird abundance was determined at the beginning and end of each observation session. Binoculars were used to identify birds to species and then a hand held mechanical tally-counter was used to quickly count individual birds. If no birds were present during the initial count a record of 'No Birds' was entered and the observer moved to the next zone. We estimated hourly gull abundance by calculating the hourly means (of all counts) for each observation zone and then summing these means to yield the hourly mean gull count for the study area (dam). Similarly, we estimated daily gull abundance by calculating the daily mean for each observation zone and then summing these means to yield a daily mean gull count for the entire study area.

Quantifying fish consumption requires knowing the number of attacks and the proportion of successful attacks for each day. Consumption was estimated for gulls using the equation:

$$F_c = A \times P_a \tag{1}$$

Where F_c is fish consumption for that observation, A is the number of attacks during that 30 minute attack scan, and P_a is the proportion of successful attacks (successful attacks / total attacks) for the following 30-minute evaluation scan. More robust than the focal individual approach (for practical difficulties see Major III et al. 2005) this method does not depend on an estimate of the predator population to calculate fish consumption. Rather, it requires that the observer monitors the behavior of all birds in a zone, counting attacks over a 30 minute period (which ranged between 0-10 attacks per minute). We felt this gave us a reliable value when compared to counting a flock of 100+ flying birds during instantaneous counts. Also, the modified focal individual approach is not subject to bias caused by atypical behavior of any given focal individual. Calculating fish consumption for each observation allows us to capture the weekly, daily, and hourly variability of gull behavior.

Because observers were not present in all zones at all times consumption values had to be expanded. For each day/zone combination, fish consumption estimates were averaged, expanded to one day, and then summed resulting in overall study site (dam) consumption. Expansion was accomplished by a factor of 30, derived from expanding the 30 minute attack rate to one hour, and the one hour estimate to 15 hours of gull activity in one day ($2 \times 15 = 30$).

$$F_{C_{total}} = 30 * \sum_{i=1}^z \sum_{j=1}^d \sum_{k=1}^{n_{ij}} \frac{F_{C_{ijk}}}{n_{ij}} \quad (2)$$

Where $F_{C_{total}}$ is total fish consumption during the April-July outmigration, i is the zone being observed, n_{ij} is the number of observation sessions in zone i during day j , $F_{C_{ijk}}$ is the observed fish consumed in zone i on day j during observation period k and 30 is the expansion factor. The sum of these is our point estimate and the 95% confidence intervals were calculated using the percentile bootstrap process re-sampled 10,000 times. The method of calculating seasonal per capita fish consumption (fish/gull/hour) is described in Zorich et al. 2011.

JOHN DAY DAM

The study area was divided into ten observation zones, two in the forebay and eight in the tailrace. The zones were defined in such a way as to allow a comparison between areas protected and unprotected by avian lines; six tailrace zones were covered by the avian array and two were not (Figure 2).

Two shifts with two observers per shift collected data Monday through Friday and occasional weekends, sampling all daylight hours. The morning shift began at sunrise (05:00 to 06:00 hrs) and the evening shift ended at sunset (20:00 to 21:00 hrs). Observers switched study site or shift every week to reduce observer bias. On each shift one person covered the north shore zones and one the south shore zones; on the next day they would switch sides. For the two forebay zones the north shore observer only recorded counts at the beginning and ending of a shift and did not evaluate attacks, as attacks were so infrequent there in 2009.

Total smolt passage at John Day Dam was calculated by Ben Sandford (NOAA) from daily collection counts expanded by estimated collection efficiency as detailed in Sandford and Smith (2002).

THE DALLES DAM

The study area was divided into eight observation zones, one in the forebay and seven in the tailrace. The forebay zone encompassed the entire forebay stopping at a line perpendicular to the river at the most upstream part of the earthen dam (Figure 3). The tailrace zones extended from the dam face downstream to a line perpendicular to the river at the US Coast Guard's green navigation marker on river right.

Observers collected data at The Dalles during all daylight hours, Monday through Friday and occasional weekends. In the morning, observers began at sunrise (05:00 to 06:00 hrs) and in the evening observers remained until sunset (20:00 to 21:00 hrs). Observers at The Dalles began on opposite sides of the dam and rotated through the zones, one clockwise and one counterclockwise. When samplers met at a zone, the second one to arrive would skip that zone and move to the next one in their rotation.

RESULTS

JOHN DAY DAM

OBSERVATIONS

California gulls were again the most dominant piscivorous bird at John Day Dam from April – July 2011. Seven observers worked four months completing 7,383 observation sessions (which included both one hour observations and count-and-go observations) during which time they made 9,526 counts used to estimate bird numbers, counted 1,963 gull attacks used to determine attack rates, and evaluated an additional 1,391 gull attacks used to determine success. Based on hourly mean counts, gulls were foraging for about 15 hours a day or 1,830 hours over the four month study. The two person teams observed in two, seven hour shifts, five days a week, for 80 days yielding 1,120 hours when observers were present. That is, they were present 61% of the time gulls were foraging at John Day Dam. Consumption estimates were expanded to account for the time observers were not present (see Methods).

BIRD ABUNDANCE AND FISH CONSUMPTION

In addition to California gulls there were seven other species of fish eating birds seen within the study area (Figure 5). In order of prevalence they were; western grebes found only in the forebay, American white pelicans, double-crested cormorants, osprey, great blue heron, Caspian terns, and common merganser. American white pelicans and California gulls occasionally loafed downstream of the study site (dredge islands) but no counts were collected this season.

