AVIAN PREDATION AT JOHN DAY AND THE DALLES DAMS 2010:

ESTIMATED FISH CONSUMPTION USING DIRECT OBSERVATION WITH DIET ANALYSIS.

By

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EXECUTIVE SUMMARY

Avian predators are one highly visible cause of smolt mortality at hydropower dams. In the Columbia basin, if severe enough this predation may prevent a dam from meeting its survival goals required by the Biological opinion for Endangered Species Act listed salmonid passage. In 2010, the second year of this study, our task was to determine the impact of avian predators on fish passing John Day and The Dalles Dams. Our objectives were: 1) Determine species composition, number, and distribution of piscivorous birds 2) Estimate smolt consumption by gulls 3) Compare smolt consumption by gulls (*Larus spp.*) between years and between dams.

To quantify avian consumption, observers used binoculars to count gulls, the rate of attacks (dives), and determine if an attack was successful (fish in bill) during the smolt outmigration period from 8 April to 28 July 2010. We then estimated salmonid consumption using those variables and diet information from weekly gull stomach collections. Additionally, counts were collected for other fish eating birds present at the dams.

California gulls (*Larus californicus*) were the dominant piscivore at both dams followed by western grebes (*Aechmorphorus 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 8 April to a brief high of 118 on 14 June, declining rapidly to two on 17 June, yielding a seasonal mean of 17. At The Dalles Dam gull daily abundance ranged from zero on 12 April to a high of 133 on 19 May, slowly decreasing to four on 27 July, yielding a seasonal mean of 34.

Overall, 349 California gull stomachs were collected for diet analysis. Stomachs from John Day Dam contained 101 salmonids, 12 Pacific lamprey macropthalmia (*Entosphenus tridentatus*), three other fish, eight unidentified fish, and insects. We also recovered 18 PIT tags, 12 of which were un-readable tags. Gull stomachs from The Dalles Dam contained 75 salmonids, 113 Pacific lamprey macropthalmia, and three unidentified fish as well as five readable and four un-readable PIT tags and landfill scraps (e.g. old french fries). Fewer macropthalmia were collected at John Day likely because high winds made it unsafe to operate our collection boat during the week of peak lamprey outmigration.

At The Dalles Dam our estimate of smolt consumption, was 98,000 (58,000 - 145,000 95% CI). At John Day Dam our estimate of smolt consumption, was 18,000 (11,000 - 26,000 95% CI). Consumption estimates include both additive and compensatory sources of mortality. This is a reduction of 62,000 (76%) from 2009 when 80,000 smolt were consumed at John Day and is attributed to intensive boat hazing and a large avian deterrent line array.

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INTRODUCTION

BACKGROUND

Predation on juvenile salmonids and Pacific lamprey macropthalmia by piscivorous avian predators has long been a problem at Columbia River hydroelectric dams (Ruggerone 1986, Wiese et al. 2008). At the lower river dams, Bonneville, The Dalles, and John Day, predation by gulls has been documented (Jones et al. 1998, 1999, Jonas et al. 2008). In recent years project biologists at The Dalles and John Day have noted an increase in the number of gulls feeding at both projects (Figures 1 & 2). In an attempt to reduce the impact on migrating fish a variety of methods have been employed including avian line arrays in the tailrace areas of the dams as well as active hazing methods such as pyrotechnics and propane cannons. In addition to this, lethal take has been employed sporadically to reinforce the effectiveness of hazing. Gull predation on fish passing The Dalles and John Day dams may be aggravated by the presence of a nearby colony of California and ring-billed gulls on Miller Island Rocks (Roby et al. 2011).

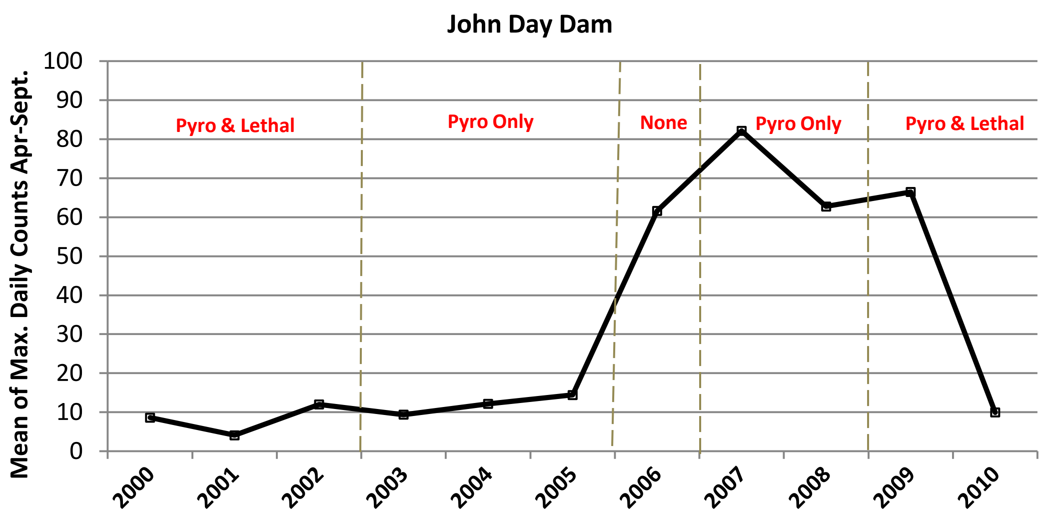

Figure 1. Mean yearly gull count from maximum daily counts provided by the project biologists at John Day Dam (in all areas) from April to September during fishway inspections.

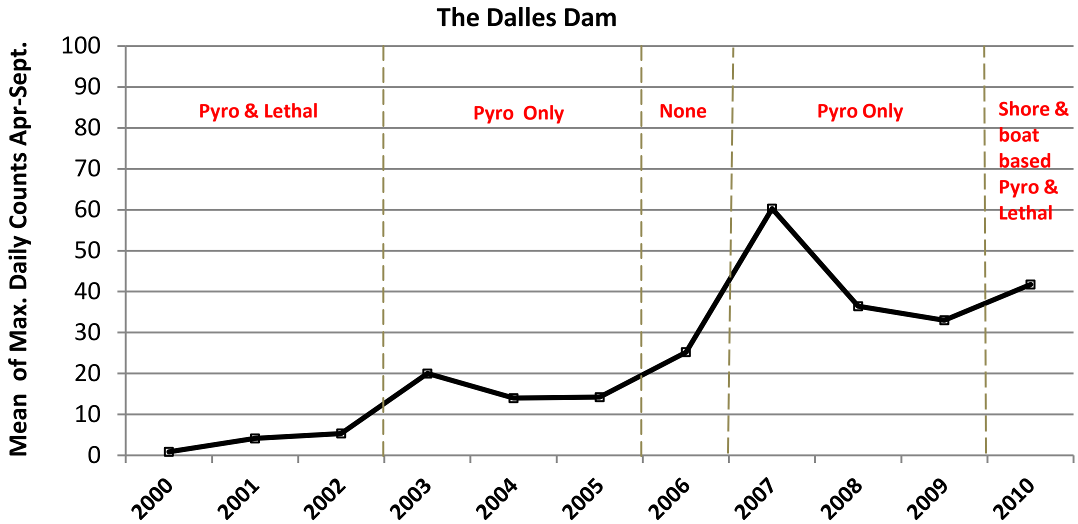

Figure 2. Mean yearly gull count from maximum daily counts provided by the project biologists at The Dalles Dam (in all areas) from April to September during fishway inspections.

Gulls exploit multiple food sources including juvenile fish, agricultural land, and garbage from landfills. All of these food sources are available to the birds on the gull breeding colony at Miller Island Rocks. There is a large landfill at Arlington, OR upstream of John Day Dam and a landfill on the outskirts of The Dalles, OR near The Dalles Dam. The dams, agriculture lands, and landfills provide the gulls from Miller Island Rocks a variety of food sources and the option to change their feeding habits as circumstances dictate. Human intervention, such as hazing, may move the gulls from one food source but they readily move to other sources. From a management perspective this is problematic because hazing activity merely moves the gulls into someone else's area of concern.

Researchers have yet to quantify the additive and compensatory proportions of bird caused mortality. Gulls consume juvenile salmonids and lamprey in the tailrace of the dams but to date there are no effective methods of determining whether the fish they consume are moribund (compensatory mortality) or healthy fish (additive mortality). Ruggerone (1986) recognized this problem 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 determining the impact of avian predators on juvenile salmonids, some of which are federally listed as threatened or endangered, and evaluating the effectiveness of the fully deployed synthetic avian line array installed at John Day Dam in 2010. Concerned that birds deterred from John Day Dam would simply feed at The Dalles Dam, we dispatched a smaller observation team there.

We had three objectives:

1) Determine species composition, number, and distribution of piscivorous birds.
2) Estimate smolt consumption by gulls.
3) Compare smolt 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 straight north-south line starting with the navigation lock, spillway, and then powerhouse (Figure 3). 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 2010 spill was 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. The TSW's were in service from April 10, 2010 to July 21, 2010. 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.

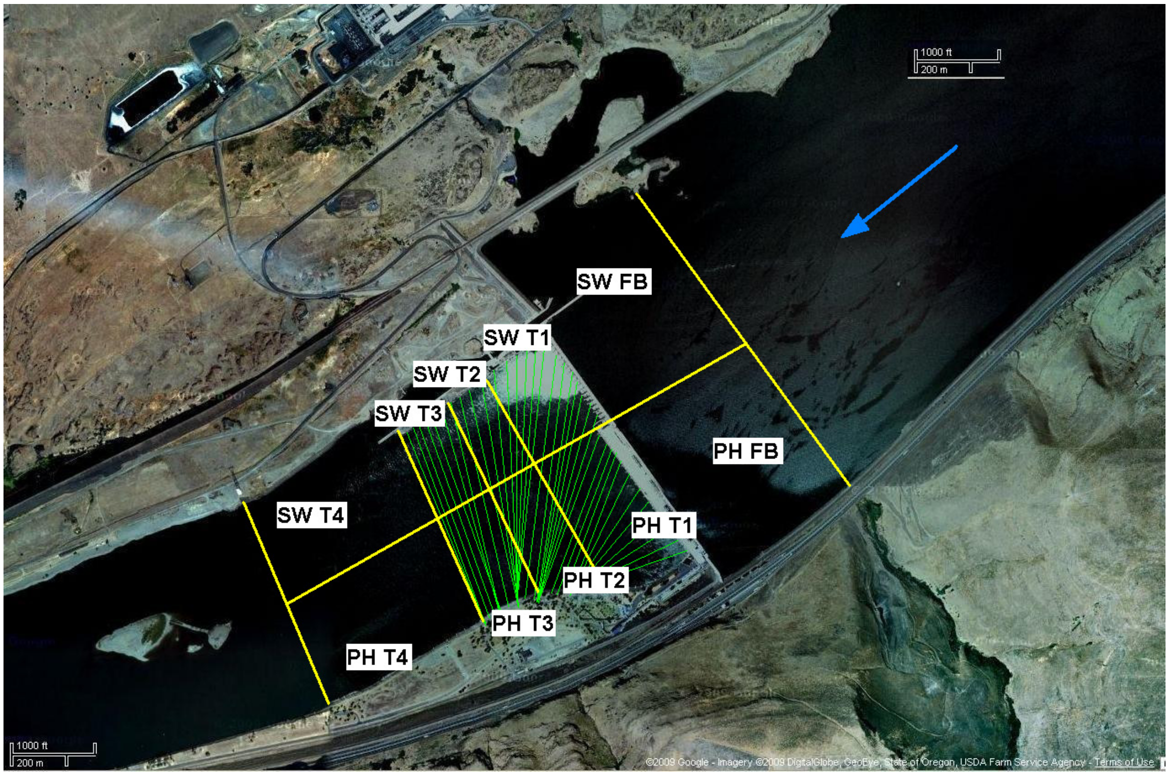

Figure 3. Image of John Day Dam at Columbia River mile 216 (©Google Images 2009). Flow is from right to left with the 2010 avian array represented by thin diagonal lines and the observation zones demarked by yellow lines.

Avian deterrents at John Day Dam included both a passive line array and active boat based hazing. The avian line array was designed to include 128 main lines plus lower 'filler' lines, however, three lines failed early in the season. Therefore in 2010 the array consisted of 125 lines composed of 3/16" Plasma® 12 stand (by Cortland)[1]. The material weighs 1.7 kg / 100 m with a minimum tensile strength of 5,500 lbs. Lines close to the dam span the river from towers on the shore to attachment points on the powerhouse, spillway, and navigation lock. Downstream the lines span the river from tower to tower or steel cable anchor lines between the towers. The USDA was on site April through July operating boats in the John Day tailrace. On days when they entered the boat restricted zone (BRZ) they employed two boats, one for hazing and one as a safety boat. The USDA agents fired pyrotechnics from the boat to discourage gulls from feeding in the vicinity of the dam. They also conducted lethal take of gulls to reinforce the effectiveness of pyrotechnics. These animals were used in our diet studies.

