

**An Evaluation of Avian Predation and Control Measure
Effectiveness at Priest Rapids and Wanapum Dams,
Mid-Columbia River, Washington, 2007**

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Executive Summary

On May 3, 2004, the National Marine Fisheries Service (NMFS - then referred to as NOAA Fisheries) issued its Biological Opinion of the effects (Biological Opinion) of the proposed action on listed species, in accordance with Section 7 of the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.), regarding the Federal Energy Regulatory Commission's (FERC's) proposed action amending Public Utility District No. 2 of Grant County's (Grant PUD's) existing license for the Priest Rapids Hydroelectric Project (Project) to authorize implementation of an Interim Protection Plan for listed anadromous salmonids. On December 16, 2004, FERC adopted the Biological Opinion, which includes NOAA Fisheries' Reasonable and Prudent Alternatives (RPAs) and Incidental Take Statement for Upper Columbia River (UCR) spring-run Chinook salmon (*Oncorhynchus tshawytscha*) and UCR steelhead (*Oncorhynchus mykiss*).

Under the Biological Opinion, Grant PUD is required to achieve 95% juvenile dam passage survival and 93% juvenile project (one dam and reservoir) survival as described in RPA No. 1 (Performance Standards). In order to achieve the Performance Standards, Grant PUD has begun implementation of the measures outlined in the Biological Opinion. These measures include the construction and operation of juvenile fish bypasses at Priest Rapids and Wanapum dams, installation and testing of advanced turbines, exploring spill measures (top-spill), assessing turbine operations, and conducting northern pikeminnow and avian predator control programs. The avian predator control program measures were outlined in RPAs 10 and 19 and require Grant PUD to reduce avian predation at Priest Rapids and Wanapum dams. These RPA measures include the installation and maintenance of avian wire arrays downstream of spillway and powerhouse discharge areas to discourage avian predation. As part of its avian control program, Grant PUD entered into a ten-year cooperative work agreement with United States Department of Agriculture Wildlife Services (WS) to implement annual avian predator control and to collect data to evaluate the effectiveness of avian control measures.

During the 2007 smolt out-migration period, WS performed control actions on 15,900 avian predators (including Caspian terns, gulls, cormorants, mergansers, etc.) at Priest Rapids Dam and 7,092 avian predators at Wanapum Dam from May 1–August 2, 2007. A total of 413 avian predators were lethally taken at Priest Rapids Dam and 277 avian predators were lethally taken at Wanapum Dam.

Avian predator intensities at Priest Rapids Dam and Wanapum Dam were significantly related to the abundance of available out-migrating salmonids traveling through the Project. A total of 679 avian predator stomachs were collected and analyzed in 2007, and 72% of the stomach samples contained smolt. A total of 377 coded-wire tags, 42 PIT-tags, and 2 hydroacoustic tags were collectively found in the 679 stomach samples. These tags were used to identify salmonid remains to species. Gulls were the most abundant avian predator at Priest Rapids and Wanapum dams. Dietary data showed that gulls consumed salmonid species in proportion to their in-river availability, except for the larger steelhead smolt. Steelhead smolt consumption was less than the in-river availability of steelhead smolt at the time of consumption.

Wire arrays were effective at deterring avian predators. Observations indicated that most avian predators concentrated foraging efforts below the mid-river top-spill bulkhead discharge, mid-river sluiceway discharge, and where spill discharge merged with the powerhouse discharge. These forage areas were not covered with wire arrays in 2007. Grant PUD proposes to install wire array(s) installed in the Priest Rapids Dam tailrace prior to 2008 spring spill.

Grant PUD will continue to annually contract WS to perform avian predator control efforts at Priest Rapids and Wanapum dams. Grant PUD will also identify areas for the construction of additional wire arrays at Priest Rapids and Wanapum dams, evaluate avian control measure effectiveness, and collect stomach samples to evaluate avian predator diet for future avian impact evaluations.

DRAFT

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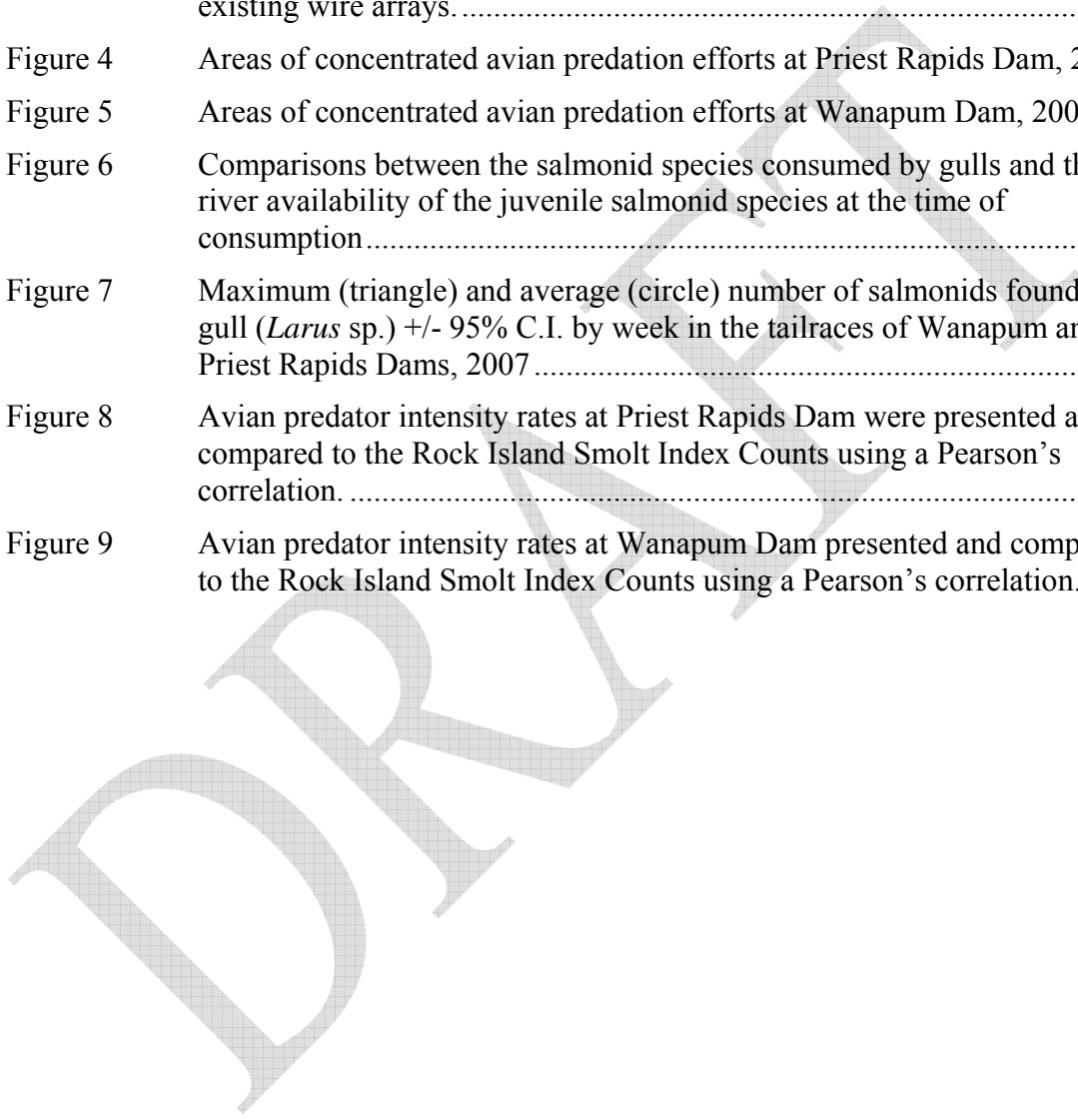
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1.0 Introduction

On May 3, 2004, the National Marine Fisheries Service (NMFS - then referred to as NOAA Fisheries) issued its Biological Opinion of the biological effects (Biological Opinion) of the proposed action on listed species, in accordance with Section 7 of the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.), regarding the Federal Energy Regulatory Commission's (FERC's) proposed action amending Public Utility District No. 2 of Grant County's (Grant PUD's) existing license for the Priest Rapids Hydroelectric Project (Project) to authorize implementation of an Interim Protection Plan for listed anadromous salmonids. On December 16, 2004, FERC adopted the Biological Opinion, which includes NOAA Fisheries' Reasonable and Prudent Alternatives (RPAs) and Incidental Take Statement for Upper Columbia River (UCR) spring-run Chinook salmon (*Oncorhynchus tshawytscha*) and UCR steelhead (*O. mykiss*).

Under the Biological Opinion, Grant PUD is required to achieve 95% juvenile dam passage survival and 93% juvenile project (one dam and one reservoir) survival as described in RPA No. 1 (Performance Standards). In order to achieve these Performance Standards, Grant PUD has begun implementation of the measures outlined in the Biological Opinion. These measures include the addition of top-spill juvenile fish bypasses at Priest Rapids and Wanapum dams, installation and testing of advanced turbines, exploring alternative spill measures (top-spill), assessing turbine operations, and conducting northern pikeminnow and avian predator control programs. The avian predator control program measures were outlined in RPAs 10 and 19 and require Grant PUD to implement a program to reduce avian predation at Priest Rapids and Wanapum dams. These RPA measures include the installation and maintenance of avian wire arrays downstream of spillway and powerhouse discharge areas to discourage avian predation. As part of its avian control program, Grant PUD entered into a ten-year cooperative work agreement with United States Department of Agriculture Wildlife Services (WS) to implement an annual avian predator control program and to collect data to evaluate the effectiveness of avian control measures. Grant PUD continues to improve and modify its avian predator control program as May 2004 Biological Opinion RPAs are implemented.

Man-made developments and land-use practices have altered local environments in the mid-Columbia region (Figure 1). East of the mid-Columbia River in this region is a vast expanse of irrigated cropland known as the Columbia Basin Irrigation Project. Water from the Columbia Basin Irrigation Project is diverted from the Columbia River at Grand Coulee Dam into Banks Lake. The outflow of Banks Lake fills an extensive network of canals and re-regulating structures (BOR 2007). The development of irrigated lands and agricultural areas near the Columbia River has contributed to increasing populations of piscivorous avian species (Finger and Tabor 1997; Roby et al. 1998; USDA 2003).

The Potholes Reservoir, formed as a result of the construction of O'Sullivan Dam between 1947 and 1949, is located ~35 miles northeast of Priest Rapids Dam and ~30 miles east-northeast of Wanapum Dam. This development is representative of man-made, water-based ecosystems in an area of arid high desert that offers breeding, nesting, and feeding habitats suitable for Caspian terns (*Sterna caspia*), ring-billed gulls (*Larus delawarensis*), and California gulls (*L. californicus*) (Figure 1). Such breeding and nesting habitats were not available to avian predators prior to the construction of the Columbia Basin Irrigation Project and Grand Coulee Dam

(Demarchi et al. 2003). At the Potholes Reservoir between 1982 and 1997, the Washington Department of Fish and Wildlife (WDFW) reported that California and ring-billed gull populations increased 36% and 24%, respectively (Finger and Tabor 1997).