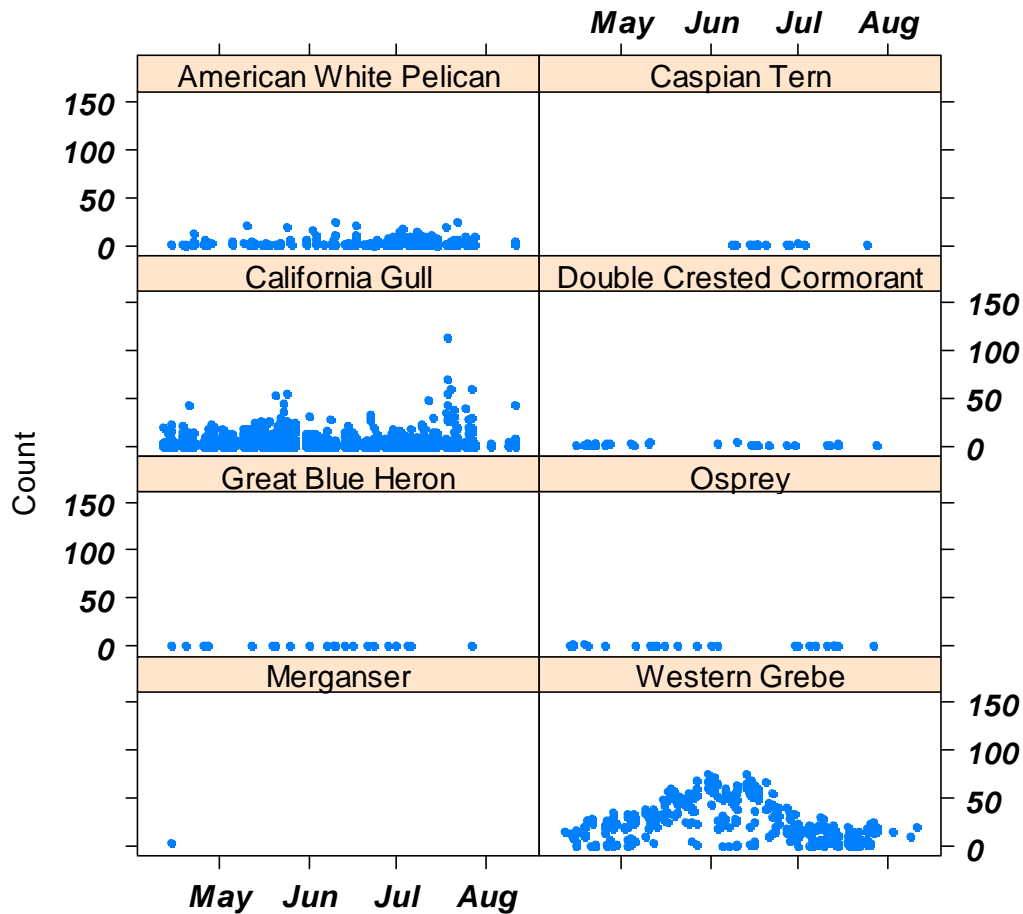


Figure 5. Piscivorous bird counts taken during each observation session at John Day Dam in 2011 (all behaviors, raw data).

Gull counts at John Day Dam were lower than in recent years, but peak counts continued to coincide with lamprey macrophthalmia passage and dropped as smolt passage dropped (Figure 6). Except for an early peak in April reflecting an increased buildup of gulls loafing in the forebay, the pattern of gull counts follows fish passage. In 2009 and 2010 peak gull counts and peak lamprey passage occurred in mid-June (Zorich et al. 2010, 2011). However in 2011, perhaps due to higher than normal flows, peak lamprey passage came during the last part of May, and was two orders of magnitude smaller than 2010. It also coincided with the peak smolt outmigration in 2011, unlike previous years.

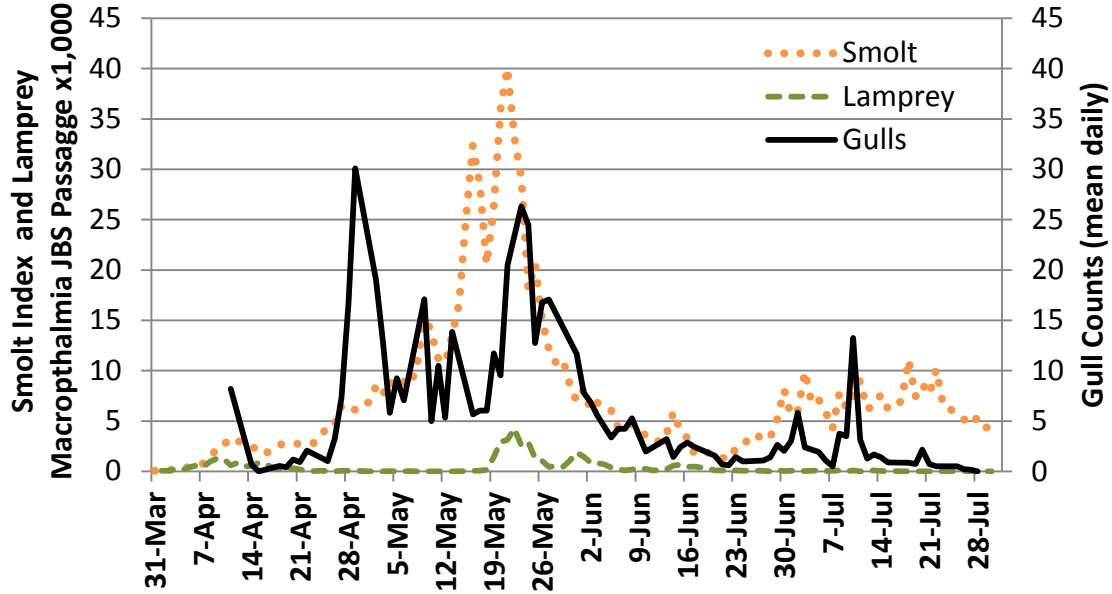


Figure 6. Daily mean gull counts at John Day Dam in relation to the smolt index (Columbia River DART webpage) and lamprey macrophthalmia passage numbers from the smolt monitoring facility during 2011.

Not many gulls were observed in zones closest to the dam covered by avian deterrent lines. Gull abundance was highest in the SW T4 zone on the spillway side of the river, one of the two tailrace zones not covered by avian deterrent lines. This zone averaged 2.2 gulls throughout the season (Figure 7). The second highest counts were in the powerhouse forebay (PH FB) where 1.3 was the mean gull count. The third highest count was 0.8 in the PH T4 zone which was the other tailrace zone not covered by the avian lines. The lowest counts were in SW T1 and SW T2 on the spillway side of the river with 0.01 and 0.03 respectively. Although fewer gulls were present, gull abundance in each zone was similar to the pattern we saw in 2010, the first year with the current avian lines installed (Zorich et al. 2011).

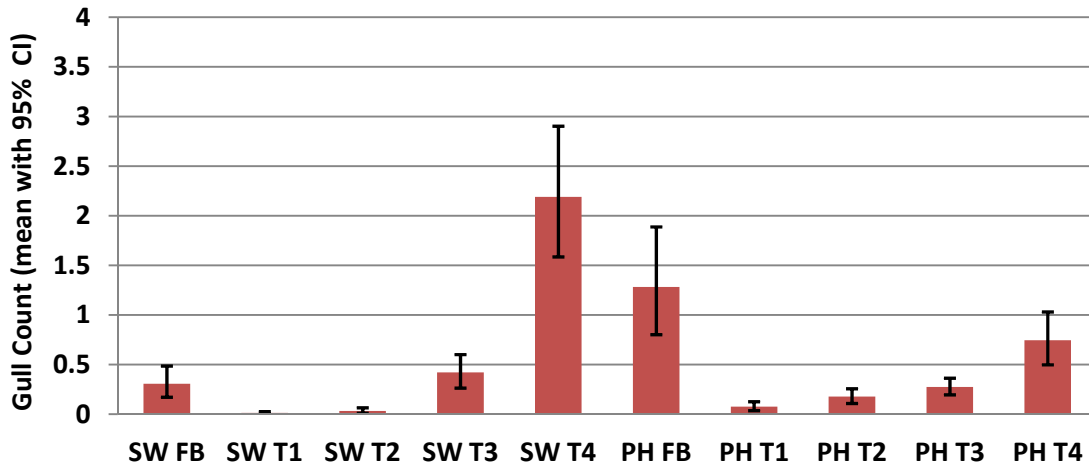


Figure 7. Seasonal mean gull counts at John Day Dam by observation zone with 95% bootstrapped CI's. SW FB = spillway forebay, PH FB = powerhouse forebay, SW T1 to SW T4 = spillway tailrace zones, PH T1 to PH T4 = powerhouse zones.