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

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 with the spillway perpendicular to the flow and the powerhouse with a non-overflow monolith parallel to the flow (Figure 4). The powerhouse is not screened for juvenile fish. Instead an ice-and-trash sluiceway is used to intercept juvenile fish and divert them away from the turbines to an outfall chute between the monolith and powerhouse. In 2010 spill was regulated to 40% night and day. The only deviation from this occurred if the saturated gas cap was exceeded and spill was reduced to ameliorate these elevated levels.

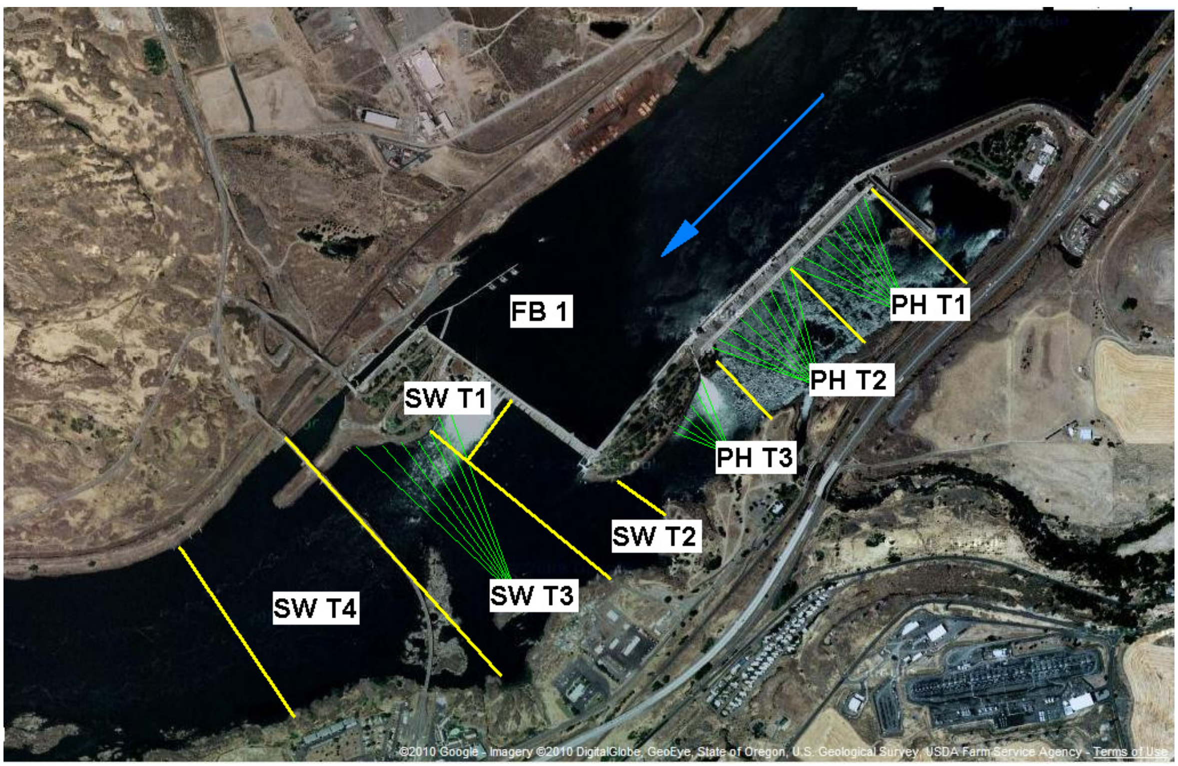

Figure 4. Image of The Dalles Dam at Columbia River mile 192 (©Google Images 2009). Flow is from right to left with the avian array represented by thin green diagonal lines and the observation zones demarked by yellow lines.

Avian deterrents at The Dalles Dam included a passive line array as well as active boat based and shore based hazing. The avian line array consisted of 46 stainless steel lines crossing the tailrace side of the powerhouse and spillway. Lines connected to poles on the Oregon shore spanned the powerhouse tailrace to attachment points on the powerhouse hand rail and fencing downstream of the ice and trash sluiceway. Downstream of the spillway lines spanned the river from a pole on an island near the Oregon shore to attachment points along the Washington shore.

The USDA was on-site from April through July either operating boats in The Dalles tailrace, hazing from the Washington shore, or both. The USDA agents fired pyrotechnics from the boats to discourage gulls from feeding in the vicinity of the dam. They also conducted lethal take of gulls to reinforce the pyrotechnics. These animals were used in our diet studies.

METHODS

COMMON TO BOTH DAMS

The two major components of this study were direct observation of foraging behavior and collection of stomach contents to determine which species of fish were being consumed. We collected quantitative, behavioral, and dietary information on California gulls. Secondarily, we collected quantitative data on western grebes, American white pelicans, great blue heron (*Ardea herodias*), double-crested cormorants, and Caspian terns (*Hydroprogne caspia*) when they were in the area. The study areas at both dams were divided into observation zones. Observers were on-site all daylight hours, Monday through Friday during the April through July juvenile salmonid outmigration. Birds removed for management purposes were processed by the FFU staff.

OBSERVATIONS

One observation sample 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 (Leupold[2] 10 x 50 magnification with 5° field of view) to focus on any diving individual to evaluate 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. Finally the observation period ended with another count of each species in the zone and then the observer moved to the next zone.

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[2] Use of brand name does not imply endorsement by the USACE.

BIRD ABUNDANCE AND SMOLT CONSUMPTION

Bird abundance was determined at the beginning and end of each observation. Binoculars were used to identify birds to species and then a hand held mechanical tally-counter was used to quickly count individual birds. We estimated hourly gull abundance by calculating the hourly means (of all counts) for each observation zone and then summing these means to yield an hourly mean gull count. 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 project.

Quantifying smolt consumption requires knowing the number of attacks, the proportion of successful attacks, and diet composition for that week. Consumption was estimated for gulls in the observation zones by slightly modifying Equation 6 from Weiss et al. 2008:

$$S_c = A \times P_a \times P_d \tag{1}$$

Where S_c is smolt consumption for that observation sample, A is the number of attacks during that 30 minute attack scan, P_a is the proportion of successful attacks (successful attacks / total attacks) for the following 30 minute evaluation scan, and P_d is the proportion of salmonids found in the diet that week. More robust than the focal individual approach, this method does not depend on a population estimate to calculate smolt consumption. Rather, it requires that the observer monitors the behavior of all birds in a zone, counting attacks over a 30 minute period (range of 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.

Because observers were not present in all zones at all times consumption values had to be expanded. For each week/zone combination, estimates were averaged, expanded to one week, and then summed to provide overall project consumption. Expansion was accomplished by a factor of 210, derived from expanding the 30 minute attack scan to one hour, 15 active hours in one day, and seven days in one week.

$$S_c\ project = \sum_{i=1}^{Zones}\left(\sum_{j=1}^{Weeks}\left(\left(\frac{\sum_{k=1}^{n} Sc_k}{n}\right) * 210\right)\right) \tag{2}$$

Where $S_{c\ project}$ is total smolt consumption during the April-July outmigration, *i* is the zone being observed, *n* is the number of observations in zone *i* during week *j*, *k* is an individual observation, and 210 is the expansion factor. The mean for each zone-week combination is multiplied by 210 to expand for all daylight hours that week. The sum of these is our point estimate and the 95% confidence intervals are calculated using the percentile bootstrap process.

Seasonal per capita fish consumption (fish/gull/hour) was estimated using the following set of calculations for each zone (*z*):

$$K_z = \frac{\sum_{j=1}^{d} k_j}{d} * 2 \tag{3}$$

Where K_z is the seasonal mean per capita consumption for zone *z*, and *d* is the number of days zone *z* had non-zero gull counts, k_j is the daily mean per capita consumption for zone *z* on day *j*, and 2 is the factor expanding the 30 minute mean to one hour.

$$k_j = {}^{s}/_{g} \tag{4}$$

Where *s* is the mean daily consumption for zone *z* on day *j*, and *g* is the daily mean number of gulls in zone *z* on day *j*.

$$s = \frac{\sum_{i=1}^{n} Sc_i}{n} \tag{5}$$

Where S_c is the consumption for each 30 minute observation in zone *z* on day *j* and *n* is the number of observations in zone *z* day *j*.

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. The two forebay zones were separated mid-river where the powerhouse and spillway meet, drawing a line upstream to a floating white can buoy marking the forebay boat restricted zone. The upstream boundary was created by drawing a line from a triple culvert on the Oregon shore to the Coast Guard navigation marker situated on an island near the Washington shore. The eight downstream zones were also bisected by a line extending from the junction of the powerhouse and spillway, essentially following the middle of the river. In the tailrace, zones were separated north to south as follows: 1) a line running from the upstream avian array tower on the north shore to the Smolt Monitoring Facility (SMF) outfall, 2) a line from the middle avian array tower to the new upstream tower on the south shore, 3) a line from the downstream tower on the navigation lock peninsula to the downstream tower on the south shore. The power lines crossing the river delineated the downstream boundary of the study area (Figure 3).

Two three person shifts collected data Monday through Friday, 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). Morning and evening crews switched every two weeks to reduce sampler bias. Each crew consisted of a person covering the north shore, one on the south shore, and a rover that cycled through all zones switching roles daily. Observers only counted birds in the two forebay zones and did not observe attacks, as attacks were so infrequent there in 2009. Samplers were assigned random zone starts at the beginning of each shift and then rotated through their designated zones.

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. The powerhouse tailrace had three zones. The zone lines in the powerhouse tailrace were as follows: 1) a line beginning at the east fishway entrance and running perpendicular to the powerhouse and terminating on the Oregon shore, 2) a line beginning at the middle of the powerhouse and running parallel to the first line to the Oregon shore, 3) a line beginning at the west fishway entrance across to the pumping station downstream of Fifteen Mile Creek, and 4) a line running through the middle of and parallel to the spillway dam extending across the river. The spillway tailrace had four zones. The zone lines were defined as follows: 1) a line running parallel to the spillway dam and touching the tip of the spillway deflection wall, 2) a line running the length of the spillway deflection wall, 3) a line starting at the navigation lock peninsula at the base of the US-197 bridge and running parallel to the main bridge structure across to the Oregon shore. The downstream boundary of the study area is defined by a line crossing the river approximately 100 meters downstream of the bridge (Figure 4).

Observers collected data at The Dalles during all daylight hours, Monday through Friday. 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). At The Dalles, there was typically only one observer on site at any given time so some days did not have complete diurnal coverage. To collect more samples, observers only did counts and did not perform attack scans in the forebay or in zones that did not have gulls during the initial count. Samplers were assigned random zone starts at the beginning of each shift and then systematically rotated through all zones.

DIET ANALYSIS

The USDA Wildlife Services was contracted by the USACE to reduce gull predation at both dams using a variety of deterrents including lethal take with shotguns. The FFU examined the gut contents of birds taken as a result of this management action. Analyzing these stomach contents allowed us to determine the species of fish likely being consumed during successful attacks. We collected stomachs from California gulls which were processed according to a standard protocol (Appendix A). We recorded species and age based on plumage, whole bird weight, cord length (bend in wing to tip of longest primary feather), scanned for PIT tags, and sexed birds when gonads were visible. Stomach contents were removed and on ice within two hours of collection to prevent further digestion of soft tissue.

SOFT TISSUE FROM THE FOREGUT

Gull stomachs consist of two compartments the foregut (protoventriculus), and the gizzard (ventriculus). As fish are digested most of the fleshy tissue is dissolved in the foregut with harder bones moving down into the gizzard where they may be worked by strong muscles and bits of gravel. Since fish are digested head first, identification using whole fish morphology is not always possible, at times less than half the fish remained. Once removed, whole or partially digested fish were enumerated then all gut contents were placed in a Whirl-pak®[3] and weighed. Finally they were then transferred to a freezer. We assume all soft tissue, primarily whole or partial fish, collected from the foregut were most representative of the diet near the dams. This may not be valid if a bird recently moved into to the study area after feeding elsewhere.

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[3] Use of brand name does not imply endorsement by the USACE.

HARD PARTS FROM GIZZARD

Stomach contents were delivered to the University of Washington's bird laboratory to confirm identification of soft tissue (whole and partially digested fish), and to identify hard tissue (cranial bones and otoliths removed from the gizzard). Contents were identified to fish species or food group (invertebrate, vegetation, and detritus). Their analysis included numbers of fish and percent biomass for major prey items. Fin clips from a subset of the salmonids were sent to the Washington Department of Fish and Wildlife (WDF&W) Molecular Genetics Laboratory for stock determination and species verification.

Each bird carcass was scanned for a PIT tag with an FS2001 full duplex PIT tag reader and hand held antenna (Destron-Fearing[4]). Tag codes and fates were uploaded to the Columbia Basin PIT Tag Information System (PTAGIS) database. To provide added information on the behavior of fish that were consumed by birds, we determined the last known detection (PIT) and / or passage route for all readable tags.

RESULTS

JOHN DAY DAM

OBSERVATIONS

The majority of our observations were focused on John Day Dam since thorough evaluation of boat hazing and the new avian line array were important. California gulls were again the most dominant piscivorous bird at John Day Dam from April – July 2010. Six observers worked four months completing 3,818 observation records during which time they made more than 9,000 counts used to estimate bird numbers, counted 10,301 gull attacks used to determine attack rates, and evaluated an additional 8,366 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 three 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).

[4] Use of brand name does not imply endorsement by the USACE.