Annual avian predator population increases have occurred steadily in the mid-Columbia region. Roby et al. (1998) reported that gull (*Larus* sp.) populations have increased 5–8% annually since 1970. Roby et al. (1998) also reported that the Hanford Reach gull colony exceeds 70,000 birds. Gulls have been and continue to be the dominant avian predator at the Priest Rapids and Wanapum tailraces (Demarchi et al. 2003; Searing and Bentley 2003, Clement et al. 2005; Turner et al. 2006), and gulls appear to be the dominant predator of out-migrating anadromous salmonids in the Columbia River Basin (Thompson and Tabor 1981; Ruggerone 1986; Roby et al. 1998, Jones et al. 1999).

The May 2004 Biological Opinion requires specific measures currently implemented by Grant PUD to reduce avian predation and increase smolt survival through the Project. Grant PUD has implemented those measures and continues to explore all methods to minimize predation and facilitate fish passage at Priest Rapids and Wanapum dams. These measures include the installation and maintenance of avian wire arrays downstream of spillway and powerhouse discharge areas to discourage avian predation. Grant PUD has also contracted with WS to conduct avian predator control efforts and to collect data to evaluate avian control measure effectiveness at Priest Rapids and Wanapum dams.

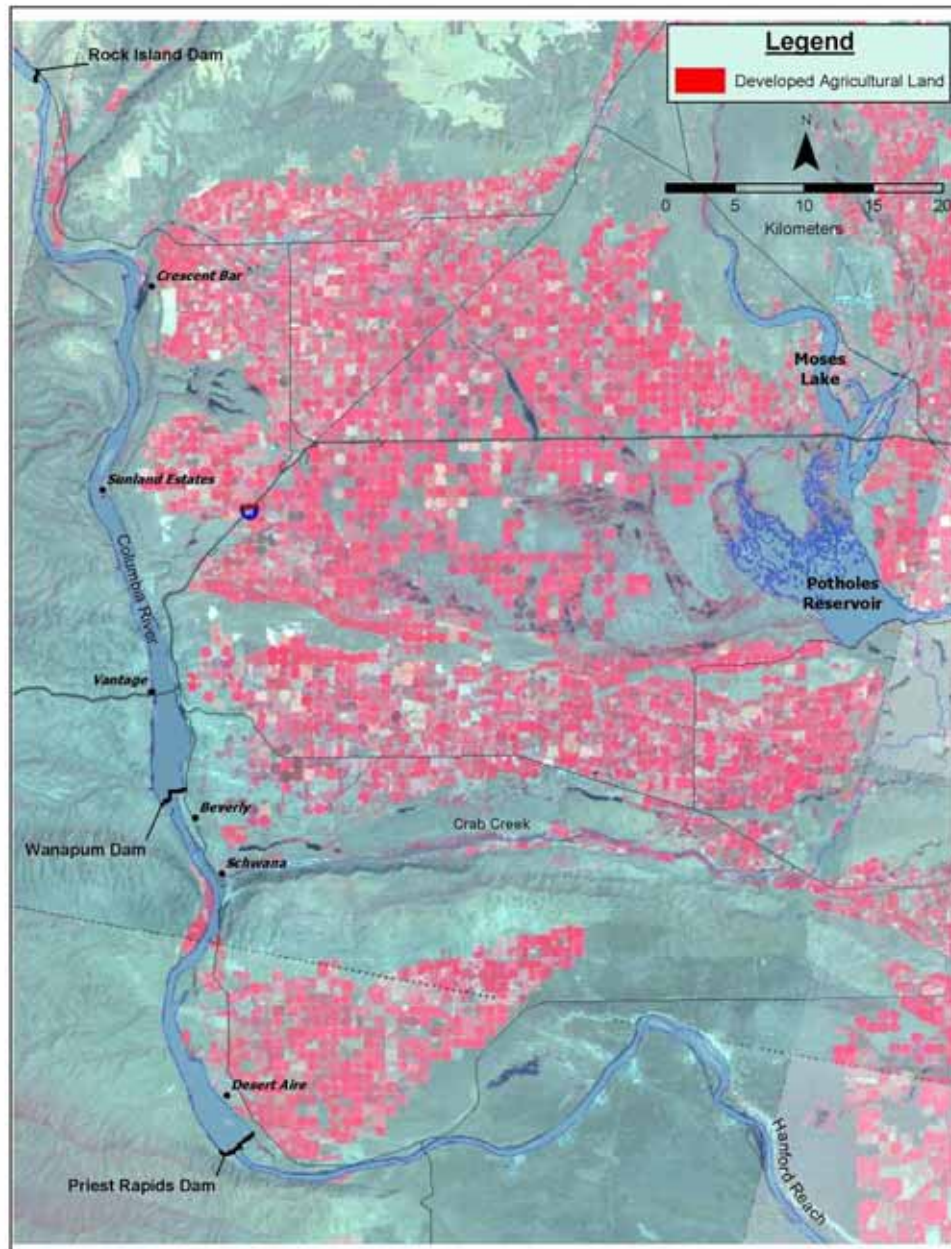


Figure 1 The Priest Rapids Project Area, adjacent agricultural lands, and waterways.

2.0 Study Area

The Priest Rapids Hydroelectric Project is located on the mainstem mid-Columbia River, Washington State, and consists of the Wanapum and Priest Rapids developments (FERC No. 2114). The downstream boundary of the Project begins at the Priest Rapids Dam tailrace (River Mile [RM] 397.1) and extends upriver to the Rock Island Dam tailrace at RM 453.5. Avian predator control measures were conducted in the tailrace, forebay, earth embankment, and downriver shorelines accessible to WS specialists at Wanapum and Priest Rapids dams.

Priest Rapids Dam, which was completed in 1961, consists of both earthen embankment and concrete sections that span approximately 10,103 ft across the river. Juvenile salmonids must pass Priest Rapids through the experimental top-spill bulkhead, turbines, sluiceway, spillway, or be collected and passed downriver via gatewell dipnetting. Spill was provided as an additional measure to improve Fish Passage Efficiency (FPE [i.e., passage via a non-turbine route]). Avian wire arrays are currently maintained over the Priest Rapids Dam powerhouse discharge.

Wanapum Dam, which was completed in 1964, consists of both earth embankment and concrete sections that span approximately 8,637 ft across the river. Juvenile salmonids migrating through Wanapum Dam must pass through the turbines, sluiceway, experimental top-spill bulkhead, spillway, or be collected and passed downriver via gatewell dipnetting. Avian wire arrays are in place over the powerhouse discharge and spillway to reduce avian predation.

3.0 Methods

The methodology used in 2007 was designed to evaluate avian predator use of the Project and to evaluate control measure effectiveness. In addition, avian impacts to out-migrating salmonids were evaluated through the dietary examination of lethally-removed birds. Methods were also designed to determine the effectiveness of the current avian wire arrays and identify areas to be evaluated for additional avian wire array installations.

3.1 Avian Predator Index Site Counts

Grant PUD performed bi-weekly piscivorous avian index counts at eight locations and one transect along the Columbia River from April–August 2007. According to Project-wide aerial avian predator surveys by Searing and Bentley (2003), these selected index sites had the greatest concentrations of avian predators. The avian predator index counts were compared to the Rock Island Smolt Index Counts (RISIC) via Pearson's correlation to determine if avian predator numbers were related to out-migrating salmonid abundance. In addition, predator index counts were collected to determine when WS control action efforts should be initiated for future years. The eight index sites were located at Gravel Island (RM 451), which is located below the Rock Island Dam tailrace, Crescent Bar (RM 441), Sunland Bar (RM 430), Girl Scout Island (RM 419), Beverly Island complex (RM 413), Sentinel Gap (RM 409), Goose Island (RM 398), and Priest Rapids Hatchery Release Site (RM 395). The Priest Rapids Hatchery transect was performed en route to the Priest Rapids Hatchery Release Site while traveling through the Priest Rapids Hatchery Complex (Grant PUD 2005).

Piscivorous avian index counts were performed via spot counts using a combination of Steiner® 12 x 40 binoculars and a Nikon® 16–48 X adjustable magnification spotting scope. Counts were performed over a 10–15 minute period at each vantage point. Date, time, location, avian predator

species, activity (predating, loafing, flying were abbreviated and recorded as P, L, and F, respectively), and numbers counted were recorded. Four different routes were used to perform the spot counts in order to sample the sites at different times during the study:

- 1) *Downriver*: From Gravel Island and worked downriver to the Priest Rapids Hatchery Release Site;
- 2) *Upriver*: From the Priest Rapids Hatchery Release Site and worked upriver to Gravel Island;
- 3) *Middle up*: From Girl Scout Island and worked upriver to Gravel Island then traveled down to the Priest Rapids Hatchery Release Site and worked up to the Beverly Island Complex; and
- 4) *Middle down*: From the Beverly Island Complex and worked downriver to the Priest Rapids Hatchery Release Site then traveled up to Gravel Island and worked downriver to Girl Scout Island.

3.2 Avian Data Collection at Priest Rapids and Wanapum Dams

WS specialists recorded the following data for control action events: 1) time; 2) location; 3) species; 4) number of birds observed; 5) activity of birds (predating, loafing, or flying); 5) type of control action (haze, haze/lethal); and 6) number of birds lethally removed. Lethally-removed birds were collected for dietary analyses. A response time was calculated for amount of time that occurred between control actions to compare haze and haze-lethal control actions. Collectively, the resulting data were used to evaluate existing wire array effectiveness, evaluate haze versus haze-lethal control actions, identify areas of concentrated avian predation efforts, and evaluate avian impacts to salmonids.

3.2.1 Wire Array Effectiveness

Control action data were used to evaluate avian wire array effectiveness at Priest Rapids and Wanapum dams during WS avian predator control efforts. The tailrace discharge within 800 m of Priest Rapids and Wanapum dams were categorized into functional zones representing Project operations and existing wire arrays (Figure 2; Figure 3). Chi-Square analyses were performed to evaluate avian use of the defined functional areas within the first 400 m of tailrace discharge at Priest Rapids Dam (Zones 2–5; Figure 2) and the first 800 m of tailrace discharge at Wanapum Dam (Zones 2–4; Figure 3) under various spill patterns. At Priest Rapids Dam, spill patterns included the top-spill bulkhead, top-spill with training spill, and inadvertent spill. The top-spill bulkhead was operated 24 hours per day. Inadvertent spill was defined as additional Tainter gate spill that was not part of the top-spill bulkhead or top-spill with training spill. At Wanapum Dam, the spill patterns included the sluiceway, inadvertent spill, and the top-spill bulkhead at Tainter gate 12. Inadvertent spill was defined as Tainter gate spill that was not part of the Wanapum sluiceway or the top-spill bulkhead discharge. The Wanapum sluiceway was open 24 hours per day. The Wanapum top-spill bulkhead was predominately operated during night-time hours to reduce total dissolved gas production. The area within each zone was used to calculate the proportion of the total area. These proportions were used to calculate the expected values in the Chi-Square analyses from the total number of birds that received a control action within the selected zones. Observed values were the total number of birds that received a control action within a defined zone. The null hypothesis evaluated at Priest Rapids Dam and Wanapum Dam was as following:

H_0 : There was no difference in the number of birds that received control actions under the avian wire arrays to the number of birds that received control actions outside of avian wire arrays.