Gull numbers and attack rate changed throughout the day showing no clear pattern (Figure 8). While attacks did increase with light intensity (lux) at the beginning of the day and decrease with light intensity at the end of the day, they also decreased mid-day.

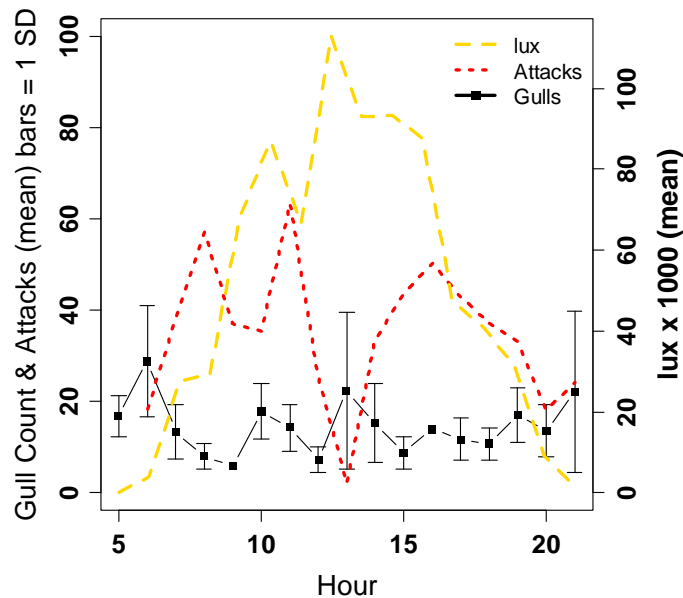


Figure 8. Hourly mean gull counts and attacks at John Day Dam in 2011. Light intensity (lux n=51) was measured at The Dalles Dam 24 river miles downstream.

Both attacks and gull numbers were likely impacted by the two shifts of pyrotechnic hazing done from a boat just downstream of the boat restricted zone in zones SW T4 and PH T4. Hazing generally started between 06:30 and 07:30 and ended around 19:00 with a break at 10:00 and a shift change around 14:00. Observers noted that gulls were quick to respond to gaps in hazing, rapidly increasing in number, but then leaving when the hazing boat returned.

The mean per capita consumption (Table 1), as measured by fish consumed per gull per hour, ranged from a low of 0.21 in the PH T3 zone downstream of the powerhouse to a high of 0.89 immediately downstream of the spillway in the SW T1 zone. John Day had a seasonal mean per capita consumption of 0.52 fish per gull per hour, lower than the values reported for John Day in 2010 (Zorich et al. 2011).

Table 1. Per capita fish consumption as measured by fish consumed per gull per hour at John Day Dam in 2011 with upper and lower bootstrap confidence intervals (95%).

	SW T1	SW T2	SW T3	SW T4	PH T1	PH T2	PH T3	PH T4
Mean	0.89	0.52	0.62	0.74	0.47	0.24	0.21	0.46
Upper	2.67	1.23	1.10	0.93	1.14	0.50	0.38	0.64
Lower	0.00	0.00	0.24	0.57	0.00	0.05	0.07	0.30
Days*	6	7	51	78	16	35	50	67

* The number of days with non-zero gull counts used to calculate per capita consumption.

The heat maps in Figure 9 display the location of attacks on fish by California gulls for each month of the study. The density of attacks displayed on the maps increases as colors change from dark to light with blue representing the lowest density and white representing the highest. It is important to note that the number of attacks (n) varied from month to month with May having 2,314 attacks and April only 240. The location of attacks varied by month, but the highest concentration of attacks was consistently downstream of the avian line array on the spillway side of the river. In July there were also attacks under the avian deterrent lines downstream of the TSW's, but overall number of attacks were low (n = 503).