While California gulls were the most abundant species at John Day Dam, seven other species of fish eating birds were commonly seen within the study area (Figure 5). In order of prevalence they were: western grebes (*Aechmophorus occidentalis*) found only in the forebay, American white pelicans (*Pelecanus erythrorhynchos*), common mergansers (*Mergus merganser*), great blue heron (*Ardea herodias*), osprey (*Pandion haliaetus*), double-crested cormorants (*Phalacrocorax auritus*), Caspian terns (*Hydroprogne caspia*), and infrequent sightings of ring-billed gulls (*Larus delawarensis*) usually standing on the shore or in a parking lot.

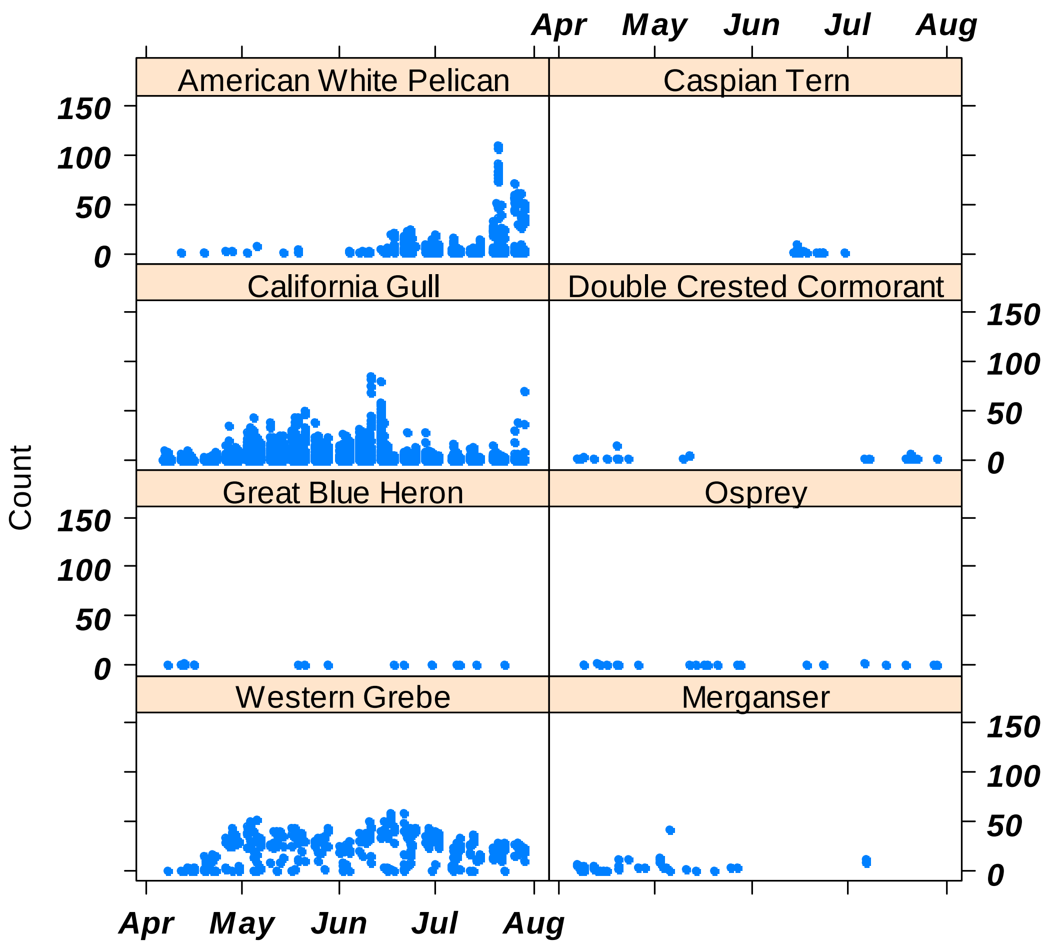

Figure 5. Piscivorous birds counted during observations at John Day Dam in 2010.

Smolt consumption was estimated for California gulls only as they were the most numerous piscivorous predator throughout the smolt migration. One possible violation of this assumption was the number of western grebes in the forebay of John Day Dam. The majority of the birds observed in the forebay were grebes. They were mainly resting, head on back, with two to four individuals diving closer to the dam and occasionally surfacing with smolt.

As in 2009, American white pelicans and California gulls frequently used the dredge islands downstream of the study area as a loafing site. These birds were not included in our analysis but are reported here (Figure 6). This appeared to be a safe place for several bird species to loaf during the day. We also saw fewer numbers of Canada geese (*Branta Canadensis*), ravens (*Corvus spp.*), and even great blue herons sharing the sandy shore of the island. Although American white pelicans were observed on the water nearby they were not observed actively feeding. From these islands birds could quickly move upstream and into the John Day tailrace as defined in figure 3.

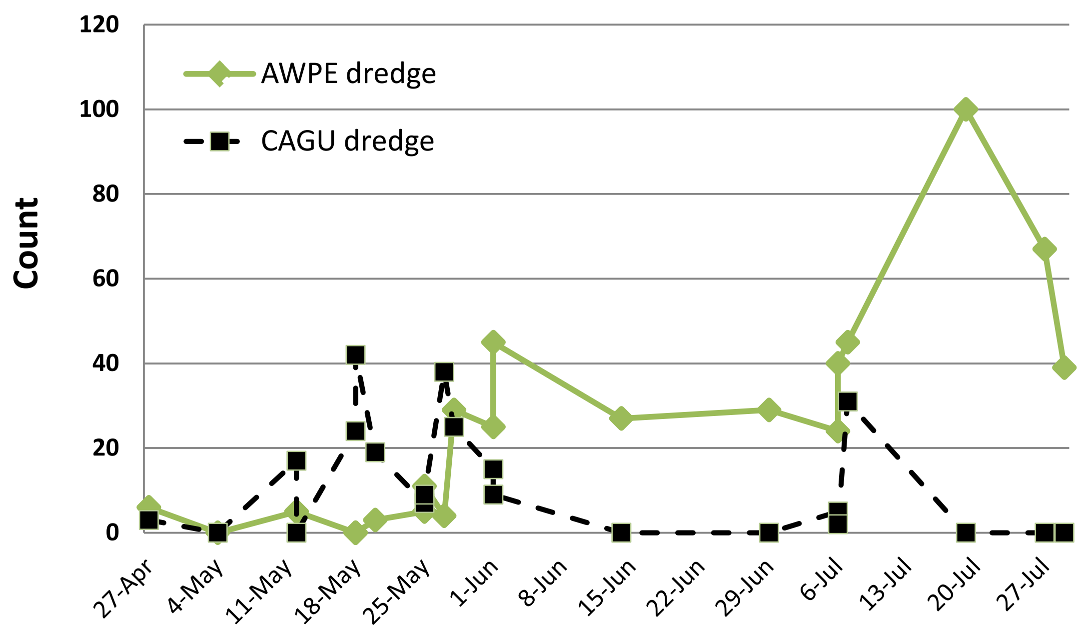

Figure 6. Convenience counts of American white pelicans (AWPE) and California gulls (CAGU) on dredge islands just downstream of the John Day Dam study area, 2010.

The hourly mean gull count started with 14.2 gulls during the 0500 hour, dropped to 9.6 gulls once hazing began during the 0600 hour, and then climbed to a morning high of 15.8 during the 0700 hour. As light levels reached near maximum during the 1300 hour gull numbers dropped again averaging 10.5 (Figure 7). Counts then increased to a daily high of 18.1 gulls during the 1900 hour. As light levels began to fall gull numbers decreased to an evening low of 10.4 during the 2100 hour prior to most gulls leaving the dam. Estimate variability was high throughout the day and is displayed by the +/- 0.5 standard deviation error bars. However, there was no discernable pattern. Similar numbers of gulls were present regardless of the time of day. Counts did not display the same crepuscular periodicity that was seen in 2009. This may be due to effective hazing from boats during all daylight hours and the greatly expanded avian line array.

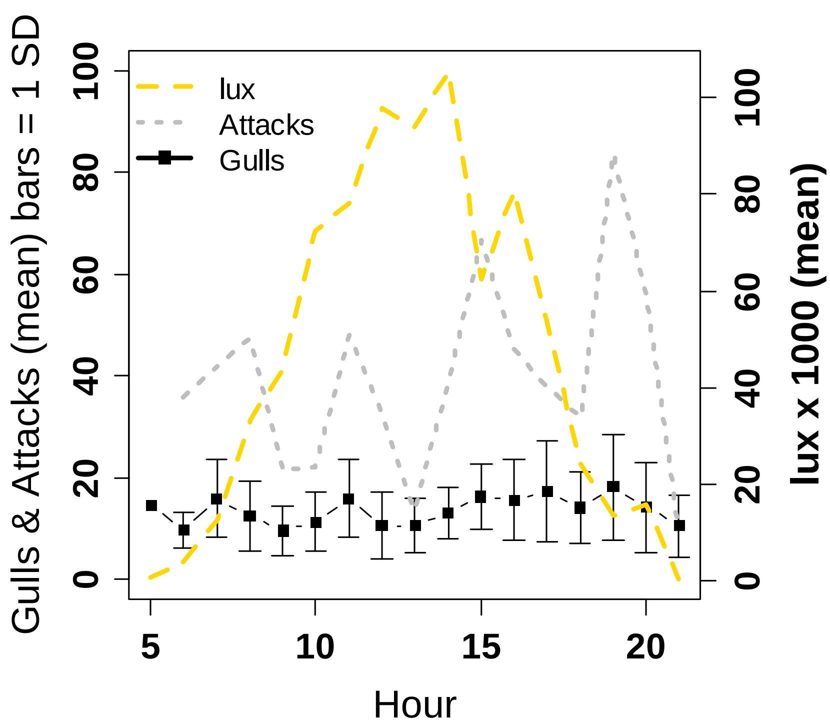

Figure 7. Hourly mean gull counts and attacks count at John Day Dam in 2010. Light intensity (lux) was measured at John Day Dam.

The presence of gulls in the tailrace can be seen in the uncovered zones furthest downstream of the dam SW T4 and PH T4 (Figure 8). Spikes in the SW T3 and PH T3 zones can be contributed to gulls working the downstream edge of the avian deterrent line array and moving slightly into the T3 zones underneath the first few avian lines.

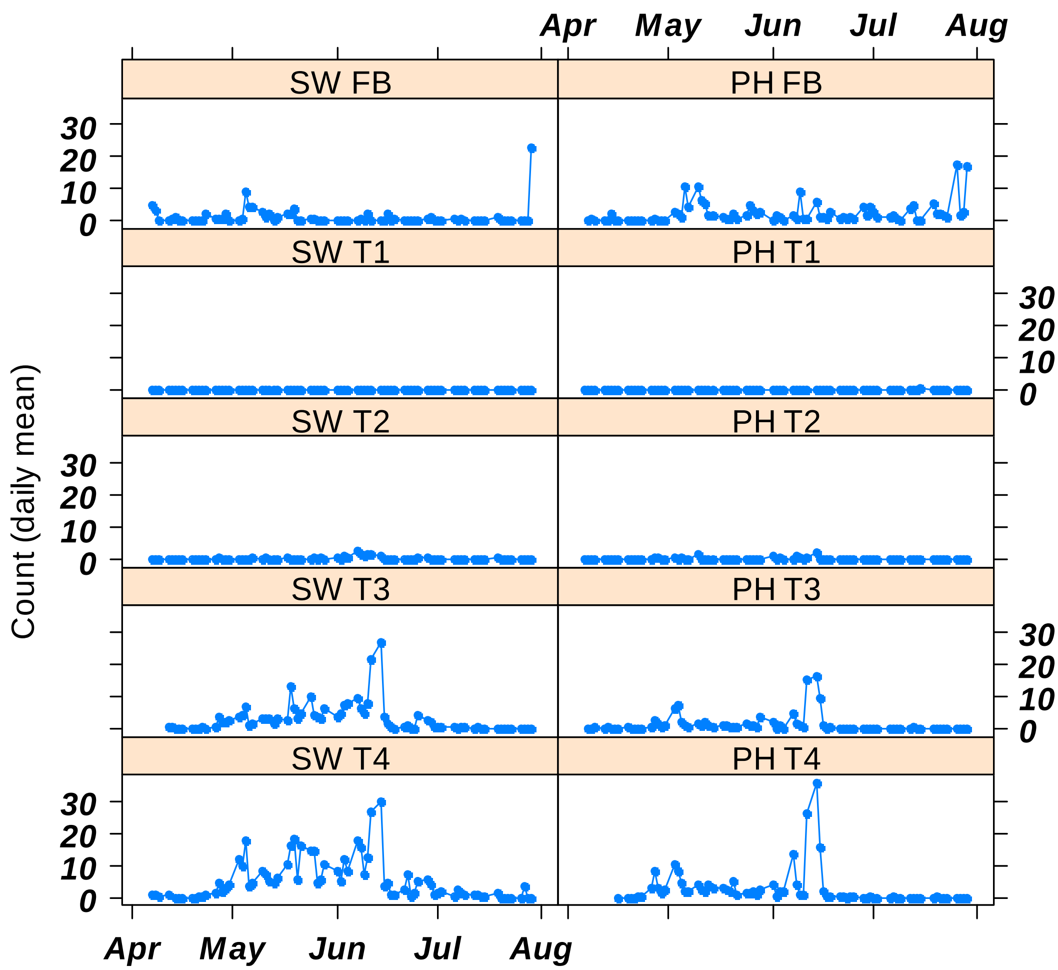

Figure 8. Daily mean gull counts at John Day Dam in ten zones, 2010. See Figure 3 for zone locations. SW = Spillway and PH = Powerhouse. Panels are arranged from upstream (top) to downstream (bottom).