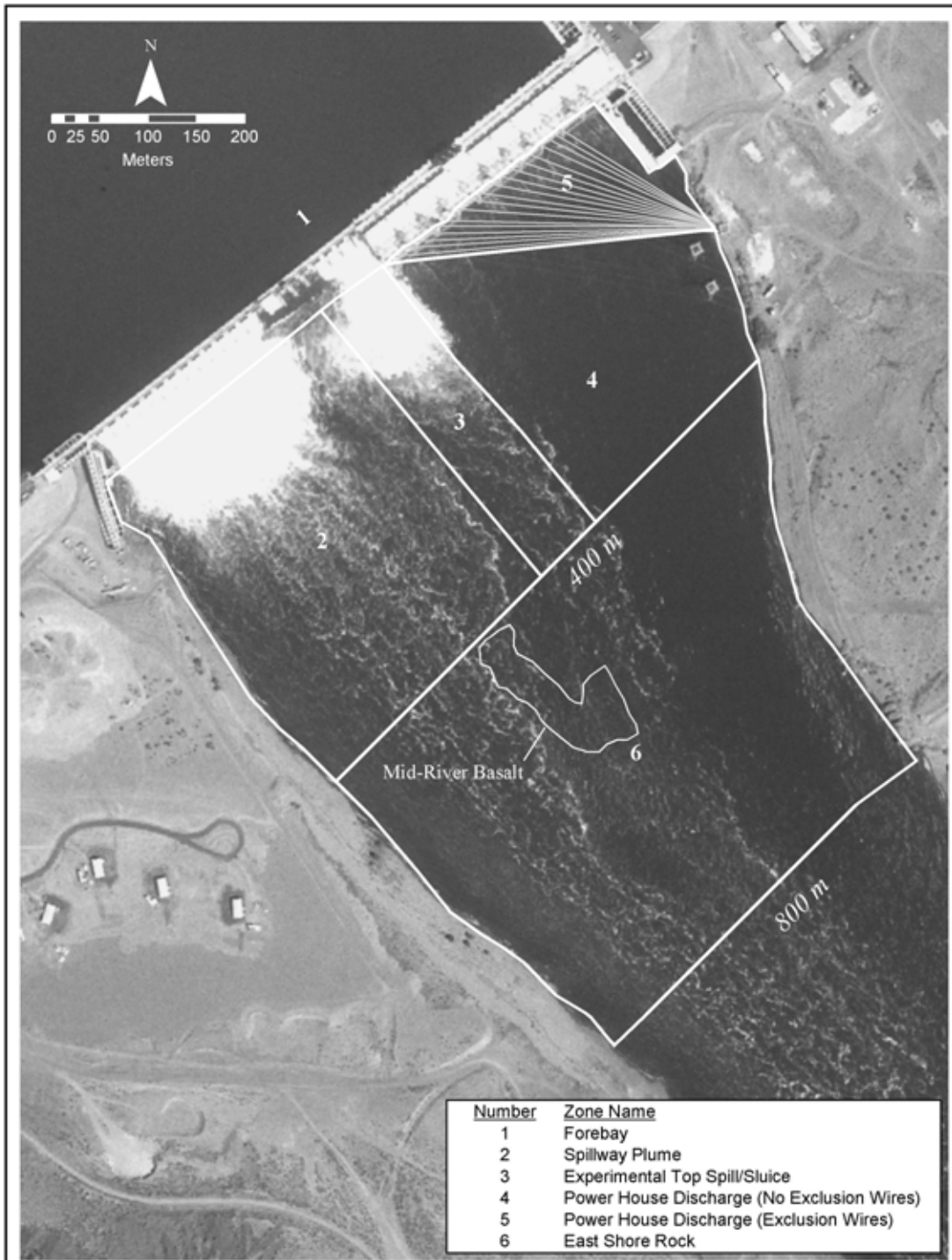


Figure 2 The Priest Rapids functional zones relative to spill operations and existing wire arrays. These zone numbers were the location codes that WS recorded for control action data. *Note: The spill pattern presented above was not representative of 2007 operations. Spill was distributed across Tainter gates 2–13 & 19–22 in Figure 2.*

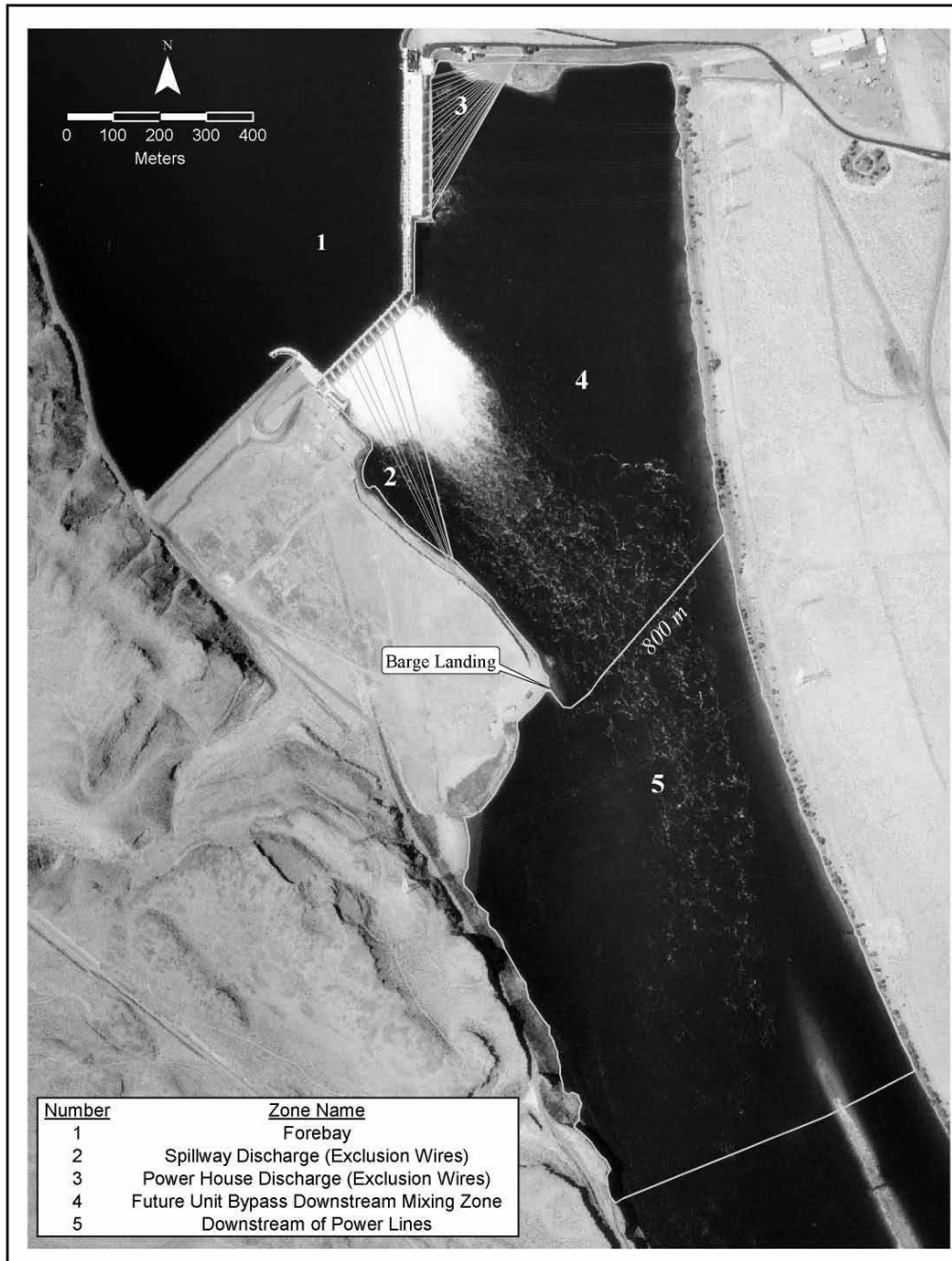


Figure 3 The Wanapum Dam functional zones relative to spill operations and existing wire arrays. These zone numbers were the location codes that WS recorded for control action data. *Note: The spill pattern presented above was not representative of 2007 operations. Spill was distributed across Tainter gates 1–12 in Figure 3.*

3.2.2 Lethal versus Non-Lethal Control Actions

Control action effectiveness was evaluated by the amount of time feeding activity was interrupted. The response time between control actions was calculated. WS specialists noted when control actions were temporarily suspended so as to remove error from the calculated avian response times. The response times for haze and haze-lethal control actions were evaluated for Wanapum Dam and Priest Rapids Dam. Depending upon data normality, a Wilcoxon Signed Rank Test or a paired t-Test was used to test the hypothesis as following:

H_0 : There was no difference in the amount of time predatory activity was interrupted between haze and haze-lethal control actions employed at Priest Rapids Dam or Wanapum Dam.

The number of minutes that predation was interrupted were paired by date for haze and haze-lethal control actions.

3.2.3 Land-Based, Non-Lethal Control Actions

Grant PUD biologists evaluated the effectiveness of land-based, non-lethal hazing activities at Priest Rapids Dam. Pyrotechnics were fired towards areas where avian predators foraged. The following data were recorded: 1) time; 2) location; 3) species; 4) number of birds observed; 5) activity of birds (predating, loafing, or flying).

3.2.4 Concentrated Areas of Avian Predation Efforts

WS specialists identified all locations where birds were lethally removed by placing a point with a reference number on the datasheet. These points were used to generate GPS positions that were spatially analyzed to identify areas of concentrated avian predation efforts. ArcView 8.3 with Spatial Analyst extension was used to create a raster graph of avian predation locations by imputing a search radius of 100 ft² and output cell size (i.e., grid resolution) of 10 ft².

3.2.5 Avian Predator Impacts

Avian predator intensity rates (i.e., the number of avian predators hazed per hour) and Project-wide predator index counts were compared to the RISIC. SigmaStat 3.5 software was used to perform a Pearson's correlation of avian predator intensity rates and Project-wide predator index site counts to the RISIC to determine if avian predator intensity rates and/or index counts were correlated to the number of out-migrating salmonids.

Avian predator impacts to salmonids were assessed by analyzing the stomach contents of lethally-removed birds. All lethally-removed birds that were recovered had foregut contents collected for dietary analysis. WS specialists collected the gizzard, stomach, esophagus, and all regurgitation and stored them in a Ziploc® bag. A "Write in the Rain" label with the recorded sample number and bird species code was placed on each stomach sample bag. The stomach samples were frozen until dietary examinations could occur.

Grant PUD biologists performed the dietary examinations. Dietary items were enumerated and identified to family and species when possible. Foregut contents were scanned for Passive Integrated Transponder tags (PIT-tag), coded wire tags (CWT), and hydroacoustic tags. All PIT-tags and PIT-tag pieces were removed, scanned, and reported to the PIT-Tag Information System

(PTAGIS). When a CWT was detected, it was extracted, secured to the datasheet, and read at a later date. CWT species data were obtained through Fish Passage Center (www.fpc.org), Regional Marking Processing Center (www.rmhc.org), United States Fish and Wildlife Service, Washington Department of Fish and Wildlife (WDFW), and the Yakama Nation. Hydroacoustic tag origin (i.e., Grant PUD/Chelan County PUD) was determined from color. All recovered hydroacoustic tags were tested for functionality.