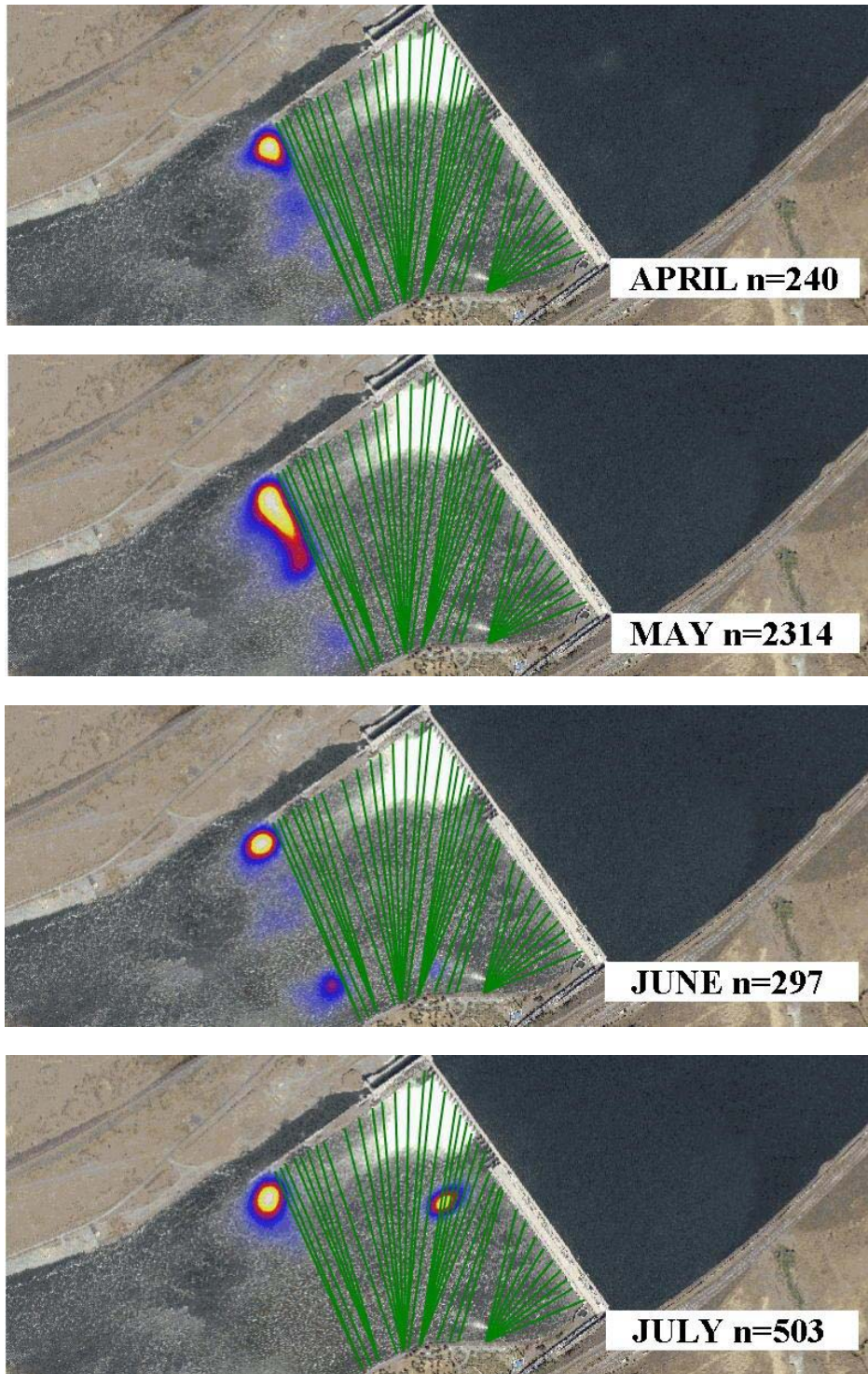


Figure 9. Heat map of attack locations by California gulls at John Day Dam in 2011. Density of attacks increase as colors change from dark to light (blue to red to yellow to white). The n indicates the number of attacks plotted each month.

At John Day Dam estimates of fish consumption, which includes additive and compensatory sources of mortality, were 6,000 (95% CI 4,000 – 8,000) or 0.02% of the estimated 31.3 million smolt passing this dam (Ben Sandford personal communication 3/1/12). This is a reduction of 32,000 (84%) from 2010 when an estimated 38,000 fish were consumed and a reduction of 102,000 (94%) from 2009 when 108,000 fish were consumed.

THE DALLES DAM

OBSERVATIONS

Eight observers worked four months completing 4,853 observation sessions during which time they made 7,730 counts used to estimate the bird numbers, counted 5,678 gull attacks used to determine attack rates, and evaluated an additional 3,920 gull attacks used to determine success. Based on hourly mean counts, gulls were foraging for 15 hours a day or 1,830 hours over the four month study. Observers were present 61% of the time yielding 1120 observation hours at The Dalles Dam. Consumption estimates were expanded to account for the time observers were not present (see METHODS).

BIRD ABUNDANCE AND FISH CONSUMPTION

In addition to California gulls seven other species of fish eating birds were commonly seen within the study area (Figure 10). In order of prevalence the other seven were double-crested cormorants (in the forebay loafing on the north side transmission towers), osprey, American white pelicans, western grebes, Caspian terns, common mergansers, and great blue heron. Due to high water, gulls and American white pelicans were unable to loaf downstream on the basin islands.

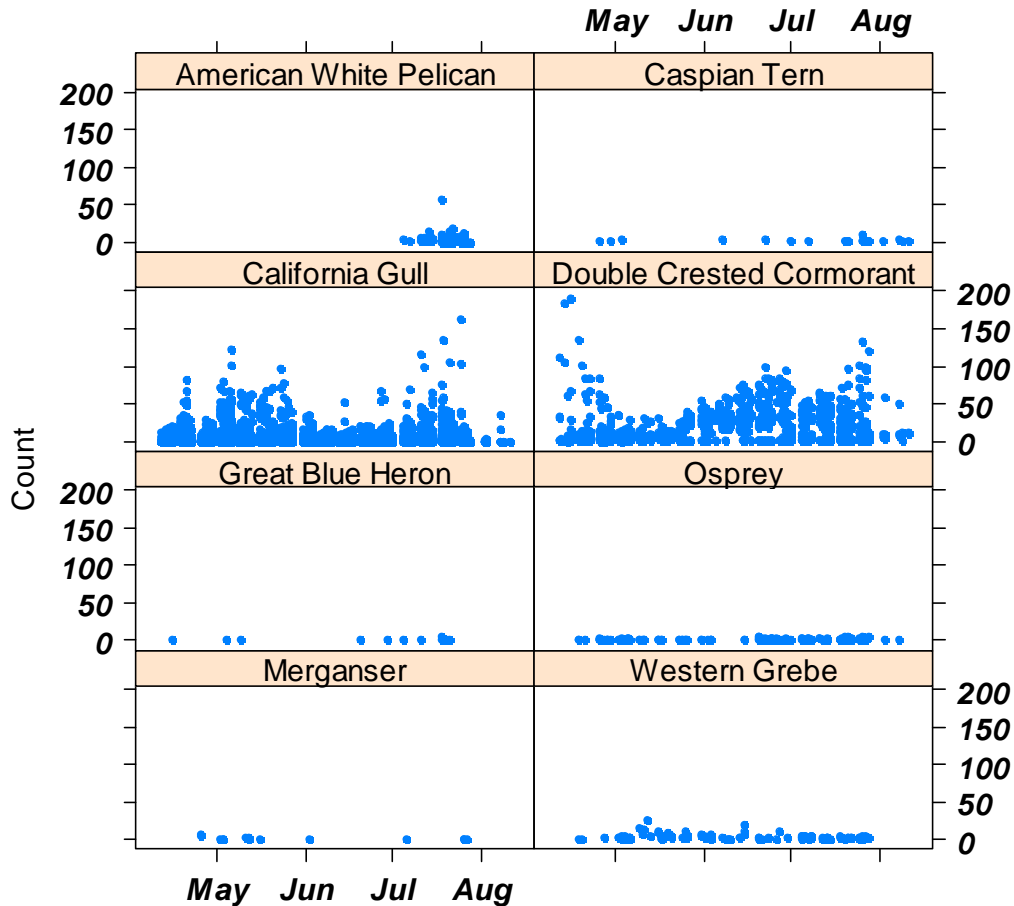


Figure 10. Piscivorous bird counts taken during each observations at The Dalles Dam in 2011(all behaviors, raw data).

Gull counts at The Dalles Dam were highly variable with the highest counts occurring in late May and tapering off through the rest of the fish passage season (Figure 11). Reduced gull numbers can be attributed to the pre season expansion of the avian array and boat hazing as well as to swift flows and high tail water levels which occurred from the end of May throughout the month of June. The high water levels submerged islands within and just downstream of the spillway tailrace which are frequently used by gulls and other piscivorous avian predators as resting locations. The lack of near dam areas to congregate coupled with the highly turbid rapidly moving water swiftly carrying juvenile fish through the tailrace likely discouraged gulls from remaining around project.