At the end of July there were also groups of hatch year birds that would loaf on the water or shore of the dam's forebay. Typically they were not actively feeding.

Similar to 2009, gulls arrive at the dam with the beginning of smolt passage. However their numbers were not well correlated with the magnitude of smolt passage. Instead the two highest peaks in mean daily gull counts correlated with the peaks in Pacific lamprey macropthalmia passage rather than smolt passage (Figure 9). Lamprey macropthalmia pass the dams in large numbers during or after high flow events. In 2010 during a seven day period in June the peak passage through the smolt monitoring facility reached an estimated 140,000 before swiftly declining.

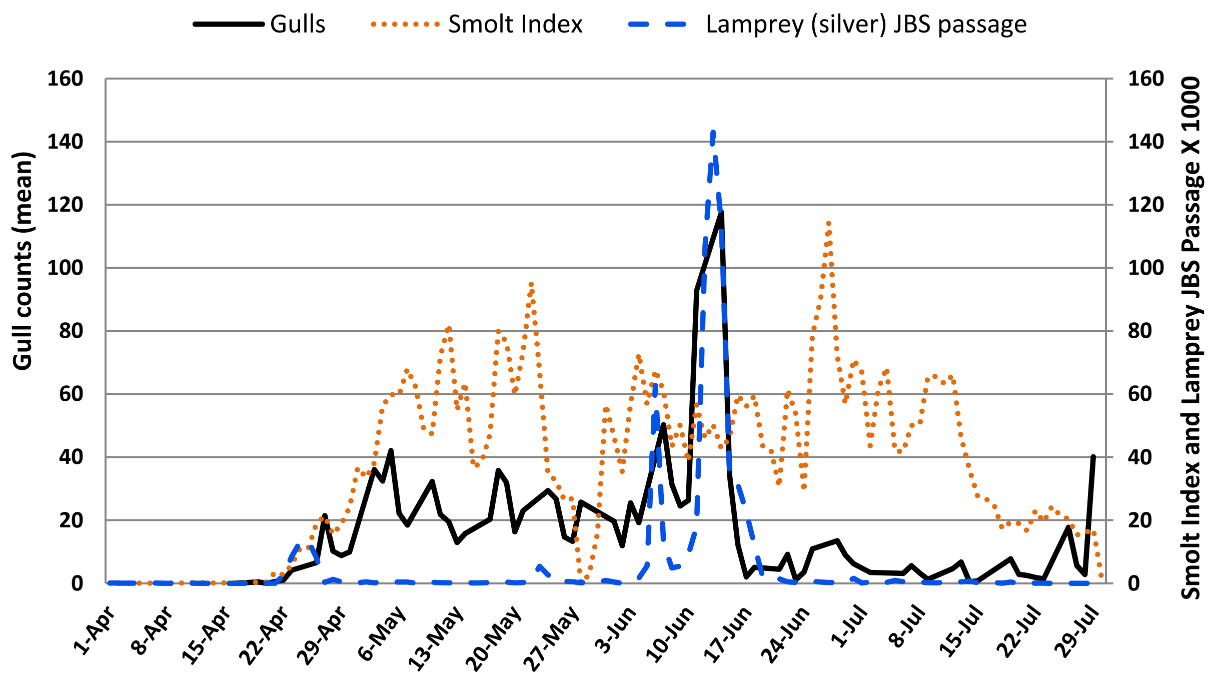

Figure 9. Daily mean gull counts at John Day Dam in relation to the smolt index and lamprey macropthalmia passage numbers from the smolt monitoring facility during 2010.

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 the avian array. This zone averaged 5.7 gulls throughout the season (Figure 10). The second highest counts were in the SW T3 zone which was immediately upstream of the SW T4 zone and covered by the array. The mean gull count in SW T3 was 3.0 though birds did not regularly penetrate the avian deterrent lines. The portion of SW T3 used by gulls was the most downstream edge. The zones immediately downstream of the powerhouse (PH T1) and spillway (SW T1) had the lowest mean gull counts with 0.03 and 0.01 respectively.

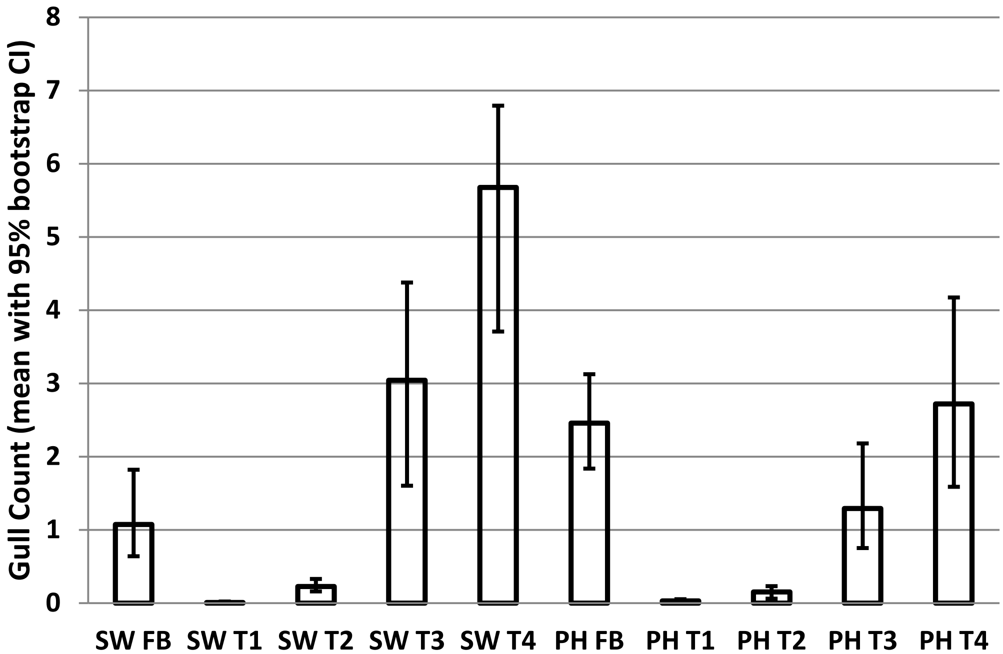

Figure 10. Seasonal mean gull counts in 2010 at John Day Dam by observation zone with 95% bootstrap confidence intervals for days when all zones were sampled. SW FB = spillway forebay, PH FB = powerhouse forebay, SW T1 to SW T4 = spillway tailrace zones with 1 being closest to dam, PH T1 to PH T4 = powerhouse zones with 1 being closest to dam.

The mean per capita consumption (Table 1), as measured by fish consumed per gull per hour, ranged from a low of 0.00 in the SW T1 zone immediately downstream of the spillway to a high of 1.19 in the SW T3 zone with most of the activity in SW T3 occurring in the crescent shaped section created by the wind blowing the avian line upstream of the zone line.

Table 1. Per capita consumption as measured by smolt consumed per gull per hour at John Day Dam in 2010 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	**0.00**	**1.05**	**1.19**	**0.78**	**0.73**	**0.52**	**0.94**	**0.60**
Upper	0.00	2.46	1.60	0.95	1.54	1.24	1.38	0.82
Lower	0.00	0.19	0.83	0.64	0.09	0.06	0.55	0.40
n*	6	30	60	64	13	25	51	53

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

To illustrate the seasonal mean gull distribution, white circles (each representing a count of one gull in the seasonal mean) were placed on the map in specific parts of each zone. Most of the gulls observed at John Day Dam typically foraged downstream of the avian line array (Figure 11). A few birds were also observed in the forebay.

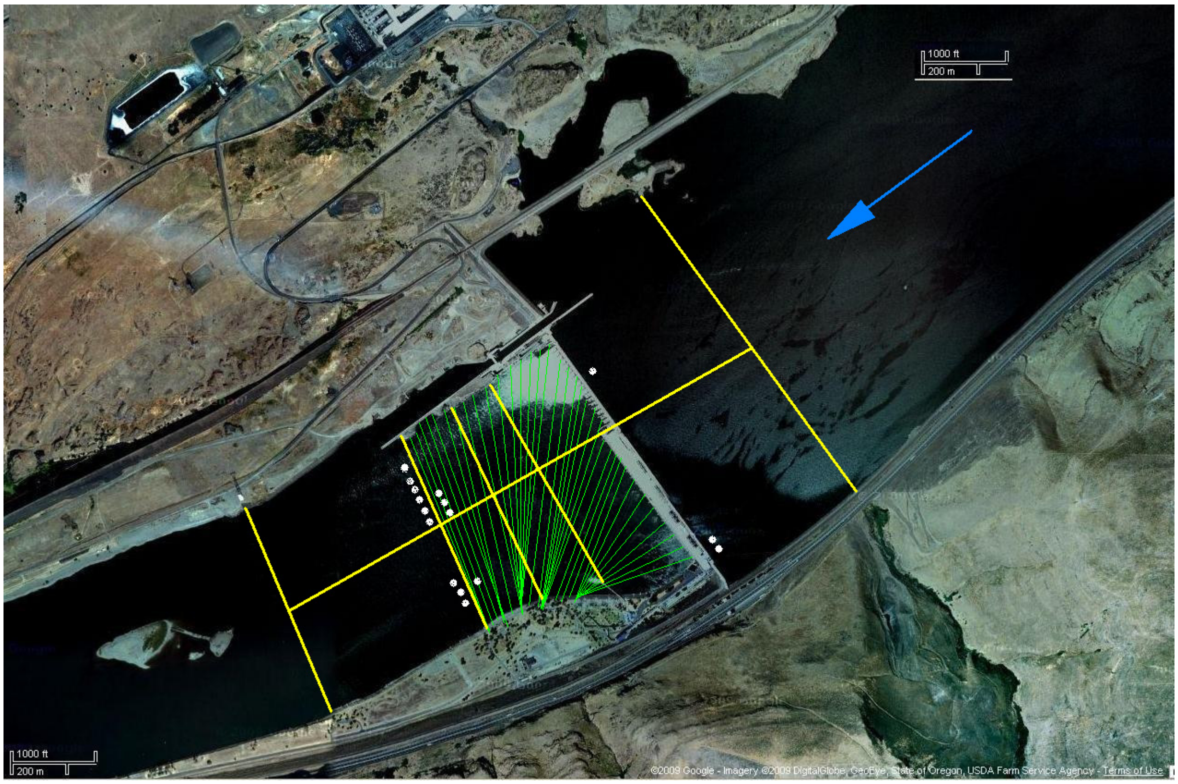

Figure 11. Gull distribution at John Day Dam in 2010 represented by seasonal mean counts. Yellow lines indicate zone boundaries, green lines represent the avian array, and each white circle represents a count of one gull in the seasonal mean.

The scarcity of gulls in 2010 is a marked contrast to the previous year. In 2009, the seasonal mean illustration shows gulls were more numerous and concentrated throughout the tailrace area especially in unprotected zones downstream of the spillway (Figure 12).

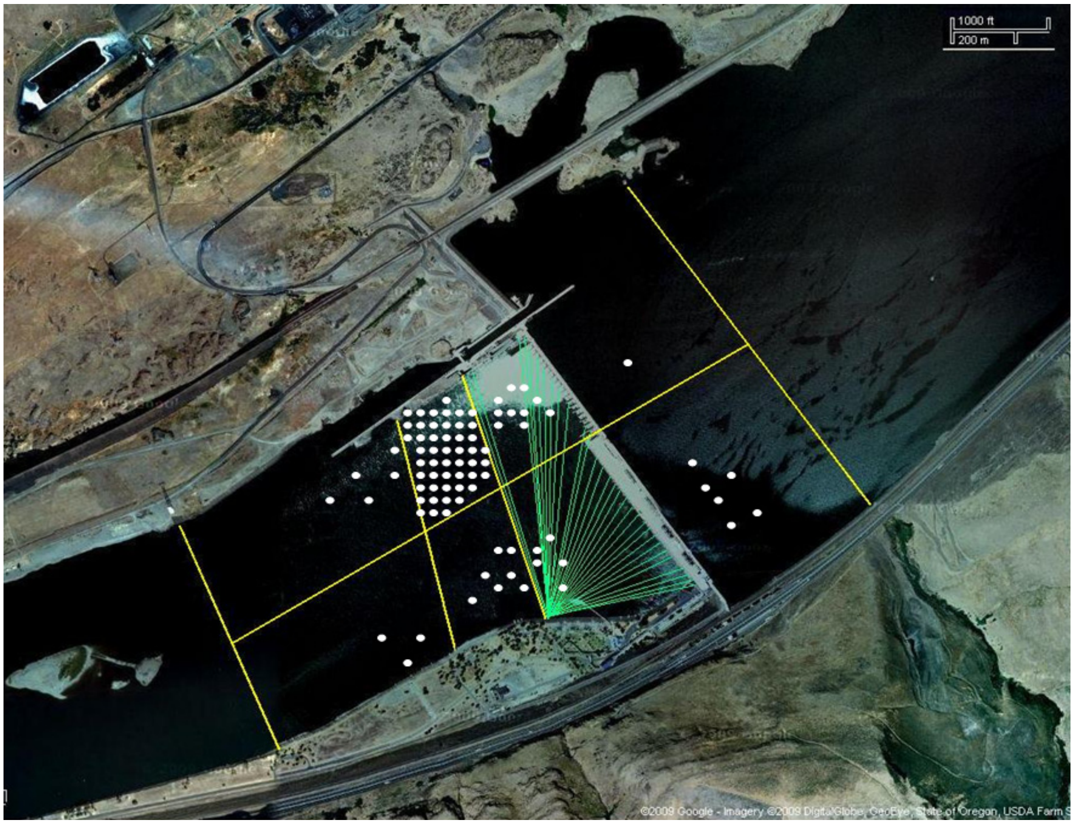

Figure 12. Gull distribution at John Day Dam in 2009 represented by seasonal mean counts. One white circle represents a count of one gull in the seasonal mean.