A dietary comparison was performed on all 2007 gull stomach samples to determine if gulls were targeting a particular salmonid species. The proportions of salmonid species that were consumed by gulls were compared to the in-river availability of each salmonid species. The RISIC was used to represent the in-river proportions of salmonid species that were available for gulls to consume during weekly consumption periods. A two-day delay was incorporated into these analyses to compensate for salmonid out-migrating travel time between Rock Island Dam and Priest Rapids dams (Timko et al. 2007). In 2006, Grant PUD was unable to obtain all CWT tag code information prior to the annual reporting deadlines. Therefore, the 2006 analyses were appended to the 2007 report.

4.0 Results

Wildlife Services' avian control activities were initiated on May 1, 2007 and concluded on August 2, 2007. At Priest Rapids and Wanapum dams, the vast majority of the project-related avian predation occurred in tailrace areas that were not covered with avian wire arrays. Control action data showed that avian predator intensity rates (i.e., the number of birds hazed per hour) were significantly related to the number of juvenile salmonids out-migrating through the Priest Rapids Project. These data showed that avian predation efforts were concentrated near areas affected by spill operations and where spill discharge merged with the powerhouse discharge.

4.1 Wire Array Effectiveness

Avian predation was not evenly distributed throughout the tailraces of Priest Rapids and Wanapum dams. Since each dam operated a very consistent spill pattern throughout 2007 control efforts, all control action data were pooled for Chi-square analyses. The null hypothesis (i.e., H_0 : There was no difference in the number of birds that received control actions under the avian wire arrays to the number of birds that received control actions outside of avian wire arrays) were rejected at Priest Rapids and Wanapum dams. The Chi-Square results for avian predation distributions at Priest Rapids Dam were $X^2=167,788$; $p<0.001$ (Table 1). Avian predator foraging was concentrated in the Priest Rapids Dam top-spill bulkhead discharge area. Significantly fewer birds than expected were observed underneath the Priest Rapids Dam avian wire arrays. At Wanapum Dam, the Chi-square results for avian distributions were $X^2=237,382$; $p<0.001$ (Table 2). The number of birds observed underneath the wire arrays at Wanapum Dam was also significantly fewer than expected.

Gulls and Caspian terns were seldom hazed at locations covered with wire arrays. At Priest Rapids Dam, a total of 607 control actions were conducted on 13,857 gulls, but only 1 control action was conducted on 5 gulls foraging underneath the existing wire arrays. A total of 288 control actions were conducted on 1,962 Caspian terns, but only 2 of these control actions were conducted on a total of 10 Caspian terns underneath the existing Priest Rapids Dam wire arrays. At Wanapum Dam, a total of 545 control actions were conducted on 6,471 gulls, but only 2 of these control action were conducted on a total of 5 gulls underneath the existing wire arrays. A

total of 122 control actions were conducted on 320 Caspian terns, but only 1 control action was conducted on 2 Caspian terns underneath the Wanapum Dam wires arrays.

Table 1 Chi-Square results for Priest Rapids Dam avian predation distributions during 2007 avian predator control efforts.

Location Description	Spillway	Top Spill	Powerhouse (No Avian Wire Arrays)	Powerhouse (Avian Wire Arrays)
Observed	1,486	8,622	3,549	15
Expected	6,659	1,628	3,900	1,485
Observed - Expected	-5,173	6,994	-351	-1,470
(Observed - Expected) ²	26,759,854	48,917,072	123,217	2,161,071
(Observed - Expected) ² /Expected	18,008	5,674	35	144,071
X ² =167,788; p<0.001				

Table 2 Chi-Square results for Wanapum Dam avian predation distributions during 2007 avian depredator control efforts.

Location Description	Spillway (Avian Wire Arrays)	Tailrace (No Avian Wire Arrays)	Powerhouse (Avian Wire Arrays)
Observed	4	6,420	3
Expected	830	5,147	450
Observed - Expected	-826	1,273	-447
(Observed - Expected) ²	681,878	1,620,405	199,981
(Observed - Expected) ² /Expected	170,469	252	66,660
X ² =237,382; p<0.001			

4.2 Lethal versus Non-Lethal Control Actions

During the 2007 out-migration period, WS hazed 15,900 avian predators at Priest Rapids Dam and 7,092 avian predators at Wanapum Dam. A total of 66 days of avian control activities were conducted at Priest Rapids Dam, but only 32 of those 66 days employed lethal control actions. A total of 413 avian predators were lethally removed at Priest Rapids Dam with 200 California gulls, 193 ring-billed gull, 4 herring gulls (*Larus argentatus*), 14 double-crested cormorants (*Phalacrocorax auritus*), and 2 common mergansers (*Mergus merganser*) composing the total number of lethally-removed birds by species. For the 32 days when both non-lethal and haze-lethal control actions were performed, predatory activities were interrupted a significantly greater period of time for non-lethal control actions than for haze-lethal control actions (Table 3). The median time between non-lethal hazing techniques was almost 28 minutes, whereas the median time for lethal control actions to interrupt feeding was about 10 minutes.

Table 3 Wilcoxon Signed Rank Test results for haze and haze-lethal control actions at Priest Rapids Dam.

Wilcoxon Signed Rank Test					
Data source: 2007 Avian Control Data at Priest Rapids Dam					
Normality Test: Failed (P < 0.050)					
Group	N	Missing	Median	25%	75%
Haze	32	0	27.8	17.1	44.2
Haze-Lethal	32	0	9.5	4.9	12.0
W= -522.000; T+ = 3.000; T- = -525.000					
Z-Statistic (based on positive ranks) = -4.880					
p<0.001					

A total of 64 days of avian control activities were conducted at Wanapum Dam, but only 38 days employed lethal control actions. A total of 277 avian predators were lethally removed at Wanapum Dam with 137 California gulls, 131 ring-billed gulls, 1 herring gull, and 8 double-crested cormorants composing the total number of lethally-removed birds by species. For the 38 days when both non-lethal and haze-lethal control actions were performed, predatory activities were interrupted a significantly greater period of time for non-lethal control actions than for haze-lethal control actions (Table 4). The average time between non-lethal hazing techniques was almost 23 minutes, whereas the average time for birds to resume predating after lethal control actions was about 17 minutes.

Table 4 Paired t-Test results for haze and haze-lethal control actions at Wanapum Dam.

Paired t-Test					
Data source: 2007 Avian Control Data at Wanapum Dam					
Normality Test: Passed (p = 0.058)					
Treatment	N	Missing	Mean	Std Dev	SEM
Haze	38	0	22.7	11.5	1.9
Haze-Lethal	38	0	16.6	9.7	1.6
Difference	38	0	6.2	12.3	2.0
t = 3.093 with 37 degrees of freedom; (p = 0.004)					

4.3 Land-Based & Non-Lethal Control Actions

Avian predators were hazed in the tailrace of Priest Rapids Dam by Grant PUD biologists during the dates of May 25–27, 2007. WS was not contractually obligated to provide depredation activities during this time. All control actions were land-based and non-lethal. The average amount of time between control actions was 3.7 minutes. These land-based, non-lethal hazing activities were barely effective for the first 2.5 hours of the non-lethal hazing efforts. Eventually, the birds became non-responsive to all land-based hazing efforts.

4.4 Concentrated Areas of Avian Predation Efforts

Avian predators concentrated their foraging efforts on the top-spill bulkhead discharge at Priest Rapids Dam (Figure 4). Specifically, avian predators focused their foraging efforts on the lateral edges of the white water discharge and in the downriver flow of the top-spill bulkhead discharge.

At Wanapum Dam, the amount of powerhouse and spill discharge determined where birds concentrated their predation efforts. Avian predation was primarily concentrated in the sluiceway discharge, below inadvertent spill via Tainter gates 1–11, and where the sluiceway and Tainter gate discharge merged with the powerhouse discharge (Figure 5). Avian predators targeted the sluiceway discharge and foraged further downstream when inadvertent spill occurred.

4.5 Avian Predator Impacts

Seventy-two percent of all the 2007 avian predator stomach samples (n=679) contained salmonid remains. In addition to key physical characteristics, a total of 377 coded-wire tags, 42 PIT-tags, and 2 hydroacoustic tags were also used to identify salmonids to species. The hydroacoustic tags found in the avian stomachs were not functional; however, the color indicated these tags were from Grant PUD or Chelan PUD survival study fish. Collectively, Chinook smolt composed 60.1%; coho smolt composed 28.0%; sockeye smolt composed 9.8%, and steelhead smolt

composed 2.1% of the identifiable salmonids. By avian species, 100% of common mergansers stomach samples (n=2), 36.8% of double-crested cormorant stomach samples (n=19), and 75.1% of gull stomach samples (n=658) contained juvenile salmonids. For all the salmonid remains found in the stomach samples, 429 salmonids were identified to species. A total of 238 salmonids could not be identified to species, and 70 birds contained juvenile salmonid vertebrae that represented an unknown number of salmonids (at least one). Exploitation rates and the total number of smolt avian predators consumed within the tailrace areas could not be calculated with the data available. However, the proportion of salmonids species consumed was available and compared to the in-river availability of salmonid species at the time of consumption (Figure 6). Gulls consumed salmonid species in proportion to their in-river availability, except for steelhead smolt. Steelhead consumption proportions were less than the in-river availability of steelhead smolt (See Appendix C for 2006 results).

Variation was observed between avian predator species with respect to consumed-smolt-to-bird ratios. The greatest consumed-smolt:bird ratio at 1.16 smolt per bird was observed for mixed gulls (n=658). The gull consumed-smolt:bird ratios varied by week (Figure 7). In May, gulls had consumed 1.2 smolt per bird on average at the time of lethal removal. During the first two weeks in June, gulls had consumed 1.12 smolt per bird on average at the time of lethal removal. After the first two weeks in June, gulls had consumed an average of 0.3 smolt per bird at the time of removal. For the common merganser (n=2), the consumed-smolt:bird ratio was 1:1. Two unknown salmonids were identified in the common merganser stomachs. Double-crested cormorants (n=19) had the lowest consumed-smolt:bird ratio at 0.8 smolt per bird at the time of lethal removal. A total of 2 coho and 13 unknown salmonids were found in the cormorant stomachs.

Gulls had the most diverse diet of all avian predators despite being the largest consumer of salmonids. A list of dietary items found in gulls included the following: Chinook, coho, sockeye, steelhead, native cyprinids, juvenile lamprey (*Lampetra tridentatus*), aquatic macroinvertebrates, mollusks, terrestrial insects, macrophytes, grasses, berries, alfalfa, blackbird (Family Icteridae), tadpoles, and rodents. Juvenile salmonids were the only dietary item found in common mergansers. In addition to the 15 smolt present in double-crested cormorant stomach samples, five cyprinids were also found.

Avian predator intensity rates were compared to the RISIC during the out-migration period. Avian predator intensity rates at Priest Rapids Dam ($p < 0.0001$; Figure 8) and Wanapum Dam ($p < 0.0001$; Figure 9) were significantly correlated to the RISIC. Bi-weekly project-wide avian predator index counts were initiated on April 3, 2007 and concluded on August 6, 2007 (Table 5). Total project-wide avian predator counts were not correlated to the RISIC. Of all avian predators observed, Caspian tern counts were the only avian species counts that were significantly correlated to the RISIC (Table 6). Additionally, 76% of all observed Caspian terns observed during the Project-wide avian predator counts were counted at the Beverly Island Complex Site (~2,000 m downriver of Wanapum Dam) and the Goose Island Site. The Goose Island Site observation point is located on the Priest Rapids Dam earthen embankment.