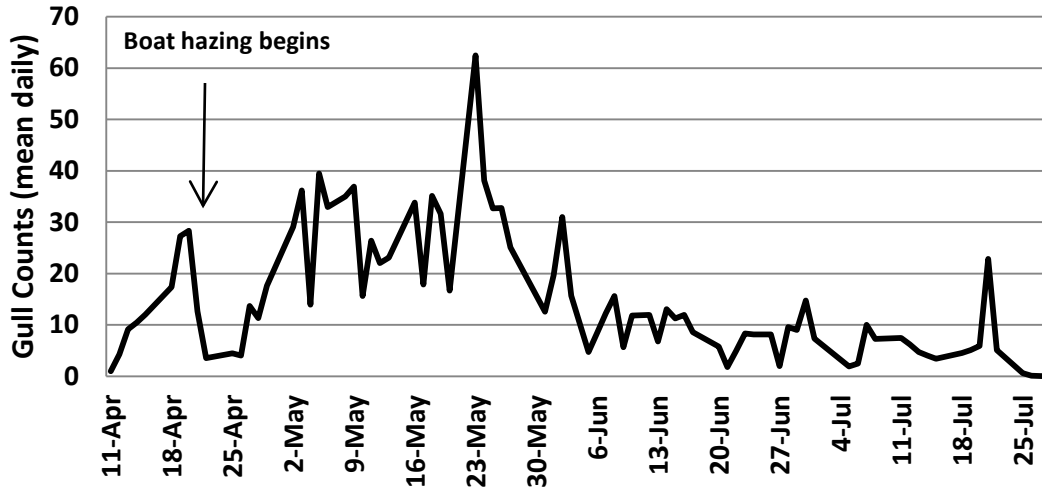


Figure 11. Daily mean gull counts at The Dalles Dam collected from April through July of 2011.

Seasonal mean gull counts by zone were highest in zone SW T4 downstream of the US-197 bridge averaging 7.4 gulls throughout the season (Figure 12). The second highest count was a mean of 2.3 in the SW T2 zone which was downstream of the spillway south of the spill wall. The SW T3 zone has both an avian deterrent array and an area that is not covered by lines. Most of the activity was in the area not covered by the lines or the two downstream most lines. The zone immediately downstream of the spillway, SW T1, and the forebay (FB 1) had the lowest seasonal mean gull counts with 0.01 each.

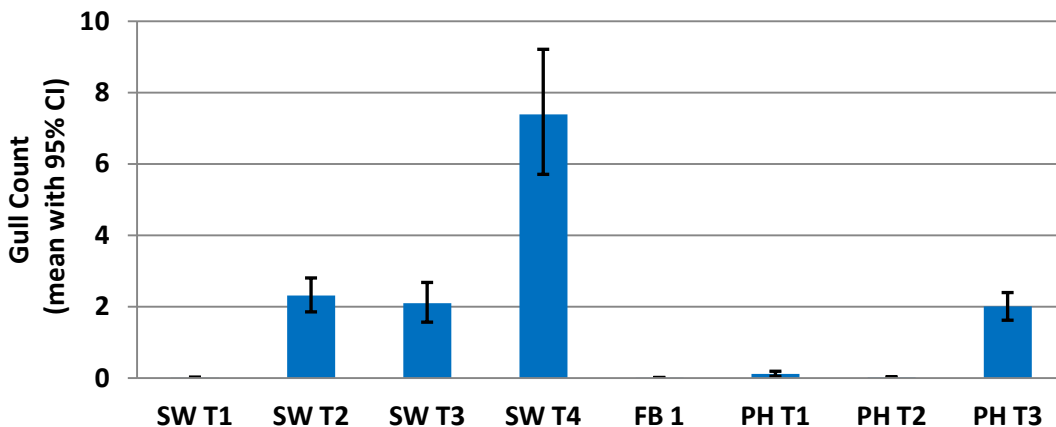


Figure 12. Seasonal mean gull counts at The Dalles Dam by observation zone with 95% bootstrapped CI's. FB = forebay, SW T1 to SW T4 = spillway tailrace zones with, PH T1 to PH T3 = powerhouse zones. SW T1, SW T2, PH T1, And PH T2 are adjacent to dam.

The frequency of gull numbers and attacks changed throughout the day. Attacks were highest early in the morning and later in the evening, a pattern somewhat similar to gull counts, but were also impacted by hazing which generally started between 06:30 and 07:30 and ended around 19:00 (Figure 13). See also Zorich et al. 2010 for diurnal gull behavior with little or no hazing impact.

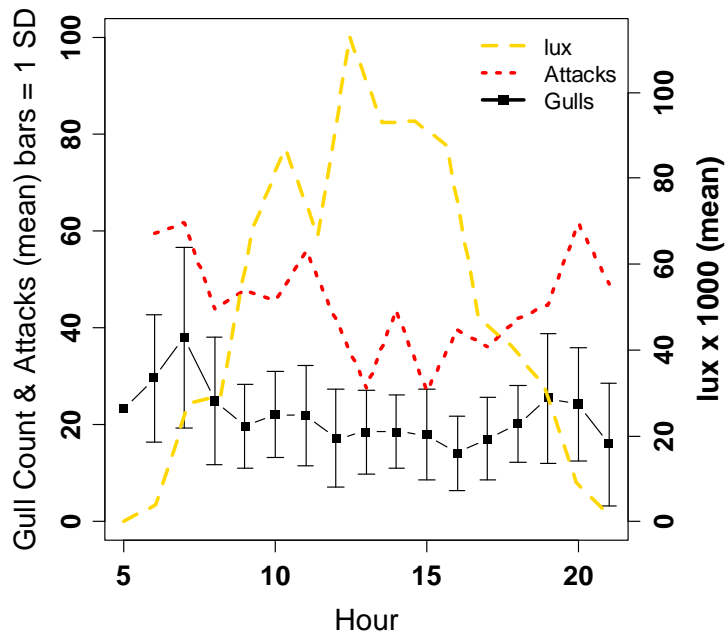


Figure 13. Hourly mean gull counts and attacks at The Dalles Dam in 2011. Light intensity (lux n=51) was measured while rotating through the observation zones.

While gull counts initially increase with light intensity (lux) and decrease with light intensity at the end of the day, the number of attacks seemed to do the inverse unlike the pattern at John Day. Attacks dropped mid-day possibly due to glare on the water caused by the high angle of the sun, again the impact of hazing is a confounding factor.

Mean per capita consumption, as measured by fish consumed per gull per hour, ranged from a low of 0 in the SW T1 and PH T2 zones to a high of 0.72 in the SW T3 zone immediately upstream of US-197 bridge (Table 2). The Dalles had a seasonal mean per capita consumption of 0.52 fish per gull per hour which was lower than the rate at The Dalles in 2010 (1.80 fish/gull/hour).

Table 2. Per capita fish consumption as measured by fish consumed per gull per hour at The Dalles Dam in 2011 with bootstrapped confidence intervals (95%).

	SW T1	SW T2	SW T3	SW T4	PH T1	PH T2	PH T3
Mean	0	0.38	0.72	0.58	0.38	0	0.52
Upper CI	0.00	0.47	0.91	0.71	0.73	0.00	0.66
Lower CI	0.00	0.30	0.53	0.46	0.09	0.00	0.39
Days*	4	75	73	79	17	4	74

* The number of days with non-zero gull counts used to calculate per capita consumption.