Smolt consumption decreased from 80,000 (50,000 to 110,000 95% CI) in 2009 to 18,000 (11,000 to 26,000 95% CI) in 2010. Lack of overlapping confidence intervals was interpreted as statistically significant.

DIET ANALYSIS

One hundred ninety four California gulls were processed in the lab to determine the species of fish being consumed during our observations. Maturity, whole bird mass, gut content mass, and wing cord length are reported in Table 2. The presence of identifiable female ovaries was found in 59 of the 194 gulls. Because 2009 gulls were grouped as either adult or hatch year (HY) based on plumage data are reported the same in 2010 for consistency.

Table 2. Description of AHY (after hatch year) and HY (hatch year) California gulls collected at John Day Dam in 2010 for diet analysis.

	Wing Cord (cm)		Whole Bird (g)		Whole Bird w/o gut content (g)		Gut Contents (g)	
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
AHY n= 172	**40.1**	**35.1 – 44.5**	**713.7**	**522.5 - 934.8**	**699.7**	**516.7 - 867.5**	**14.0**	**0.0 - 134.6**
HY n= 22	**37.6**	**33.8 - 43.2**	**592.4**	**431.7 - 784.9**	**585.4**	**424.9 - 779.8**	**7.0**	**0.0 - 83.4**

SOFT TISSUE FROM THE FOREGUT

Whole or partial fish were found in 63 of the 194 processed stomachs. Numbers of fish ranged from 0 to 23 per weekly sample with salmonids representing from 0 to 98.5% of stomach content for a seasonal mean of 63.5% (Table 3). Gravel comprised most of the inorganic materials found in the samples. For a complete breakdown of stomach contents including photos of a selection of full stomachs see Appendix B.

Table 3. Percent biomass of organic food items in the diet of California gulls collected in the John Day Dam tailrace during 2010.

INGESTED	5/3	5/11	5/17	5/24	5/31	6/7	6/14	6/21	6/28	7/5	7/12	7/19	7/26	Mean (%)
Fish	82.2	93.8	86.5	98.1	98.5	94.3		61.3	88.5	15.1	38.3	0.0	5.7	63.5
Insects and invertebrates	0.4	3.7	0.0	0.7	0.0	0.1		5.4	6.6	64.4	9.8	85.8	91.4	22.4
Blackberry	0.0	0.0	0.0	0.0	0.0	0.0		0.0	3.4	0.0	0.0	0.0	0.0	0.3
Cherry Pits	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potato	16.3	2.5	8.7	0.0	0.0	2.1		33.3	0.0	20.1	50.5	0.0	0.0	11.1
Plant	1.0	0.0	4.4	1.2	1.5	3.5		0.0	1.5	0.4	1.4	14.2	0.7	2.5
Human source organic	0.0	0.0	0.4	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	2.2	0.2
Number of stomachs	17	14	48	18	15	13	0	12	15	11	21	6	5	

During field dissection whole and partial fish are quickly identified and enumerated. These results generally concur with results from the laboratory analysis performed at the University of Washington on the frozen samples.

Results from the University of Washington using genetic, visual, and bone identification are presented in Figure 13. A total of 124 whole or partial fish were found in the samples. The composition of which is described as 49 Chinook (*Oncorhynchus tshawytscha*), three coho (*Oncorhynchus kisutch*), 30 sockeye (*Oncorhynchus nerka*), 12 steelhead (*Oncorhynchus mykiss*), seven unidentified salmonid, 12 lamprey, eight unidentifiable fish, one yellow perch (*Perca flavescens*), one peamouth (*Mylocheilus caurinus*), and one sucker (*Cotastomus spp.*). Those whole or partial fish samples with sufficient fin flesh were sent to the WDF&W Molecular Genetics Laboratory for species and stock identification. These methods are explained in Kawamura and Parish (2010). Chinook identified to stock include 20 Upper Columbia River summer/fall stock, seven Mid and Upper Columbia River spring stock, four Snake River stock, and one fish with 0.59 probability of being from the Rogue River and a 0.41 probability of being from the Upper Columbia summer/fall stock.

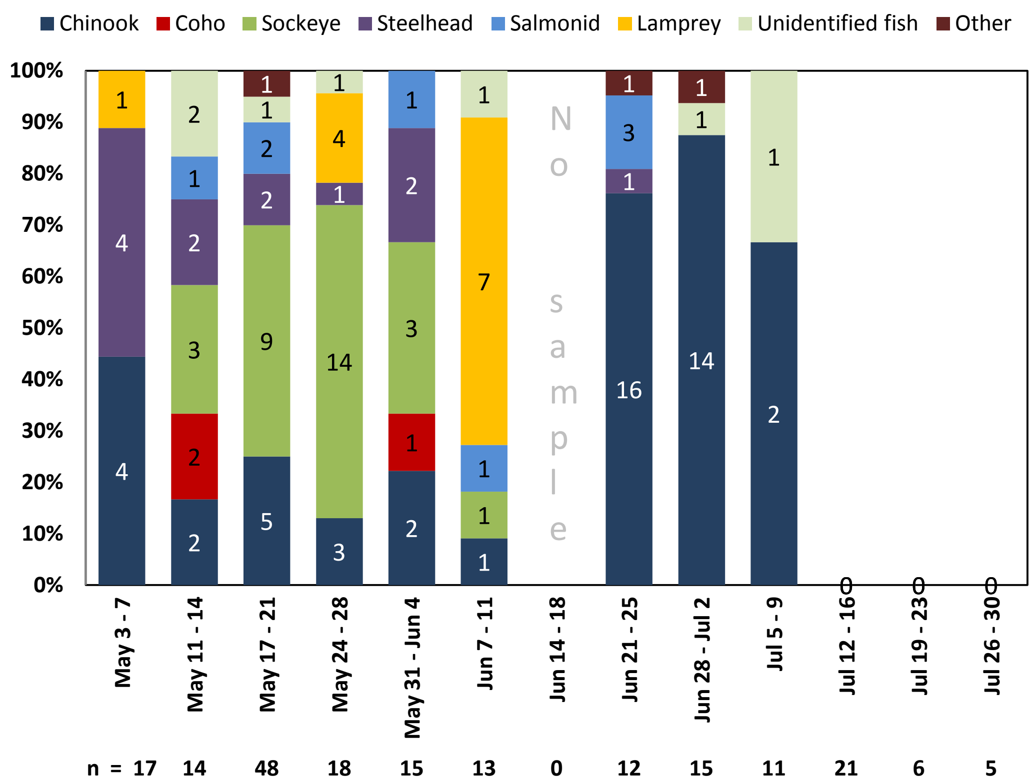

Figure 13. Diet composition found in the foregut (protoventriculus) of California gulls taken at John Day Dam. Soft fish tissue identified during laboratory analysis represents recently eaten prey. Sample size (n) ranges from 0 – 48 stomachs collected each week. The actual number of each fish prey is printed within each bar.

The number of stomachs sampled each week varied as lethal take was permitted for management purposes and not for diet analysis. During the week of June 14th high winds prevented USDA from boat hazing which also prevented take resulting in no gut samples. This happened to coincide with the peak of the lamprey macropthalmia outmigration (Figure 9) and likely explains the paucity of lamprey found in the stomachs of gulls taken at John Day Dam.

HARD PARTS FROM GIZZARD

Of the 194 gull stomachs collected, 37 of them contained hard parts identified as salmonid and four contained cartilaginous rings identified as the remainder of the oral disc of lamprey macropthalmia. Right and left cranial bones were matched up to enumerate consumed fish as described by Kawamura and Parish (2010). The species distribution was 3.1% (3) Chinook, 5.2% (5) Coho, 16.5% (16) sockeye, 1.0% (1) steelhead, 24.7% (24) unknown salmonids, 5.2% (5) other fish, 7.2% (7) lamprey, and 37.1% (36) unidentifiable fish.

TAG RECOVERY

Six working and 12 broken PIT tags were recovered from the samples. Two PIT tags were found inside intact fish the rest were discovered in the gizzard. The condition of broken PIT tags varied from mostly intact but unreadable to only the magnet remaining. Histories of the readable PIT tags describe two summer steelhead and one spring Chinook from Dworshak hatchery, one spring Chinook from Rapid River hatchery and two summer steelhead from unknown origins were tagged at Lower Granite Dam. Fork length at tagging ranged from 94-230mm. Additional tag history information from PTAGIS (accessed January 2011) can be found in Appendix C.

THE DALLES DAM

OBSERVATIONS

Observations were made at The Dalles Dam to detect if birds moved there from John Day Dam. Nine observers worked four months completing 650 observation records during which time they made more than 3,200 counts used to estimate the bird numbers, counted 15,756 gull attacks used to determine attack rates, and evaluated an additional 10,772 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. Observers were present 41% of the time yielding 756 observation hours at The Dalles Dam. Consumption estimates were expanded to account for the time observers were not present (see methods).

While California gulls were the most abundant species at The Dalles Dam, seven other species of fish eating birds were commonly seen within the study area (Figure 14). In order of prevalence they were double-crested cormorants (in the forebay loafing on the north side transmission towers), western grebes, American white pelicans, common mergansers, Caspian terns, osprey, and great blue heron. Also, there were infrequent sightings of ring-billed gulls along the shoreline areas of the dam.

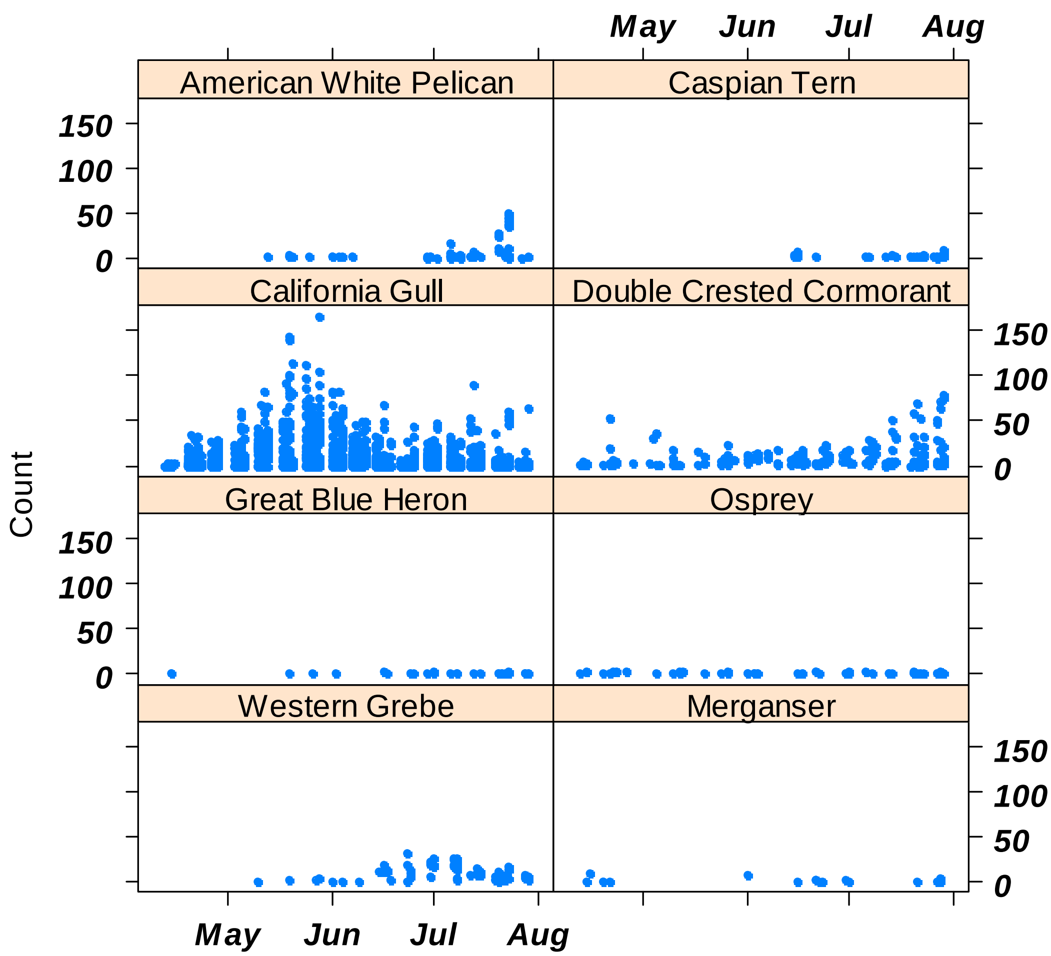

Figure 14. Piscivorous birds counted during observations at The Dalles Dam in 2010.