Figure 4 Areas of concentrated avian predation efforts at Priest Rapids Dam, 2007. *Note: The spill pattern presented above was not representative of 2007 operations. In Figure 4, spill occurred at Tainter gate 22, which is the Priest Rapids Dam sluiceway.*

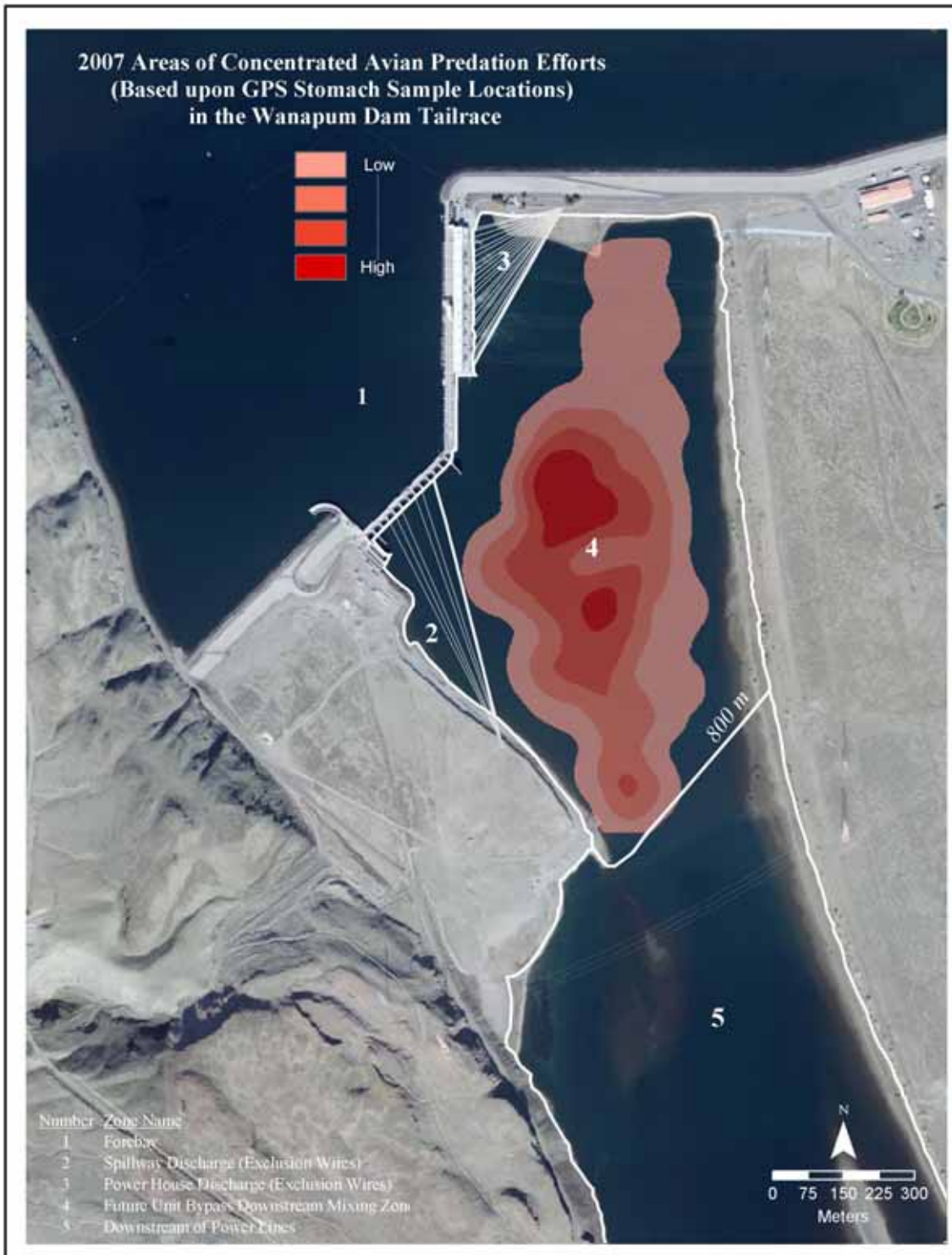
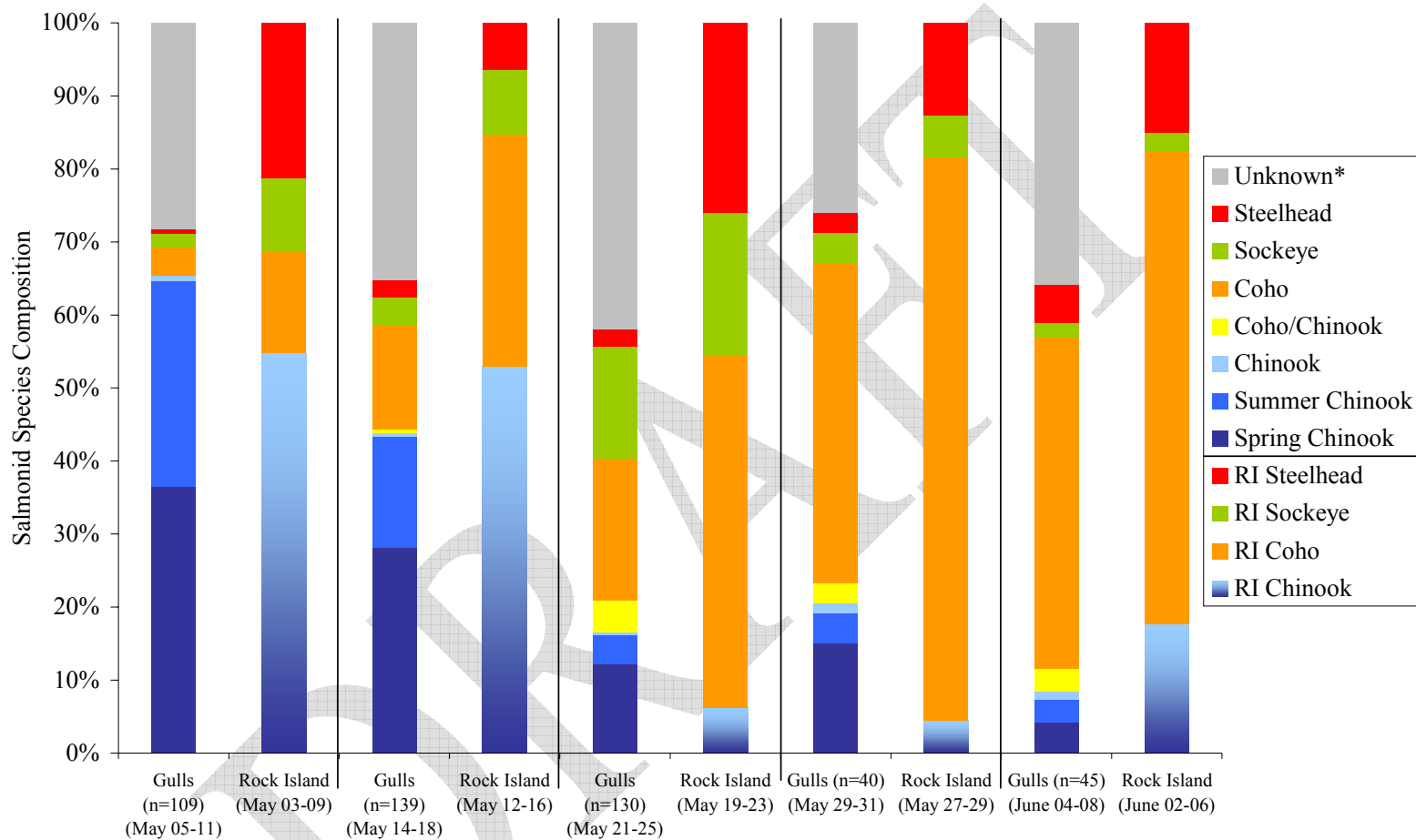


Figure 5 Areas of concentrated avian predation efforts at Wanapum Dam, 2007. *Note: The spill pattern presented above was not representative of 2007 operations. Wanapum Dam was not spilling water when the photo was taken.*



* Unknown salmonids were predominately composed of Chinook, coho, or sockeye smolt
 * Graph incorporated 2 days of out-migration time between Rock Island Dam & Priest Rapids Dam
 * n denotes the number of gull stomach samples collected for each time interval

Figure 6 Comparisons between the salmonid species consumed by gulls and the in-river availability of the juvenile salmonid species at the time of consumption. The numbers of gull stomach samples within each time period were noted with an n-value.

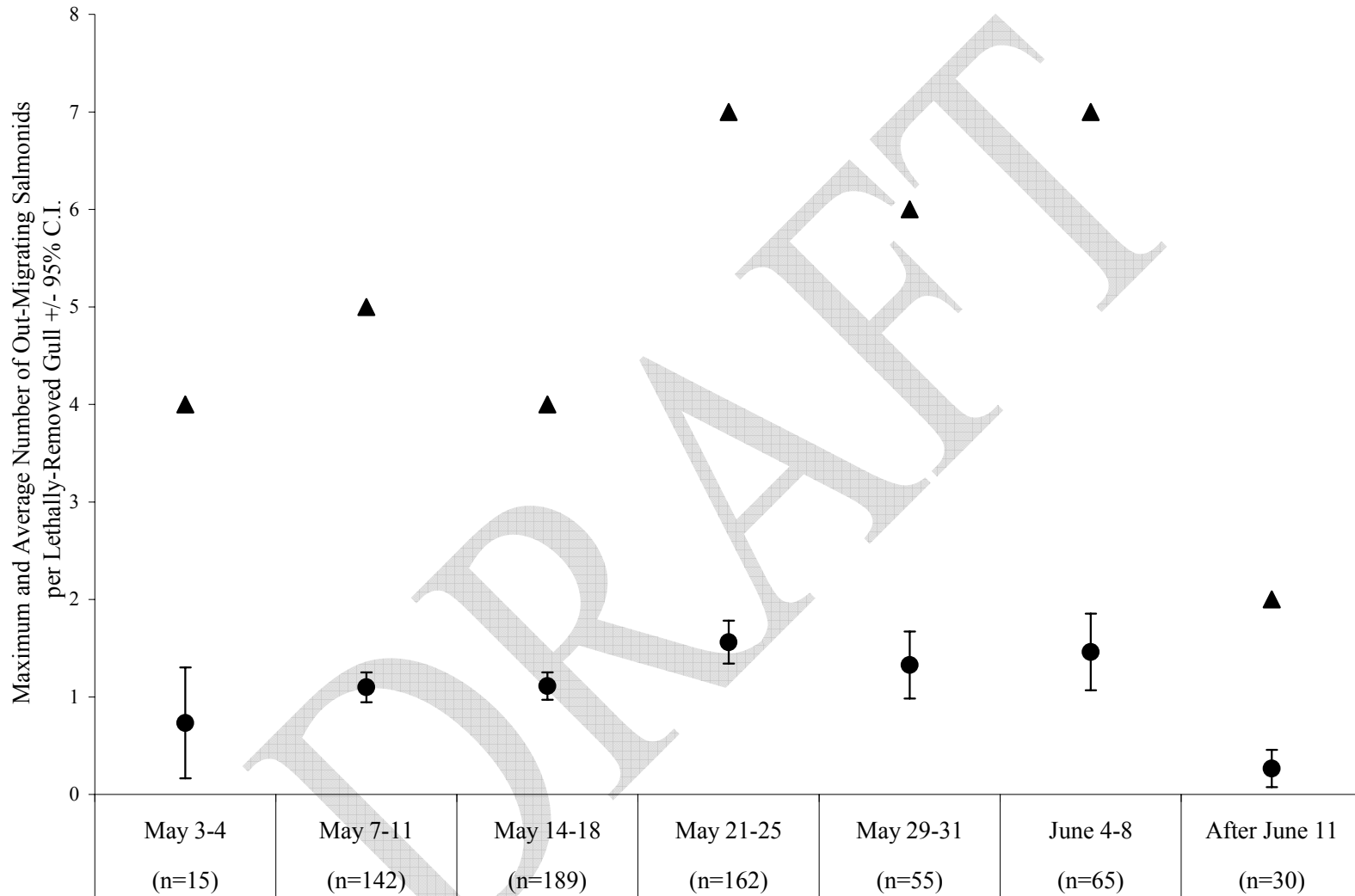


Figure 7 Maximum (triangle) and average (circle) number of salmonids found per gull (*Larus* sp.) +/- 95% C.I. by week in the tailraces of Wanapum and Priest Rapids Dams, 2007. The n-values denote the number of gull stomach samples.