At The Dalles Dam our estimates of fish consumption, which includes additive and compensatory sources of mortality, was 16,000 (95% CI 13,000-20,000). This is a reduction of 70,000 (81%) from 2010 when an estimated 86,000 fish were consumed. Here also, gulls attacks were spatially heterogeneous, focused immediately downstream of the avian lines, primarily on the spillway side of the river.

The heat maps in Figure 14 display the location of attacks on fish by gulls for each month of the study. The density of attacks displayed on the maps increases as colors change from dark to light with blue representing the lowest density and white representing the highest. It is important to note that the number of attacks (n) varied from month to month with the maximum in May (5,938) and minimum in July (1,045). The location of attacks varied throughout the sampling season. During April, May, and July the highest concentration of activity was immediately downstream of the US-197 bridge, however, in June the activity switched to the area downstream of the ice/trash sluiceway outfall and powerhouse near the Oregon shore. The image used to create this map was taken prior to the completion of a second guidance wall located between spillbays 8 and 9. The wall was constructed to direct smolt into the old river thalweg.

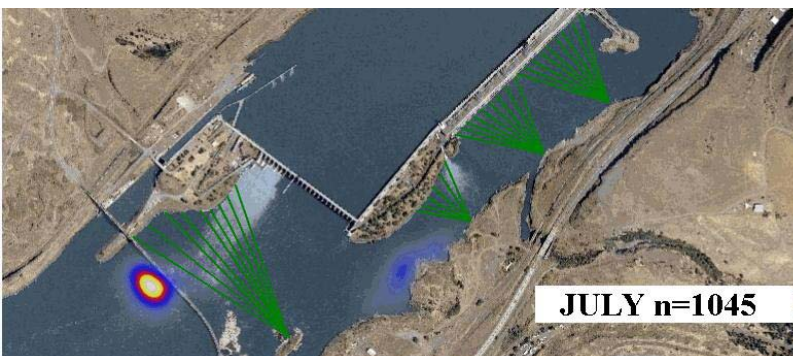
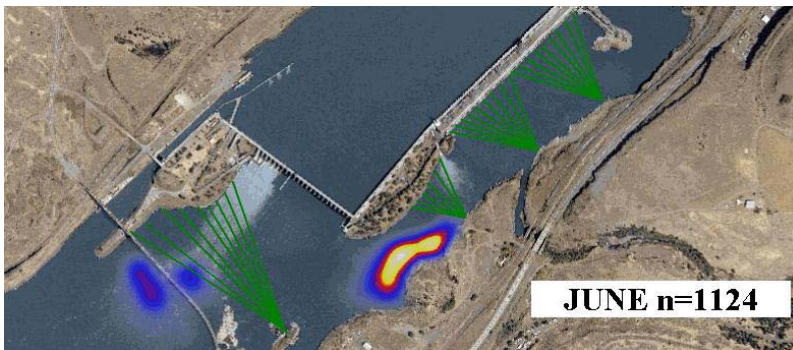
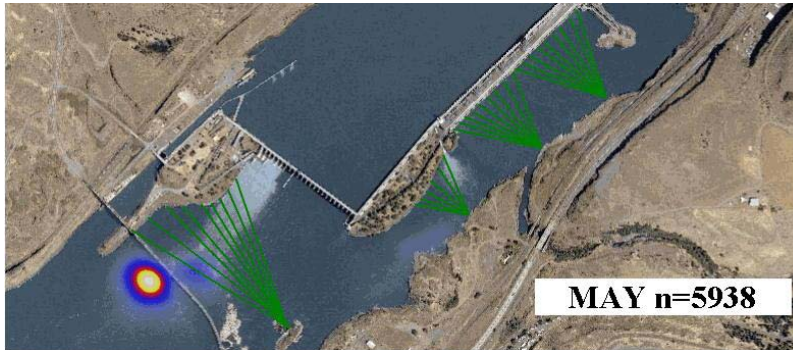
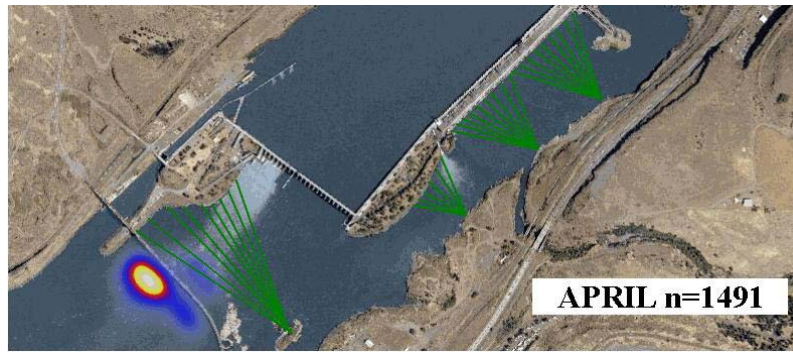


Figure 14. Heat map of attack locations by California gulls at The Dalles Dam in 2011. Density of attacks increase as colors change from dark to light (blue to red to yellow to white). The n indicates the number of attacks plotted each month.

MULTI-YEAR COMPARISON

When comparing fish consumption by gulls between years and between dams we found that consumption declined each year since its peak in 2009 (Figure 15). The lowest point estimates were seen in 2011, and was significantly different than the previous two years (lack of overlapping 95% CI's is interpreted as significant). We also found that in 2010 and 2011 John Day Dam gulls ate fewer fish than gulls at The Dalles Dam.

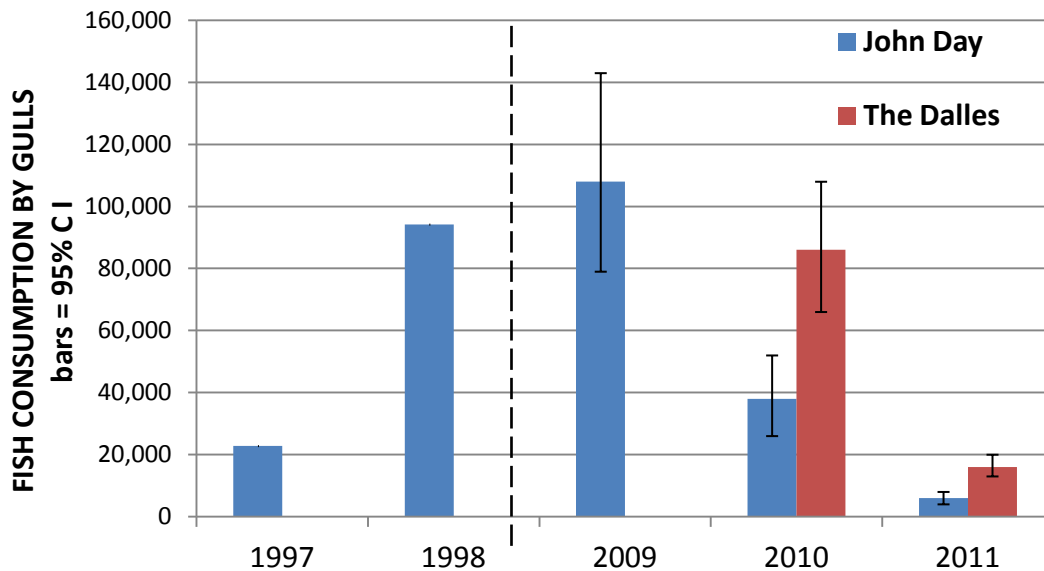


Figure 15. Comparison of fish consumption between years and dams. Estimates are from several USACE Fish Field Unit reports: 1997, 1998 (Jones et al. 1998,1999) and 2009, 2010, and 2011 (Zorich et al. 2010, 2011, and present study). See Table 3 in the Appendix for data table.