California gulls were seen in large numbers loafing on the rock islands downstream of the study area. American white pelicans also began to use these islands as a loafing spot in late June and continued to be observed there throughout the study. Similar to the birds counted on the dredge islands downstream of John Day Dam, these birds were not included in our analysis but are reported here (Figure 15). These rocks are in close proximity to foraging areas such as the Wasco County landfill and The Dalles Dam tailrace, and gulls have a tendency to loaf there throughout the day.

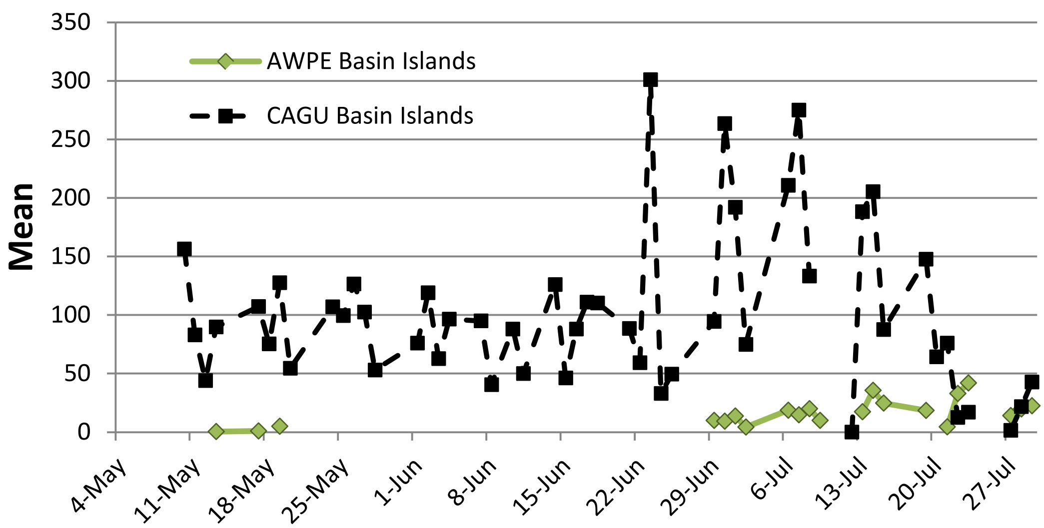

Figure 15. Birds that were seen loafing on and around the basin islands downstream of the study area, near The Dalles marina. AWPE is American white pelican and CAGU is California gull.

The hourly mean gull count started with a morning low of 19.1 gulls during the hour beginning at 0500 rose to a morning high of 37.4 during the 0900 hour and dropped to 29.7 gulls during the 1300 hour (Figure 16). Counts then rose to a daily high of 58.3 during the 2000 hour. As light levels began to fall gull numbers dropped to an evening low of zero during the one count taken after 2200 hours. Variability was high throughout the day and is displayed by +/- 0.5 standard deviation error bars.

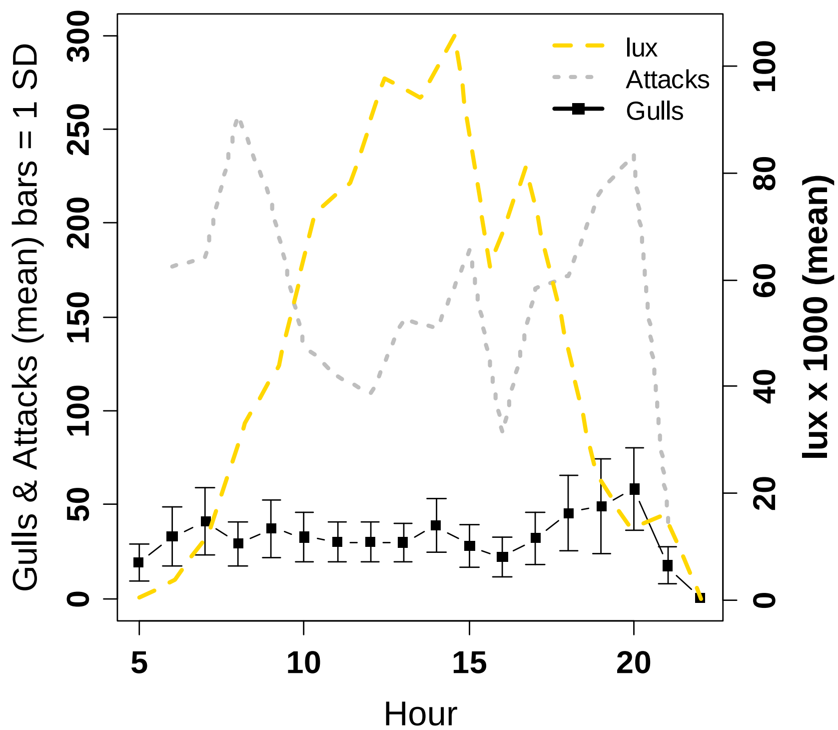

Figure 16. Hourly mean gull counts and attack counts at The Dalles Dam in 2010. Light intensity (lux) was measured at John Day Dam 24 river miles upstream.

The primary foraging area of the gulls at The Dalles Dam was on the spillway side of the river in the two most downstream zones, SW T3 and SW T4 (Figure 17). The small spike in gull numbers in the SW T2 and bumps in PH T2 and PH T3 zones can be contributed to gulls changing foraging location to take advantage of out migrating juvenile lamprey (macropthalmia) the timing of which (June 15th) slightly lags the peak collection of macropthalmia at John Day Dam (June 13th).

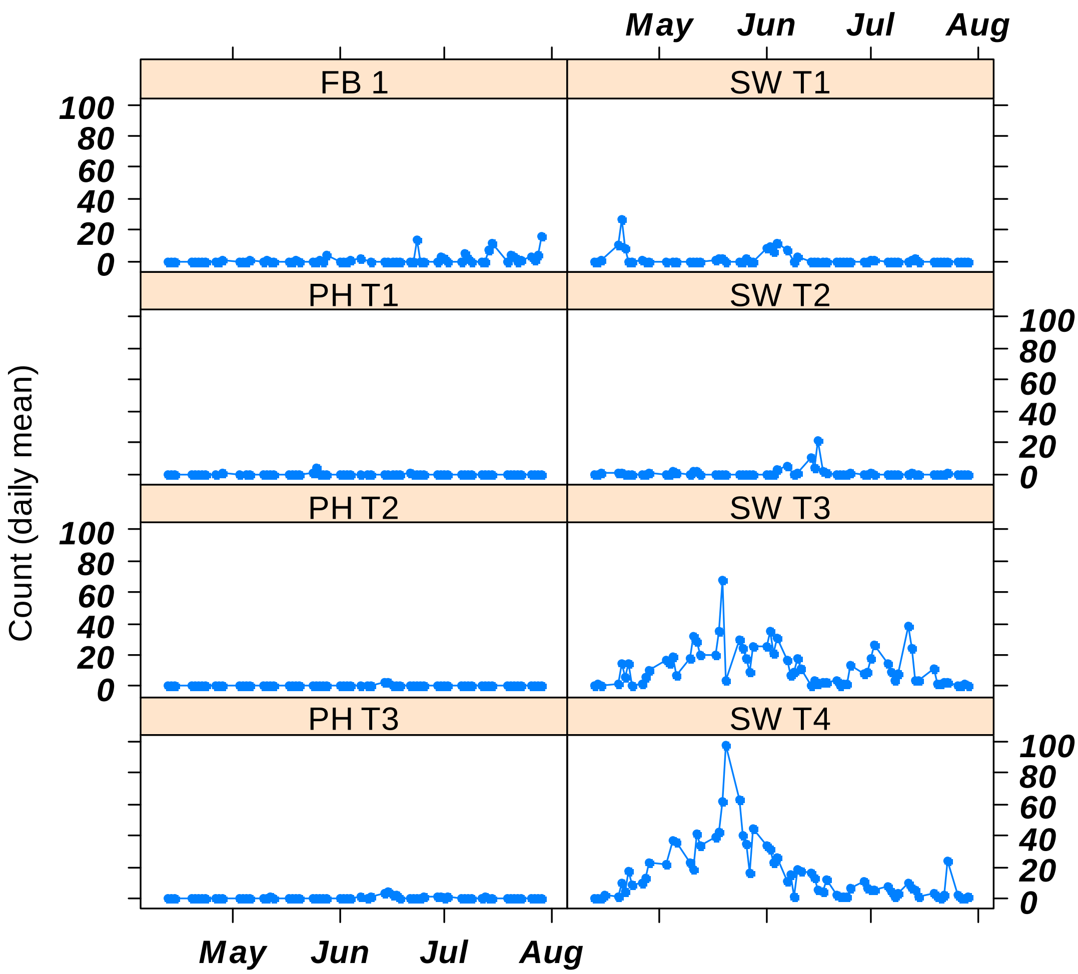

Figure 17. Daily mean gull counts at The Dalles Dam in eight zones, 2010. See Figure 4 for zone locations. SW = Spillway and PH = Powerhouse. Panels are arranged from upstream (top) to downstream (bottom) with the exceptions of SW T1 and SW T2 which are actually side-by-side.

Gull counts at The Dalles Dam were highly variable with the highest counts occurring in May (Figure 18). Daily means were reduced following the implementation of a full hazing program late in May that included hazing from shore and from a boat with the addition of lethal take. A variety of food sources are available to gulls near The Dalles Dam including fish in the tailrace of the dam, agricultural lands, and the Wasco County landfill located close to the city of The Dalles. The availability and quality of these food sources likely impact gull behavior as they try to maximize their foraging benefit.

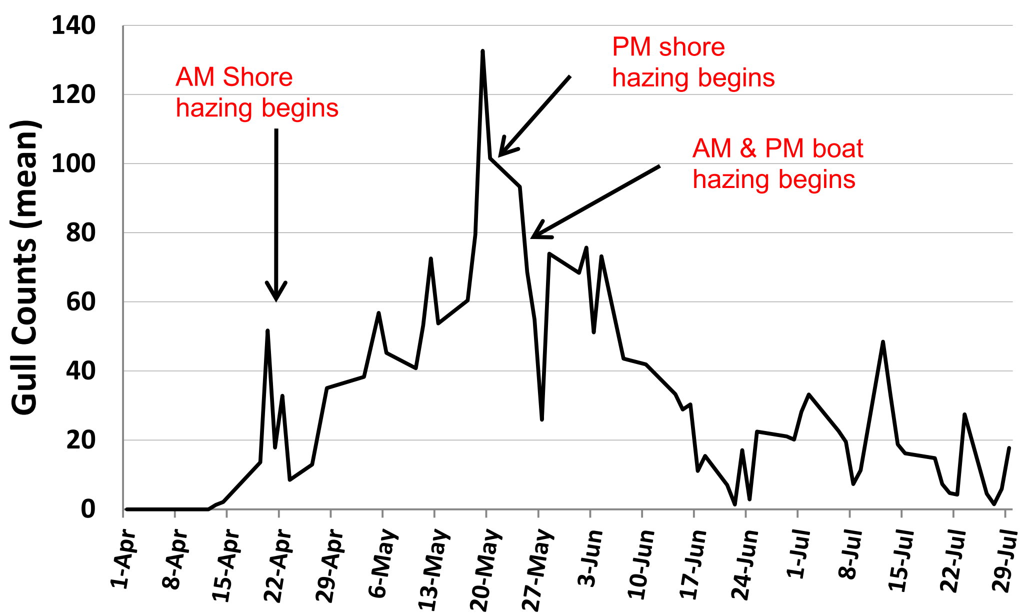

Figure 18. Daily mean gull counts for The Dalles Dam April through July of 2010.

Seasonal mean gull counts by zone were highest in zone SW T4 downstream of the US-197 bridge averaging 16.6 gulls throughout the season (Figure 19). The second highest count was a mean of 12.6 in the SW T3 zone which was immediately upstream of the bridge. The zones immediately downstream of the powerhouse, PH T1 and PH T2, had the lowest seasonal mean gull counts with 0.1 for each zone.