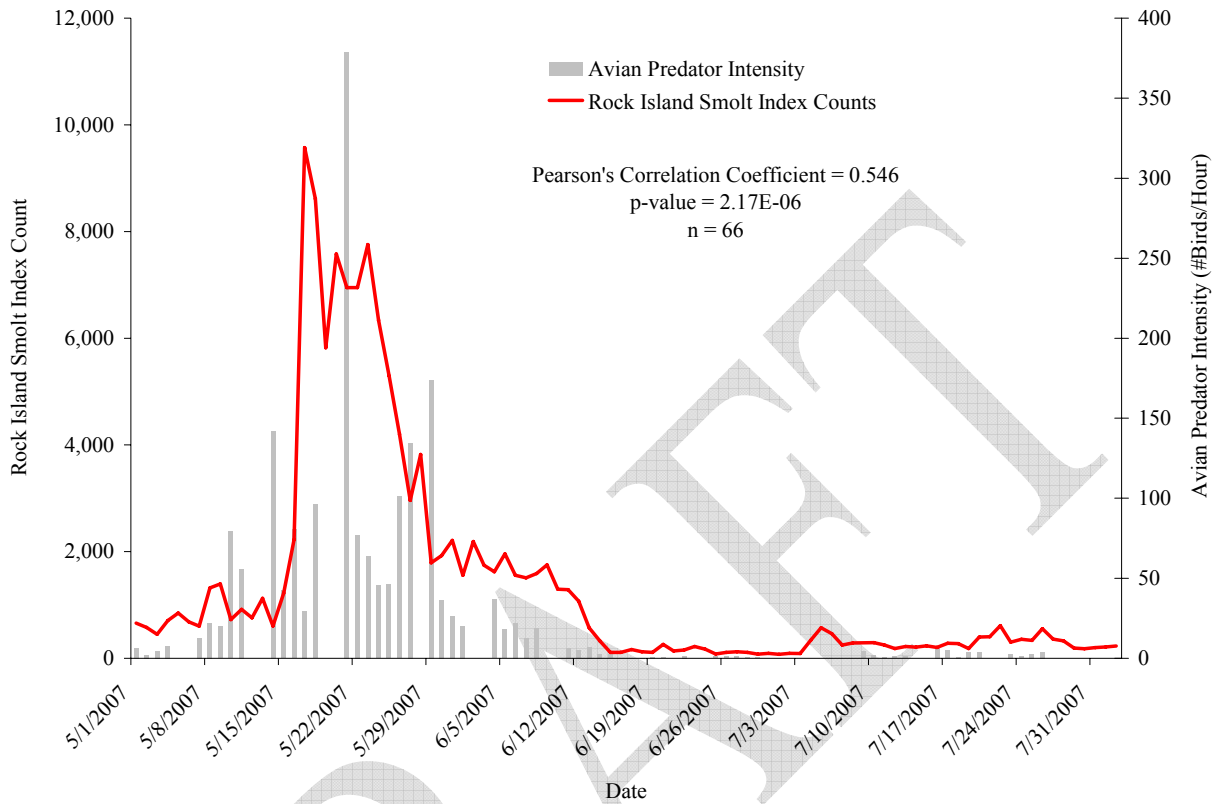


Figure 8 Avian predator intensity rates at Priest Rapids Dam were presented and compared to the Rock Island Smolt Index Counts using a Pearson's correlation.

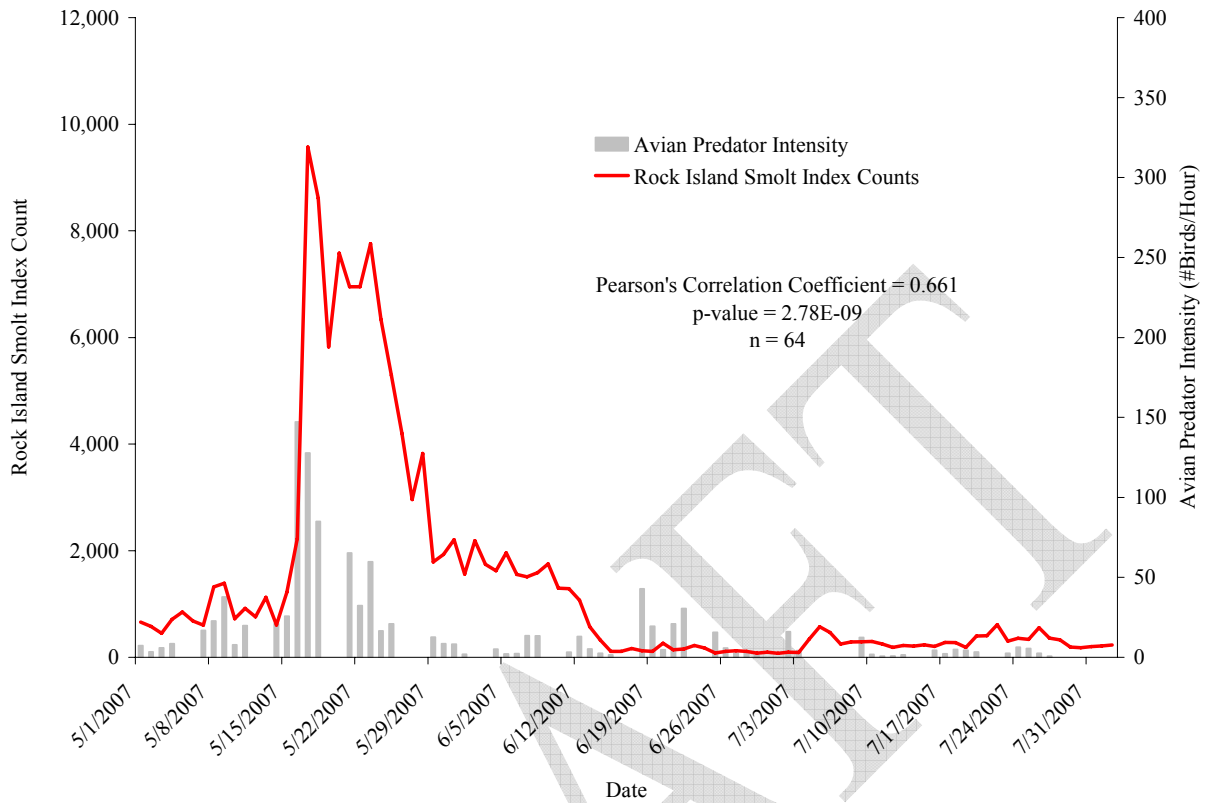


Figure 9 Avian predator intensity rates at Wanapum Dam presented and compared to the Rock Island Smolt Index Counts using a Pearson's correlation.

Table 5 Avian predator index site counts summary by date and species for the Priest Rapids Project, 2007.

Date	Gulls	Caspian Tern	Double-Crested Cormorant	Common Merganser	Hooded Merganser	Grebe	American White Pelican	Great Blue Heron	Grand Total
04/03/07	131	0	6	5	2	32	0	1	177
04/18/07	21	7	4	10	0	8	0	0	50
05/04/07	237	0	0	0	0	10	8	4	259
05/15/07	100	18	0	6	0	5	5	1	135
05/29/07	112	52	1	0	0	3	8	7	183
06/13/07	108	21	9	3	0	23	0	4	168
06/25/07	111	5	1	0	0	0	3	2	122
07/09/07	136	18	24	0	0	16	13	13	220
07/23/07	147	0	13	0	0	17	17	4	198
08/06/07	131	18	14	0	0	26	1	2	192
Grand Total	1234	139	72	24	2	140	55	38	1,704

Table 6 Pearson’s correlation coefficients and p-values for Grant PUD fixed site avian census surveys and the Rock Island Smolt Index Counts, 2007.

Avian Species Compared to RISIC	r	p-value
Gulls	0.003	0.993
Caspian Tern	0.768	0.009
Double-Crested Cormorant	-0.449	0.193
Common Merganser	-0.039	0.915
Hooded Merganser	-0.323	0.362
Grebe	-0.515	0.127
American White Pelican	0.178	0.623
Great Blue Heron	0.185	0.609
Avian Predator Total	0.083	0.820

5.0 Discussion

Based on control action data and dietary evaluations, results showed that avian predators (primarily gulls and Caspian terns) were observed to feed on juvenile salmonids below Priest Rapids and Wanapum dams. The data indicated that avian predators primarily concentrated foraging efforts in areas near the Priest Rapids top-spill bulkhead discharge and the Wanapum sluiceway. Predation at these locations has the potential to affect route-specific dam passage survival and the ability to achieve performance standards. Gulls consumed salmonid species in proportion to their in-river availability with the exception of steelhead. The combination of avian wire arrays in the tailraces of both dams coupled with WS specialists reinforcing pyrotechnic hazing with lethal control via work boats was effective at reducing avian predation.

5.1 Wire Array Effectiveness

Gulls and Caspian terns were the dominant avian predators observed during 2007 avian predator control efforts, and the wire arrays effectively discourage predation by these avian predators. According to 2007 data, 288 control actions were conducted on Caspian terns at Priest Rapids Dam, but only 2 of these 288 control actions were conducted on Caspian terns foraging underneath the avian wire arrays. A total of 607 control actions were conducted on gulls at Priest Rapids Dam, but only 1 control action was conducted on gulls underneath the Priest Rapids avian wire arrays. At Wanapum Dam, a total of 122 control actions were conducted on Caspian terns, but only 1 control action was conducted on Caspian terns foraging underneath the avian wire arrays. A total of 545 control actions were upon gulls at Wanapum Dam, but only 2 of these control actions were conducted on gulls underneath the Wanapum avian wire arrays. Turner et al. (2006) reported the existing Priest Rapids and Wanapum dam wire arrays were effective at discouraging gulls and Caspian terns from foraging in array-covered areas in 2006. Parrish et al. (2006) also reported that Caspian terns were not seen underneath the wire arrays at Rock Island and Rocky Reach dams. Based upon the very limited instances of control actions on gulls and Caspian terns necessary at locations underneath the wire arrays at Priest Rapids and Wanapum

dams in 2006 and 2007, the avian wire arrays appear to be highly effective at discouraging predation by gulls and Caspian terns in the covered tailrace areas of Priest Rapids and Wanapum dams.