In addition to gulls, we counted other species of piscivorous avian predators during the three summers at John Day and two summers at The Dalles. In 2009 at John Day, gulls were the most numerous bird counted with a mean daily count of 99.2 birds followed by western grebes with a mean daily count of 28.2 birds (Figure 16). In 2010 and 2011, western grebes were the most numerous bird counted at John Day with mean daily counts of 27.7 and 31.9 birds respectively.

At The Dalles Dam, which was not observed in 2009, the gulls outnumbered all other species in 2010 with a mean daily count of 33.6 birds followed by double crested cormorants with a mean daily count of 10.8 birds (Figure 17). This situation was reversed in 2011 with cormorants being the most numerous species with a mean daily count of 30.9 birds compared to gulls, the second most numerous species, at 14.7 birds. However, in both years the bulk of the double crested

cormorants were roosting in the transmission towers on the north side of the river – not foraging (these counts include both foraging and non-foraging birds).

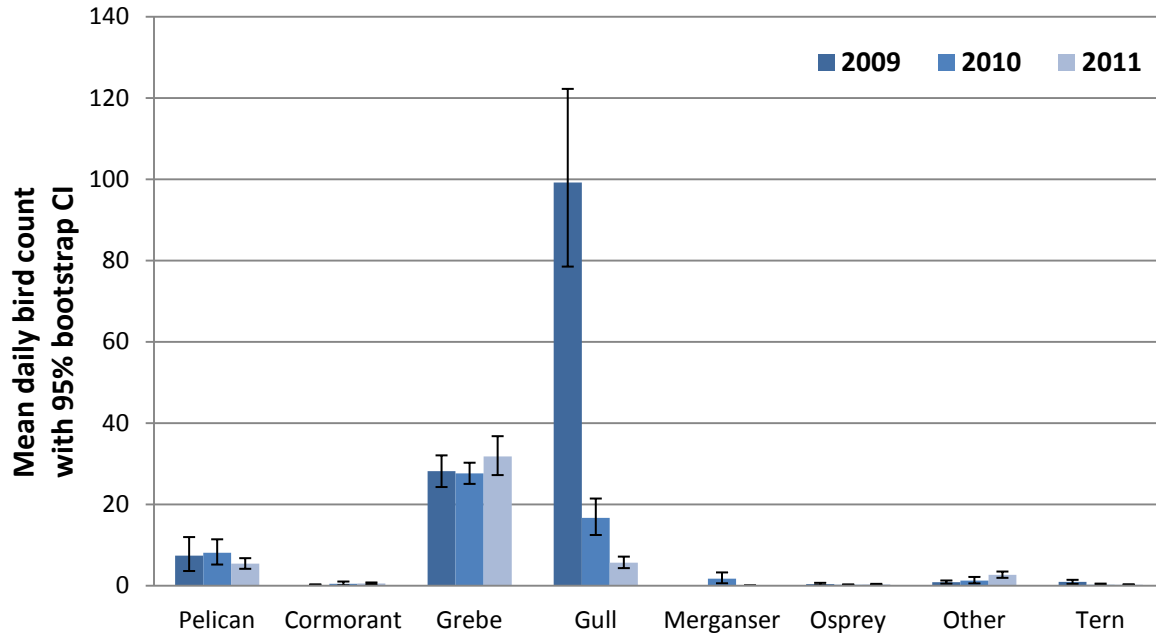


Figure 16. Mean daily bird counts from 2009-2011 at John Day Dam.

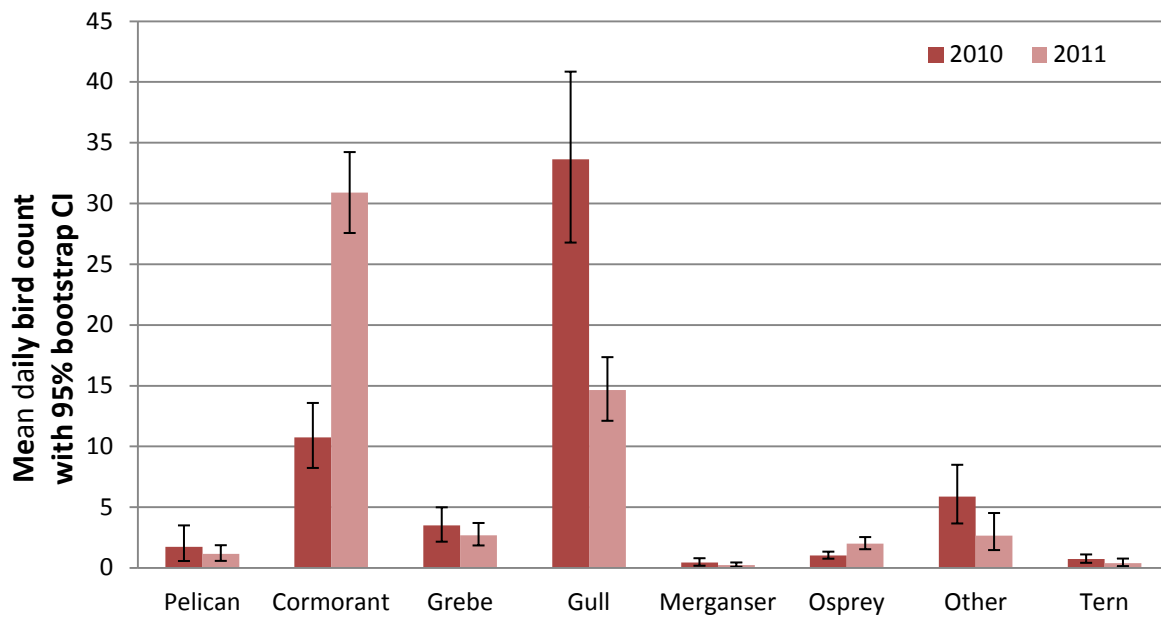


Figure 17. Mean daily bird counts from 2010-2011 at The Dalles Dam.

DISCUSSION

The abundance of California gulls and associated fish consumption decreased each year from 2009 to 2011, while the abundance of other actively foraging birds was similar each year (low). Species composition and distribution were stable at both dams through the three outmigration seasons and observed foraging was primarily in the spillway tailrace.