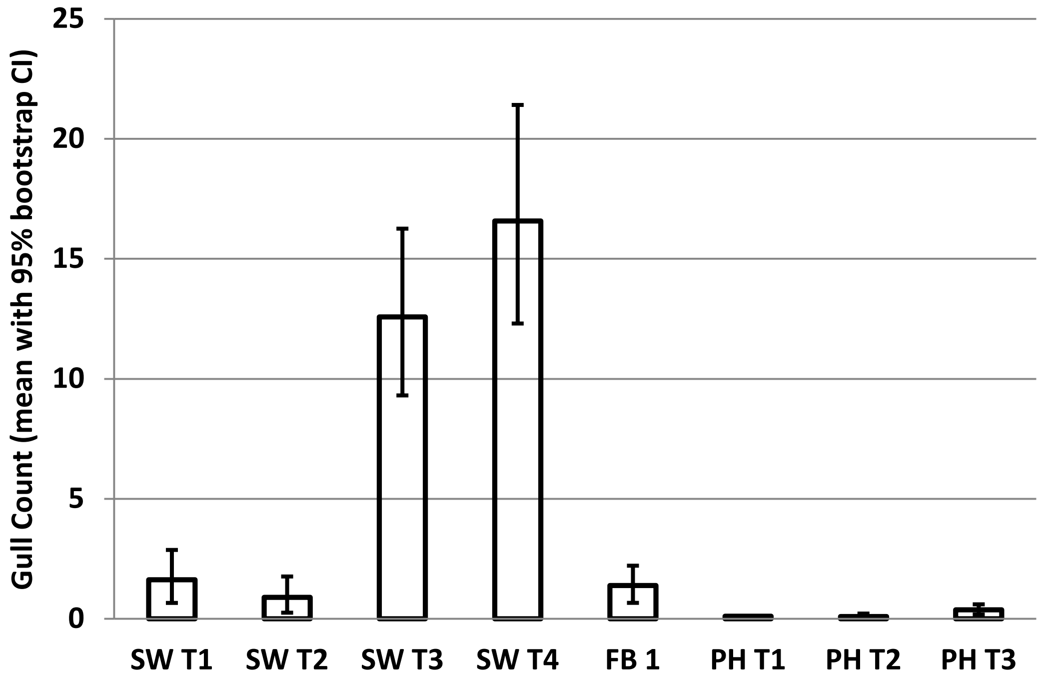

Figure 19. Seasonal mean gull counts in 2010 at The Dalles Dam by observation zone with 95% bootstrap confidence intervals for days when all zones were sampled. FB = forebay, SW T1 to SW T4 = spillway tailrace zones with 1 & 2 being adjacent to dam, PH T1 to PH T3 = powerhouse zones with 1 & 2 being adjacent to dam.

Gull distribution was spatially uneven at The Dalles Dam. They were foraging on the white water from the spillway downstream of the avian lines and downstream of the US-197 bridge. After calculating the seasonal mean count for each zone, white circles (each representing a single gull) were placed on the map in specific areas of each zone where gulls were most commonly observed (Figure 20). Gulls were most prevalent below the active spillways in areas not covered by avian lines. When hazing from a boat or the navigation lock peninsula under the bridge, USDA personnel could effectively engage birds foraging this area. However, gulls were not completely driven away, returning a few minutes after each hazing bout but usually in lower numbers than prior to the initiation of hazing.

Figure 20. Gull distribution at The Dalles Dam in 2010 represented by seasonal mean counts. Each white circle represents a count of one gull in the seasonal mean.

Mean per capita consumption, as measured by fish consumed per gull per hour, ranged from a low of 0.00 in the PH T1 zone immediately downstream of the powerhouse to a high of 5.40 in the SW T1 zone immediately downstream of the spillway, north of the spill wall (Table 4). The Dalles had a seasonal mean per capita consumption of 1.80 smolts per gull per hour, which was higher than the value of 0.81 estimated for John Day.

Table 4. Per capita consumption as measured by smolt consumed per gull per hour at The Dalles Dam in 2010 with upper and lower bootstrap confidence intervals (95%).

	SW T1	SW T2	SW T3	SW T4	FB 1	PH T1	PH T2	PH T3
Mean	**5.40***	**0.07**	**2.52**	**0.75**	**0.31**	**0.00**	**0.22**	**0.52**
Upper	9.08	0.20	3.19	0.92	0.62	0.00	0.33	1.11
Lower	2.52	0.00	1.92	0.59	0.00	0.00	0.00	0.09
n	18	17	63	64	2	2	3	14

* There were only 18 days when gulls were present in SWT1, but their consumption rates were high when foraging within this zone.

Estimated seasonal smolt consumption at The Dalles Dam was 98,000 (58,000 to 145,000 95% CI). No estimate is available for 2009, as this project was not studied. However, this estimate is significantly greater than John Day Dam 2010 estimate of 18,000 (11,000 to 26,000 95% CI) and not significantly different from the John Day Dam 2009 estimate of 80,000 (50,000 to 110,000 95% CI). Overlap of 95% confidence intervals or lack thereof, was used to decide significance.

DIET ANALYSIS

One hundred fifty five California gulls were processed in the laboratory to determine the species of fish being consumed at the dam. Maturity, whole bird mass, gut content mass, and wing cord length are reported in Table 5. The presence of identifiable female ovaries was found in 41 of the 155 gulls.

Table 5. Description of AHY (after hatch year) and HY (hatch year) California gulls collected at The Dalles Dam in 2010 for diet analysis.

	Wing Cord (cm)		Whole Bird (g)		Whole Bird w/o gut content (g)		Gut Contents (g)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
AHY n= 143	40.7	36.8 - 44.5	752.6	480.2 - 948.7	730.3	480.0 - 942.3	22.3	0.0 - 165.4
HY n= 12	39.7	38.1 - 41.9	665.4	530.9 - 864.8	656.8	522.8 - 792.5	8.6	0.0 - 72.3

SOFT TISSUE FROM THE FOREGUT

Less than half of the processed stomachs contained whole or partial fish, 33% (51/155). The number of whole or partial fish ranged from 0 to 111 each week with salmonids representing 0.0 to 72.8% of stomach content for a seasonal mean of 45.6% (Table 6). Non-fish items included anthropogenic materials that were largely thought to be scavenged locally at the Wasco County landfill.

Table 6. Percent biomass of organic food items found in the diet of California gulls collected in The Dalles Dam tailrace during 2010.

INGESTED	5/17	5/24	5/31	6/7	6/14	6/21	6/28	7/5	7/12	7/19	Mean (%)
Fish	66.0	42.1	69.8	36.5	72.8	1.9	26.3	21.1	24.3	0.0	45.6
Insects and invertebrates	0.5	<0.1	0.0	0.4	0.0	0.0	6.0	0.1	0.0	0.0	0.3
Blackberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cherry Pits	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Potato	0.0	0.0	0.0	0.0	5.1	31.1	0.0	9.2	5.5	100.0	3.0
Plant	0.7	2.3	0.3	1.9	0.0	0.0	0.6	0.0	0.0	0.0	1.1
Human source organic	32.8	55.5	29.9	61.2	22.1	67.0	67.1	69.5	70.2	0.0	50.0
Number of stomachs	25	30	29	40	10	5	5	12	5	3	

For a more descriptive breakdown of stomach contents including photos of select full stomachs see Appendix B. Results from the University of Washington's analysis using genetic, visual, and bone identification are presented in Figure 21. In total 191 whole or partial fish were found. There were 31 Chinook, five coho, 32 sockeye, four steelhead, three unidentified salmonids, 113 lamprey, and three unidentified fish. The small number of steelhead represented in the diet may be due to a later start of stomach collection at The Dalles. Samples were categorized as soft tissue parts (whole or partial fish) or hard tissue parts (bones and other). Whole or partial fish samples with sufficient fin flesh were sent to the WDF&W Molecular Genetics Laboratory for species and stock identification. Chinook identified to stock include 15 Upper Columbia River Summer/Fall, nine Mid and Upper Columbia River Spring, two Snake River, and one from the Deschutes River.

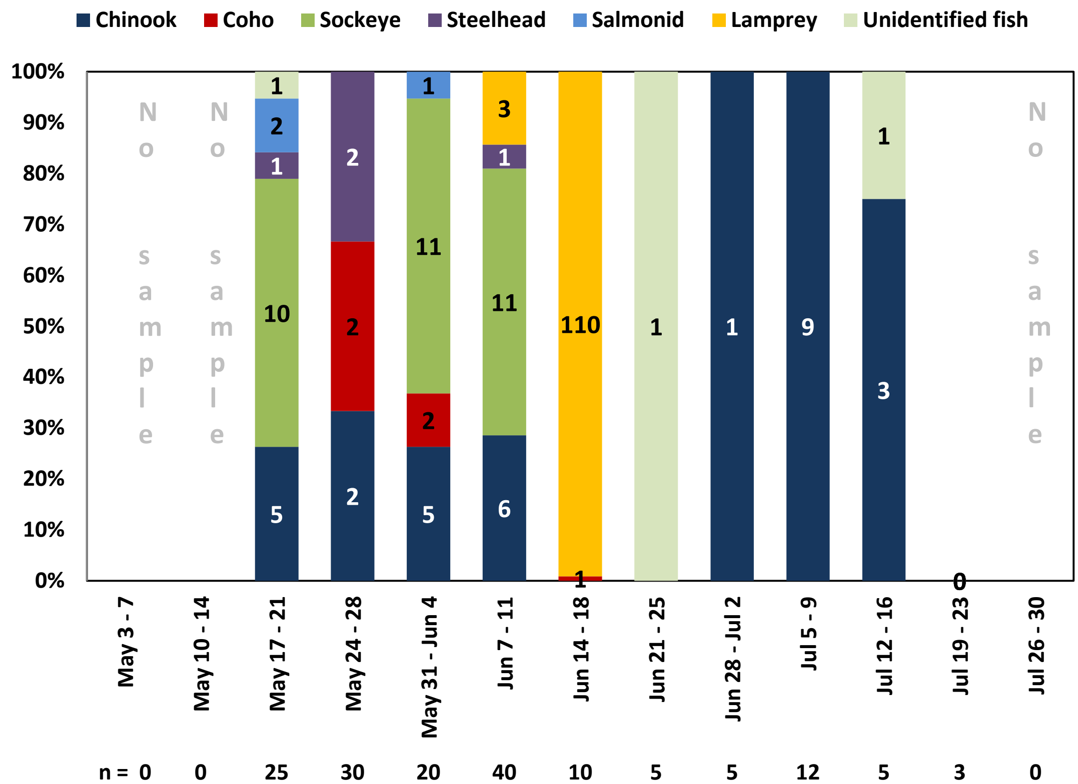

Figure 21. Diet composition found in the foregut (protoventriculus) of California gulls taken at The Dalles Dam. Soft fish tissue identified during laboratory analysis represents recently eaten prey. Sample size (n) ranges from 0 – 40 stomachs collected each week. The actual number of each fish prey is printed within each bar.

During the peak of lamprey outmigration (Figure 9) gull distribution was atypical of the previously observed foraging locations**.** Gulls were spread out throughout the spillway tailrace with more activity in zones SW2 and PH3 (Figure 4). Samples taken during mid June reflect this change in feeding patterns as gulls focused on available lamprey macropthalmia (Figure 21).

HARD PARTS FROM GIZZARD

Of the 155 gull stomachs, 25 contained hard parts that were identified as salmonid and 21 contained parts identified as the oral disc of lamprey macropthalmia. Right and left cranial bones and otoliths were matched up to enumerate fish in each sample as described in Kawamura and Parish (2010). The species distribution was 0.9% (3) Chinook, 2.3% (8) sockeye, 0.3% (1) Coho, 0.6% (2) steelhead, 5.2% (18) unidentified salmonid, 0.6% (2) other fish, 84.2% (294) lamprey, and 6.0% (21) unidentified.

TAG RECOVERY

Nine tags were recovered from stomach collection at The Dalles. Five of these were readable, PIT tag histories describe two spring Chinook from Rapid River Hatchery, one summer Chinook from East Bank Hatchery, one summer steelhead released at Lower Granite Dam, and one summer sockeye released at McNary Dam. Fork lengths at tagging ranged from 94 – 230 mm. Two of the five fish were interrogated at the McNary Dam bypass. Complete tag histories from PTAGIS (accessed January 2011) can be referenced in Appendix C.

DISCUSSION

Avian deterrents deployed in 2010 were successful in protecting juvenile salmonids and with some fine tuning may improve the protection of juvenile lamprey as well. Gulls primarily foraged the downstream edge of the avian line arrays, rarely attacking underneath them. This is the desired outcome avian lines are based on - protecting smolts until they recover equilibrium and can dive deep enough to avoid bird predation. It remains unclear whether survival has been increased system wide or whether piscivorous birds simply moved downstream of the avian lines or to other locations on the river that were not observed, such as McNary Dam.

Boat hazing and the new avian line deterrent array at John Day Dam appeared to reduce smolt consumption by 76% compared to 2009. While this result is greater than expected, it must be noted that this was an observational, not experimental study. That is, there was no control or reference site. Some of this reduction could be due to natural variation of the local gull population or simply greater food availability elsewhere. Regardless, the desired management action to reduce smolt consumption was met with the new wire array, in conjunction with hazing operations (Table 7).

Table 7. Summary of bird consumption estimates made using direct observation in the Columbia River Basin. These include both additive (eating live fish) and compensatory (eating fish that died, or would have died after dam passage).