Although the existing wire arrays deterred gulls and Caspian terns, the wire arrays did not cover the mid-river discharge of Priest Rapids and Wanapum dams. At Priest Rapids Dam, avian predators focused their foraging efforts on the top-spill bulkhead discharge (See Figure 4 and Appendix A). In response, Grant PUD has drafted several potential wire arrays to discourage gulls and Caspian terns from foraging in the Priest Rapids Dam tailrace, and Grant PUD is currently evaluating installation of additional wire array(s) in the Priest Rapids Dam tailrace prior to the 2008 juvenile salmon out-migration period. Previous studies have shown that wire arrays were effective at reducing avian predation by gulls and Caspian terns at Columbia and Snake River hydroelectric facilities (Jones et al. 1996, 1997, 1998, 1999; Parrish et al. 2006). Installing a new wire array in the Priest Rapids Dam tailrace is a high priority for Grant PUD based on its anticipated effectiveness on avian predators whose foraging efforts are concentrated in these mid-river, experimental top-spill discharge areas.

The Wanapum Future Unit Fish Bypass (WFUFB) is scheduled to be operational in spring 2008. Based on 2006–2007 observations at Wanapum Dam (Figure 5 and Appendix B), avian predators may concentrate their foraging efforts below the WFUFB discharge. Data collected in 2008 will identify areas where avian predators concentrate their foraging activity related to the WFUFB. Pending the results of the 2008 data, Grant PUD will evaluate the feasibility of constructing new wire arrays in areas where avian predators forage upon juvenile salmonids. Grant PUD is investigating several potential wire array designs to span the expected WFUFB discharge and the potential areas of avian predation. Once the data are collected and the area to be protected is identified, Grant PUD will investigate the feasibility of installing new wire array(s) in the Wanapum Dam tailrace during the winter of 2008–2009.

Although avian wire arrays appear to be effective at discouraging avian predation by gulls and Caspian terns, wire arrays are ineffective at discouraging other avian predators. Mergansers and cormorants accessed areas underneath the wires by flying near the surface of the river and landing underneath the wire arrays prior to foraging. Parrish et al. (2006) also reported that mergansers and cormorants were common predators on the water underneath the avian wire arrays at Rock Island Dam. These avian predators also foraged in areas underneath the existing avian wire arrays at Priest Rapids and Wanapum dams. However, gulls and Caspian terns were the most abundant avian predators in the Priest Rapids and Wanapum dam tailraces, and avian wire arrays were effective at discouraging predation by these species.

5.2 USDA Control Action Effectiveness

Control actions performed via work boats were highly effective and allowed WS specialists to access tailrace areas that could not be reached by land-based hazing. The combination of pyrotechnic hazing and boat harassment displaced birds from the tailrace. Gulls that did not respond to repeated non-lethal hazing efforts were lethally removed and their carcasses were recovered for dietary evaluation. Mergansers and cormorants were easily displaced by the combination of pyrotechnic and boat harassment and were seldom within pyrotechnic range of WS work boats. Parrish et al. (2006) reported that mergansers were especially sensitive to and easily displaced by pyrotechnics. WS observations indicated that as avian predators became familiar with the WS work boats, the presence of the boat was likely the next effective control measure—second only to the existing wire arrays. However, Caspian terns were the exception to this perception.

Caspian terns were difficult to displace with non-lethal pyrotechnic hazing methods in the tailrace areas of Priest Rapids and Wanapum dams. Rockets (which are only launched from land due to safety reasons) and pyrotechnic screamers were the only pyrotechnics that elicited an avoidance response from Caspian terns. Caspian terns were displaced from the tailrace areas when WS pursued the terns with the work boats while firing multiple screamers (i.e., 5–10 rounds per control action event). Land-based control actions and the lack of boat pursuit only relocated the birds to just beyond the effective range of the pyrotechnics.

Non-lethal, land-based hazing techniques were not efficient at displacing avian predators from the tailrace of Priest Rapids and Wanapum dams. The pyrotechnics did not have the range to reach birds that were feeding in the mid-river spill plumes. Additionally, once gulls and Caspian terns discovered the pyrotechnic ranges, the predators continued to forage just beyond the reach of the pyrotechnics. In summary, non-lethal, land-based hazing techniques were slightly effective for about 2.5 hours, and only effective within the range of the pyrotechnics. Once birds became habituated to pyrotechnics, the response times reported on the datasheets were actually the amount of time it took a land-based person to prepare and discharge another rocket while continuing to record data.

The lethal removal of habituated gulls is an effective tool to reduce avian predation. Jones et al. (1996) reported that lethal control increased the amount of time that birds were displaced before returning to an area. WS results showed lethal control was an effective control measure in 2006 and 2007, but the response time results differed between the years due to bird abundances and when lethal control actions were employed. In 2006, lethal control actions increased the amount of time avian predation efforts were interrupted (Turner et al. 2006); however, in 2007, the effectiveness of interrupting predation effort was greater for non-lethal control actions. Habituated gulls, which continued to forage despite ongoing pyrotechnic hazing, attracted new gulls to the dam tailraces. Gull predation was deterred by allowing WS specialists to remove non-responsive gulls while continuing pyrotechnic hazing. Once habituated gulls were removed, hazing remained effective until birds became habituated. As a result, the response times for non-lethal control action were greater than haze-lethal control actions in 2007.

The Columbia Basin supports a substantial number of gulls (Finger and Tabor 1997; Roby et al. 1998; USDA 2003), and the diet of gulls sampled at the mid-Columbia River is diverse. In addition to out-migrating salmonids, York et al. (2000) reported that grain, insects, mammals, and plant material were also important gull dietary components. Turner et al. (2006) identified alfalfa as the primary source of plant material. Therefore, it appears as if these gulls cycle throughout the agriculturally-developed Columbia Basin in search of food. As a result, it is possible that new gulls were active in the area everyday, throughout the day, and throughout the juvenile salmon out-migration period.

Of the combined 20,328 gulls hazed at both Projects, only 3.3% (667) were lethally removed. The goal of the avian predator control program is to reduce avian-related mortality upon juvenile salmonids to achieve the May 2004 Biological Opinion survival standards, not to lethally remove every gull that feeds in the tailrace areas of Priest Rapids and Wanapum dams. The few gulls that did not respond to pyrotechnic hazing were removed to prevent habituated birds from attracting additional birds to the tailrace areas. Gull populations have been steadily increasing in the mid-Columbia region concurrent with lethal control programs (Finger and Tabor 1997; Roby et al. 1998). In 2006, WS amended their lethal take permit due to the increased gull numbers observed at Priest Rapids Dam. In 2007, WS operated within the modified 2006 lethal-take allotment.

In 2008, Grant PUD anticipates the need to increase the amount of active avian predator control that WS provided in 2007. Avian predators concentrated foraging efforts on the Priest Rapids Dam top-spill bulkhead discharge in 2006 and 2007. Grant PUD has proposed several potential wire arrays to discourage gulls and Caspian terns from foraging in the Priest Rapids Dam tailrace, and is currently evaluating installation of additional wire array(s) in the Priest Rapids Dam tailrace prior to the 2008 juvenile salmonid out-migration period and additional WS staff to actively discourage avian predation within the mid-river discharge areas below Priest Rapids and Wanapum dams.

5.3 Spill Configurations and Predator Impacts

Avian predators were more abundant at Priest Rapids Dam than Wanapum Dam in 2006 and 2007. Prior to the operation of the Priest Rapids Dam top-spill bulkhead, the greater amount of avian predation occurred at Wanapum Dam. Wanapum Dam is closer to the avian predator breeding colonies located on the Potholes Reservoir, and in previous years, Wanapum Dam is one of the more convenient foraging locations for avian predators traveling from the Potholes Reservoir. In 2006 and 2007, top-spill occurred at Wanapum Dam during night-time hours. In 2006, no avian predators were observed foraging in the tailrace area of Wanapum Dam during top-spill operations (Turner et al. 2006). However, Priest Rapids Dam operated the top-spill bulkhead 24 hours per day, and avian predators focused their foraging efforts in this discharge. In 2008, Grant PUD plans to operate the Priest Rapids Dam top-spill bulkhead and the WFUFB 24 hours per day, and previous studies have documented that spill attracts avian predators to the tailrace areas of Priest Rapids and Wanapum dams (Searing et al. 2002; Turner et al. 2006).

Avian predation has the potential to affect route-specific survival and behavioral evaluation results at Priest Rapids and Wanapum dams. Searing et al. (2002) reported that foraging success rates at Wanapum Dam were significantly higher during periods of top-spill when compared to inadvertent spill (i.e. sub-surface spill through the Tainter gates). Robichaud et al. (2003) reported that juvenile Chinook salmon survival rates were greatest through the Wanapum Dam

powerhouse when compared to the spillway, sluiceway, and top-spill survival estimates. In 2006, avian predator intensity rates at Priest Rapids Dam were 2.5 times greater during top-spill than without top-spill discharge (Turner et al. 2006). Searing et al. (2002) also reported that bird numbers tripled during full-open Tainter gate spill at Priest Rapids Dam. With top-spill-juvenile-bypass structures expected to be operated 24 hours per day at Priest Rapids and Wanapum dams in 2008, avian predators will most likely be attracted to the tailrace areas of both dams throughout the out-migration period, and avian predator abundances will likely exceed those observed in 2007. As a result, Grant PUD is taking the necessary steps to reduce avian predator impacts to out-migrating salmon in 2008 by installing an avian wire array(s) over the Priest Rapids Dam top-spill bulkhead discharge.

The Avian Predation Studies Review Work Group has questioned what species-specific impacts gulls are imposing upon out-migrating salmonids; however, researchers have been unable to apply PIT-tag recovery studies to effectively determine on which salmonid species gulls forage. In 2006, Grant PUD initiated the first dietary evaluation that analyzed the foregut content of gulls and incorporated CWT and PIT-tag data into the dietary evaluations to better evaluate if gulls target specific salmonid species. Unfortunately, not all CWT code information from the 2006 releases were available at the time of 2006 reporting, but these dietary evaluations continued in 2007, and all 2007 CWT information was available prior to Grant PUD reporting deadlines. As a result, 2006 and 2007 dietary evaluations were presented within this report. The 2006 and 2007 dietary findings were that gulls consumed salmonid species in proportion to in-river availability, with the exception of the larger steelhead smolt. Steelhead smolt consumption ratios were less than in-river availability. Because the steelhead smolt are typically the largest of the smolt, gulls might lack the physical size or strength needed to catch and consume the larger steelhead smolt.

In summary, Grant PUD will continue to identify areas of concentrated avian predation in the tailraces of Priest Rapids and Wanapum dams, evaluate current and future wire array effectiveness, and research the feasibility of constructing additional wire arrays as future juvenile fish bypasses become operational. Grant PUD will continue to control avian predators through a cooperative agreement with WS and investigate further options to reduce avian predation in the juvenile salmon bypass discharge areas to meet the survival requirements of the May 2004 Biological Opinion.