Fish consumption by gulls at both dams was the lowest we have estimated in any of the three years of this study. Proportionally it is lower than estimates at other hydroelectric dams and similar to or lower than bird predation away from dams. At John Day Dam, if we assume all fish consumed were salmonids, it would be 0.02% of the estimated 31.3 million smolt passing the dam. This is less than fish consumed by ring-billed gulls (*L. delawarensis*) below Wanapum Dam on the Columbia River estimated at 2% by Ruggerone in 1986. It is also much less than the proportion of steelhead tags recovered from mixed Caspian tern and gull colonies (8.1%) and less than the proportion of recovered sockeye tags (0.6%) during a survival study at Priest Rapids Dam on the mid-Columbia (Timko et al. 2011). Finally, it was less than the 10.3% consumption of juvenile hatchery Chinook by California and Ring-billed gulls at fish structures on the Yakima River (Major III et al. 2005).

When compared to more natural systems fish consumption at John Day Dam was less than the 1.1 – 2.4% of hatchery released salmon fry (pink and chum) eaten by mixed seabirds in Prince Williams Sound (Sheel & Hough 1997). Also, proportional fish consumption by California gulls at John Day Dam was similar or lower than estimates of <0.1 to 8.4% mortality caused by common merganser on out migrating steelhead, Chinook, and Coho smolt on east Vancouver Island (Wood 1987). Since there is no juvenile collection facility at The Dalles Dam it is not possible to estimate total smolt passage or percent of the run consumed. Still, absolute fish consumption was higher at The Dalles Dam than at John Day Dam.

While fewer gulls were counted than in previous years, California gulls were still the most abundant foraging species at both dams. Ring-billed gulls were not observed actively foraging in any year despite co-nesting on Miller Island Rocks. This is consistent with the observations of York et al. (2000) who found California gulls more reliant on fish than Ring-billed gulls nesting nearby, but contrary to Ruggerone (1986) who identified Ring-billed gulls as the primary avian predator at Wanapum Dam upstream of the Snake River confluence. Perhaps this is due to the more aggressive California gulls displacing ring-billed gulls, but this is speculative. Double crested cormorants were found in similar numbers to gulls at The Dalles Dam, but these birds were loafing there in the north transmission towers – not feeding. Loafing cormorant numbers were most numerous at dawn and dusk moving out of the study area during the day and returning in the evening. Western grebes continue to be well represented in the John Day forebay.

Frequently more than 50 grebes were counted there during June (Figure 5) with fewer in the forebay of The Dalles Dam (Figure 10). Similar to previous years, osprey, great blue herons, and mergansers had only minimal presence at both dams while American white pelicans seem to be increasing.

Gull distribution was consistent with previous years. Using tablet PC's with geo-referenced maps and a stylus, observers were able to specify attack locations and how they changed over time. The heat maps show hot spots immediately downstream of the avian deterrent lines, primarily on the spillway side of the river (Figure 9 and Figure 14). This indicates that the avian lines and hazing are protecting fish immediately after dam passage, and in the case of John Day Dam, they remain protected until about 650 meters (2,100 feet) downstream of the spillway. This data collection system proved to be an excellent tool for fine scale evaluation of the avian deterrent lines. It allowed us to document how infrequently birds penetrated the lines and generated heat maps that determined the areas of highest density of attacks.

At John Day Dam estimated fish consumption decreased in each of the three study years from 108,000 to 38,000 to 6,000 (2009, 2010, 2011 respectively). At The Dalles Dam estimated fish consumption also greatly decreased from 86,000 to 16,000 (2010 to 2011). Since bird hazing method and intensity was greatly increased from 2009 to 2010 (the addition of boat hazing most daylight hours), we would expect a reduction in fish consumption. However, hazing method and intensity were similar between 2010 and 2011, and yet we saw the greatest reduction in fish consumption between these years. As the deterrent effort was similar in 2010 and 2011, we attribute the decreases in fish consumption to natural variation in the number of foraging gulls and not to level of deterrent effort. The reduction in gulls may have been due to the unusually high runoff and river level. Prey would be difficult to see due to high turbidity and high water velocity but the near dam environment was also changed. For example, at The Dalles Dam in 2010 hundreds of gulls would loaf on downstream basalt islands and make forays to the dam or to the nearby Wasco County landfill. In 2011 high river levels kept these important loafing islands covered with water for most of the spring outmigration. This may have contributed to the reduction of gulls in the area and thus the reduction of fish consumed. Regardless, the management objective of reducing avian predation was achieved in both 2010 and 2011 at John Day Dam. As well, in 2011 avian predation was reduced at The Dalles Dam aided by the expansion of the spillway avian lines and continuation of boat hazing.

RECOMMENDATIONS

The goal of protecting out migrating juvenile salmonid and juvenile lamprey at US Army Corps dams will likely become more difficult if gull populations continue to increase in the western United States (Conover 1979, 1983, and Ackerman et al. 2009). For continued protection against avian predation we recommend the current passive deterrents (avian lines) be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams. A standardized monitoring program (daily counts at Columbia and Snake river US Army Corps dams) will allow for the tracking of piscivorous bird abundance through time, and allow for the application of increased levels of active hazing as a response to flare up in bird predation.

As avian deterrent line arrays become increasingly large and complex, it is likely the maintenance requirements will also increase. To keep them working properly requires regular inspections, criteria for when an action should be taken, and a person assigned to be responsible for each array. Most of these actions are already taking place formally or informally at the project level.

A standardized monitoring program (daily counts) at all Federal Columbia River Power System Dams will help meet Biologic Opinion (NOAA 2008) requirements of Reasonable and Prudent Action (RPA) 68 regarding the monitoring of avian predators and greatly inform RPA 47 regarding the development of an inland avian management plan for Corps owned lands and RPA 48 regarding the implementation and improvement of avian deterrent programs. In support of the Walla Walla District's Inland Avian Predator Work Group and Fish Passage Operations and Maintenance committee, the Fish Field Unit has proposed such a project and is planning to begin establishing basin-wide standardized monitoring protocols in 2012.

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APPENDIX

Table 3. Data table comparing fish consumption between dams and years. Other studies included for in-basin comparison.

Fish Consumption	95% CI*	Dam	Year	Predator	Author
6,000	4,000 – 8,000	John Day	2011	CAGU	Present Study
38,000 [†]	26,000 – 52,000	John Day	2010	CAGU	Zorich et al. 2011
108,000 [†]	79,000 – 143,000	John Day	2009	CAGU	Zorich et al. 2010
94,176		John Day	1998	CAGU	Jones et al. 1999
22,772		John Day	1997	CAGU	Jones et al. 1998
16,000	13,000 – 20,000	The Dalles	2011	CAGU	Present Study
86,000 [†]	66,000 – 108,000	The Dalles	2010	CAGU	Zorich et al. 2011
119,250		Wanapum	1982	RBGU	Ruggerone 1986

[†] These fish consumption values have been calculated from the raw data to facilitate comparison to the 2011 estimates. Smolt consumption was reported in 2009 and 2010 but was not possible in 2011 due to lack of diet analysis.