Consumption Estimate (95%CI)	Dam	Year	Primary Predator	Author
18,000 (11,000 – 26,000)*	John Day	2010	CAGU	Present Study
98,000 (58,000 - 145,000)*	The Dalles	2010	CAGU	Present Study
62,000 (50,000 - 110,000)**	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
119,250	Wanapum	1982	RBGU	Ruggerone 1986

* Percentile bootstrap 95% CI
** 95% CI from the Poisson distribution

Boat hazing at The Dalles Dam was followed by a sharp decrease in the number of gulls foraging near the dam (Figure 18). Anecdotally, observers could clearly see gull numbers decrease when the hazing boat arrived in the morning and increase when the boat was absent (during lunch, at shift change, or at the end of the evening). This has proven to be an effective deterrent that can be deployed mid-season and moved from dam to dam if needed. Hazing from a boat is the most flexible and effective form of hazing we have observed.

During the winter of 2010-11 line sag of synthetic avian line material used at John Day Dam caused some lines to lower into the river where they floated on the surface. Cold temperatures lead to thinning of the Plasma® Rope fibers, thinner fibers lead to creep causing the lines to lengthen. Lengthening with cold weather and shortening in warm is a known property of Plasma® Rope and should have been planned for. Lines need to be out of the water to be effective and avoid being damage or tangled. Thus they should be adjusted to maintain 20' clearance above mean tailwater as required by project safety standards. Attachment points need to be designed for adjustment (tighten and loosen with changing temperature) and inspected for maintenance (replacement or repair).

Large numbers of macropthalmia were collected from gut samples at The Dalles Dam when compared to John Day Dam - this was likely an artifact of gut collection. We were unable to collect gut contents at John Day during the week macropthalmia spiked at the smolt monitoring facility as high winds made boat operation unsafe. This was the same week macropthalmia numbers soared in The Dalles gut samples. So this result needs to be treated appropriately. The 2010 outmigration season saw a dramatic reduction in smolt consumed by birds at John Day Dam and pointed out areas for improvement at The Dalles Dam.

RECOMMENDATIONS

Increasing the number of avian lines at The Dalles Dam and maintenance of the John Day Dam avian line array are important to increase and maintain fish protection. At The Dalles Dam adding lines to close gaps upstream of the US-197 bridge, below the ice/trash sluiceway outfall, and downstream of the powerhouse would improve deterrence efforts in these areas. Also, a preventive maintenance plan needs to be developed for the avian line arrays. Like any piece of equipment these deterrents work best when in full working order. To keep them working requires regular inspections, criteria or triggers for action, and a point person responsible for each array. This is especially true for large and complicated ones like the current John Day array. Lines need to be inspected for height above water, wear at attachment points, and failure. Future avian lines should be designed for maintenance including tightening or loosening lines and replacing them when they fail.

A basin wide perspective is needed to manage predators that have the potential to impact both smolt and juvenile lamprey across the entire basin. Partnering with local and federal agencies will be necessary to work across this large geographic area. For example to reduce food available to gulls, a request could be made of the Wasco County landfill to cover with 6” of dirt at the end of the day. This is one protocol used at Waste Management’s Arlington Landfill to reduce the number of gulls there. If fill is needed, perhaps the Corps could supply dredge material from the Columbia River creating a win-win situation.

In 2009 4,135 PIT tags were recovered from the gull colony on rocks at the head of Miller Island (Roby et al. 2011). Further study is needed to assess the effects of reducing the number of gulls nesting on Miller Island Rocks and the corresponding impact on smolt survival at both John Day and The Dalles dams. This could be something as simple as installing black silt fencing to prevent nesting. Gulls may be dissuaded from nesting on Miller Island Rocks if their line of sight is blocked by the silt fencing. Or something more comprehensive could be implemented, like connecting the nesting rocks to the main part of Miller Island using rip-rap. They may not select that as a nest site if they see it is connected to the main island which would allow access by mammalian predators, such as raccoons and coyotes.

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APPENDICES

APPENDIX A. *DIET SAMPLING PROTOCOL*

Two people are required, one data recorder/tissue bagger and one dissector. Both must be wearing clean plastic gloves. Dissection should be completed ASAP after death to reduce digestion and aid in identification of freshly eaten fish. All carcasses placed on ice in the field until processing. Samples are to be placed on ice, and frozen upon completion. Required equipment: scale, dissecting tray, gloves, scissors, scalpel, tin snips, large bags, measuring tape, permanent marker, and Whirl-paks.

1. Each bird is assigned a SAMPLE NUMBER on the data sheet.

2. Record the date/time, location collected, when collected, bird spp., age of bird (adult, sub-adult).

3. Weigh the bird with appropriate scale.

4. Take straightened WING CORD measurement.

5. Carefully cut through the ribs on either side of the sternum and lift up the breastplate, revealing the thoracic/abdominal cavity.

6. Check for fish in upper esophagus and mouth and either push excess into labeled Whirl-pak through the mouth or push into stomach.

7. Lift STOMACH from abdomen. Cut the juncture of the stomach and small intestine (pylorus) and cut as far up the esophagus as possible, freeing the anterior GI tract.

8. Carefully cut partially down the length of the esophagus and open revealing STOMACH CONTENTS. Make an initial ID of intact fish and get a count of each species.

9. Scrape all contents of stomach Whirl-pak labeled with SAMPLE NUMBER, site, bird spp., and collection date.

10. Close bag and take WEIGHT of sample on top-loading balance.

11. SEX the bird by looking for male or female gonads dorsal to the stomach. They may be diminished if not breeding season.

12. Bag left over carcass for appropriate disposal.

APPENDIX B. *STOMACH CONTENT IMAGES AND DIET SUMMARY TABLES*

Figure 22. Image of sample 622173346 showing salmonids.

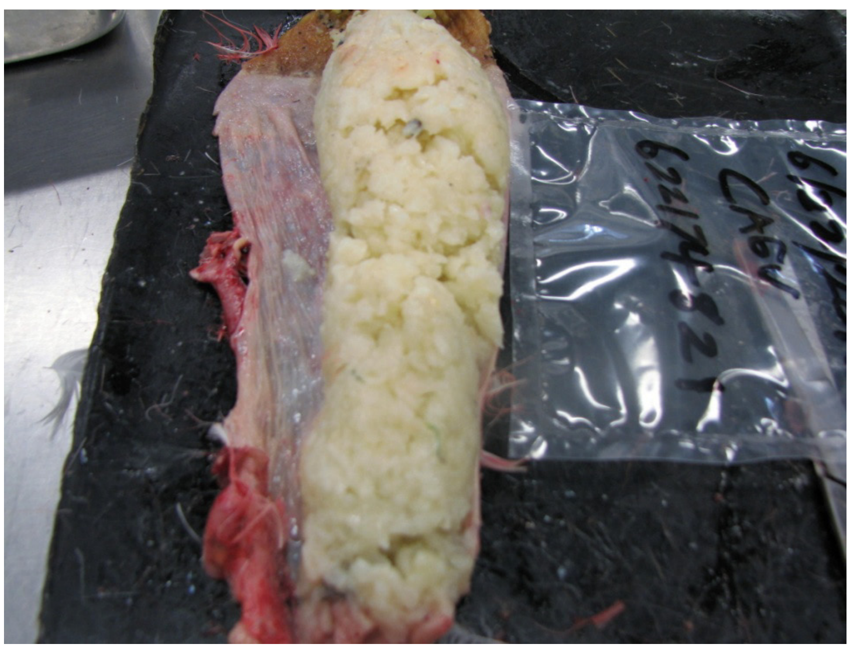

Figure 23. Image of sample 622174821 showing potato starches.

Figure 24. Image of sample 614115532 showing lamprey take at The Dalles Dam.

Figure 25. Image of sample 614113152 showing lamprey take at The Dalles Dam.

Table 8. Total mass (g) of items in the diet of California gulls taken at John Day Dam during 2010 from University of Washington's diet analysis. Dates indicate the beginning of the work week during which gulls were taken.

INGESTED	5/3	5/11	5/17	5/24	5/31	6/7	6/14	6/21	6/28	7/5	7/12	7/19	7/26	Mean (g)
Fish	411.28	332.18	235.95	224.16	79.98	47.41		235.63	122.60	9.61	24.96	0.00	0.10	143.65
Insects and Invertebrates	1.80	13.00	0.00	1.58	0.00	0.03		20.81	9.09	40.91	6.41	1.72	1.60	8.08
Blackberry	0.00	0.00	0.00	0.00	0.00	0.00		0.00	4.67	0.00	0.00	0.00	0.00	0.39
Cherry Pit	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potato	81.75	8.81	23.70	0.00	0.00	1.06		127.99	0.00	12.75	32.89	0.00	0.00	24.08
Plant	5.25	0.01	11.91	2.65	1.21	1.76		0.09	2.11	0.22	0.92	0.28	0.01	2.20
Human source organic	0.00	0.00	1.12	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.04	0.10
Rock	3.15	3.49	12.71	3.98	5.88	5.08		6.11	10.88	9.51	23.27	9.58	2.69	8.03
Shell	0.01	0.00	0.00	0.00	0.00	0.06		0.14	0.43	0.00	0.52	0.00	0.00	0.10
Human source inorganic	0.42	0.37	1.63	0.28	0.38	0.04		0.00	0.29	0.20	0.11	0.00	0.01	0.31
Bird (feathers)	0.01	0.01	0.69	0.01	0.00	0.03		0.00	0.00	0.00	0.00	0.00	0.00	0.06
Mammal	0.00	0.00	0.00	0.00	0.00	0.00		0.00	1.63	0.00	0.00	0.00	0.00	0.14
Unknown	0.68	0.06	2.72	4.09	1.93	1.24		0.00	1.11	0.99	13.60	1.17	0.20	2.32
Number of stomachs	17	14	48	18	15	13	No Sample	12	15	11	21	6	5	

Table 9. Total mass (g) of items in the diet of California gulls taken at The Dalles Dam during 2010 from University of Washington's diet analysis. Dates indicate the beginning of the work week during which gulls were taken.

INGESTED	5/17	5/24	5/31	6/7	6/14	6/21	6/28	7/5	7/12	7/19	Mean (g)
Fish	154.73	272.85	211.13	210.56	269.68	1.53	16.54	69.24	21.70	0.00	122.80
Insects and invertebrates	1.09	0.05	0.00	2.30	0.05	0.00	3.75	0.26	0.00	0.00	0.75
Blackberry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cherry Pits	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Potato	0.00	0.00	0.00	0.00	18.90	24.90	0.00	30.20	4.87	1.36	8.02
Plant	1.66	15.17	0.88	11.03	0.00	0.00	0.39	0.11	0.00	0.00	2.92
Human source organic	76.83	359.53	90.50	353.76	81.82	53.70	42.20	227.30	62.60	0.00	134.82
Rocks	1.50	6.14	2.28	22.35	1.44	3.73	2.53	10.08	3.04	3.16	5.62
Shells	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human source inorganic	48.57	7.12	0.34	15.91	0.60	14.28	3.28	3.92	0.00	0.10	9.41
Bird (feathers)	0.01	0.00	0.00	0.33	0.00	0.00	0.00	0.52	0.00	0.00	0.09
Mammal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02
Unknown	7.25	5.90	3.78	15.87	1.49	2.22	3.66	0.03	1.50	0.20	4.19
Number of stomachs	25	30	20	40	10	5	5	12	5	3	

APPENDIX C. *PIT TAG HISTORIES*

Table 10. Histories of the 11 readable tags that were recovered from stomachs of California gulls at John Day and The Dalles Dam in 2010. McN is McNary Dam, RPH is Rapid River Hatchery, TDA is The Dalles Dam, and JDA is John Day Dam.

Tag	3D9.1C2D500726	3D9.1BF25ABD45	3D9.1C2D469903	3D9.1C2D46DF51	3D9.1C2D868F57	3D9.1C2D3693B1
Run	summer sockeye	summer chinook	spring chinook	spring chinook	summer steelhead	spring chinook
Hatchery		East Bank	Rapid River	Rapid River	Unknown	Rapid River
release site	McNary Dam	Chelan River	Rapid River Hat.	Rapid River Hat.	Lower Granite Dam	Rapid River Hat.
release date	6/10/2010	4/29/2010	3/15/2010	3/15/2010	5/6/2010	3/15/2010
rkm	470	810	522.3	522.3	522.17	522.3
Tagging FL (mm)	98	94			221	
Interrogated	McN bypass		21/ Apr RPH.	21/Apr RPH.		21/Apr RPH.
Interrogated			23/ May McN bypass			12/May McN bypass
Mortality	6/14 TDA gull pred.	6/3 TDA gull pred.	5/27 TDA gull pred.	5/25 JDA gull pred.	5/20 JDA gull pred.	5/17 TDA gull pred.

Tag	3D9.1C2D856EF7	3D9.1C2D8B7235	3D9.1C2D277393	3D9.1C2D1CCEA0	3D9.1C2D678BE6
Run	summer steelhead	summer steelhead	summer steelhead	spring chinook	summer steelhead
Hatchery	Unknown	Unknown	Dworshak	Dworshak	Dworshak
release site	Lower Granite Dam	Lower Granite Dam	Dworshak Mainstem	Dworshak North Fork	Dworshak Mainstem
release date	5/6/2010	5/30/2010	4/21/2010	3/31/2010	4/21/2010
rkm	522.17	522.17	522.22	522.22	522.22
Tagging FL (mm)	230	153		107	
Interrogated					
Mortality	5/17 TDA gull pred.	5/13 JDA gull pred.	5/13 JDA gull pred.	5/13 JDA gull pred.	5/04 JDA gull pred.