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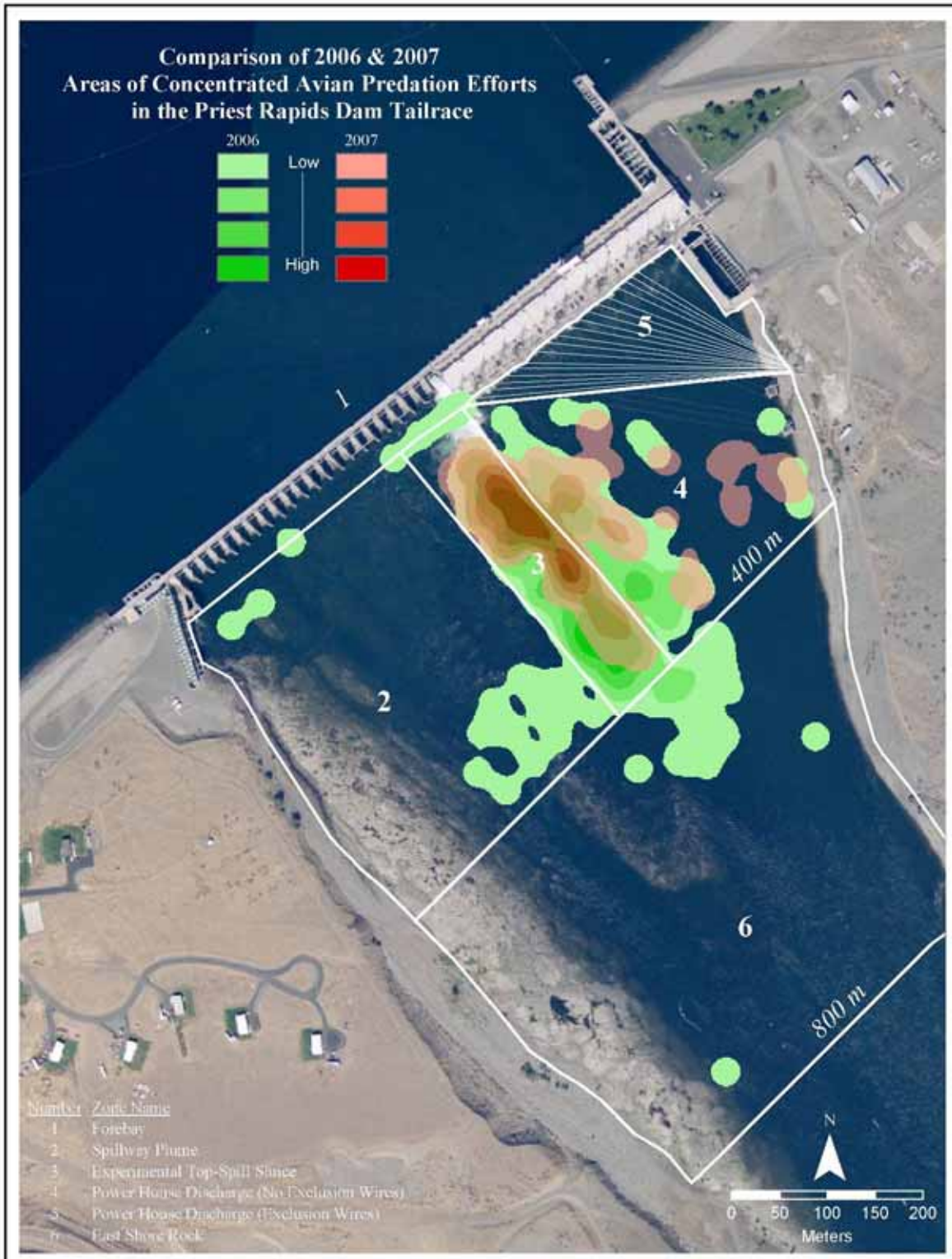
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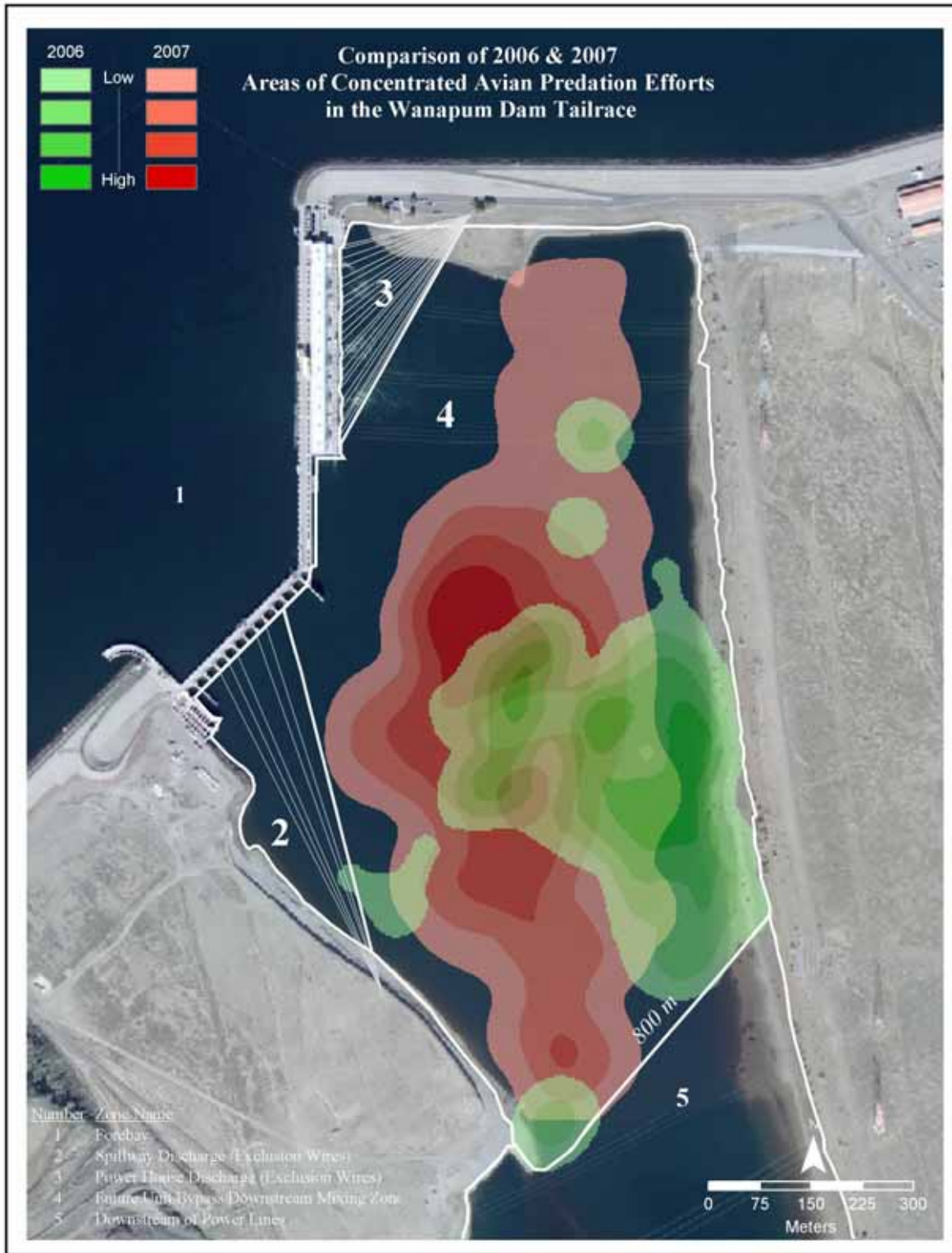
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Appendix A
2006–2007 Areas of Concentrated Avian Predation Efforts at Priest Rapids Dam

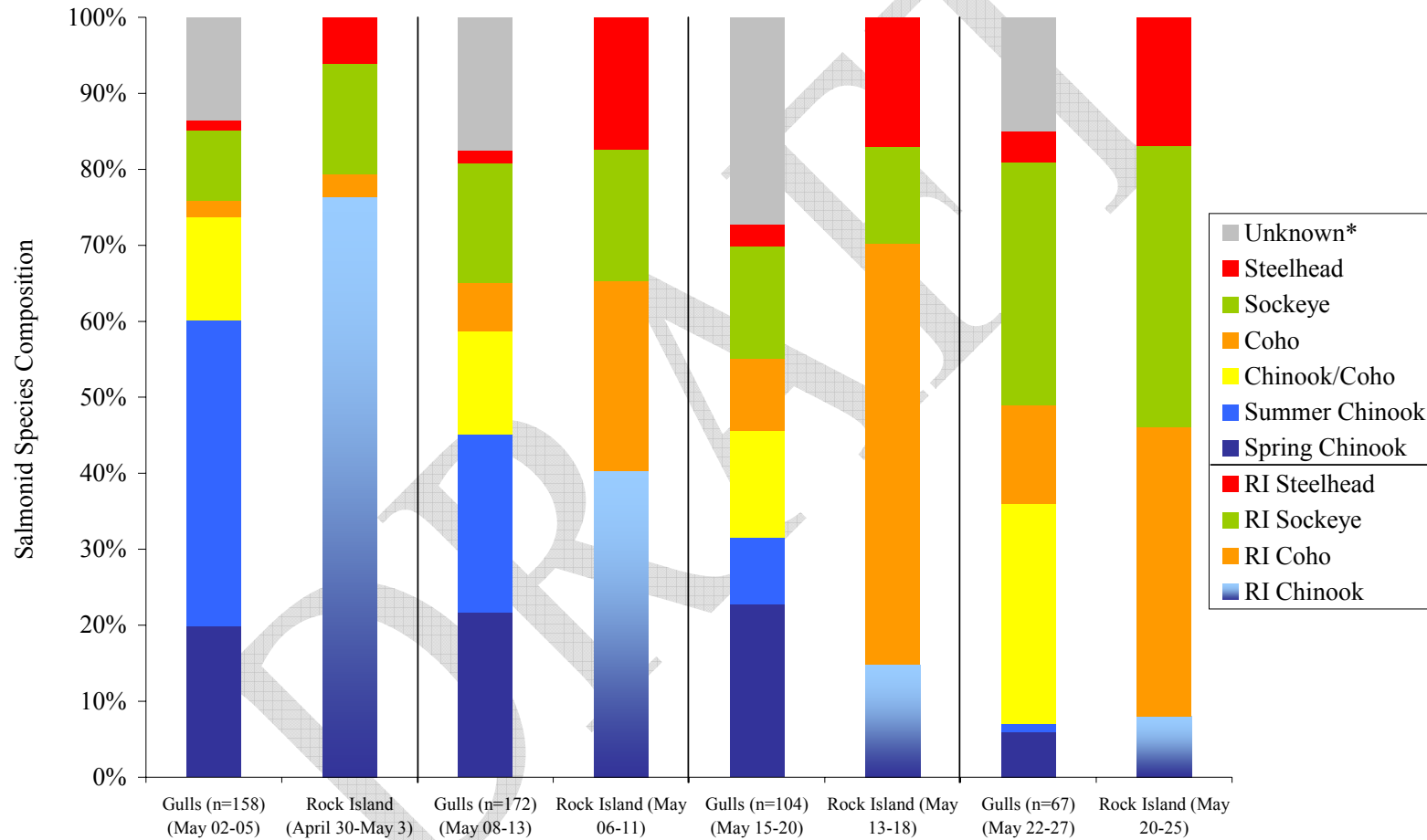


Appendix B
2006–2007 Areas of Concentrated Avian Predation Efforts at Wanapum Dam



B-1

Appendix C
2006 Comparisons between the Salmonid Species Consumed by Gulls and the In-River Availability of the Juvenile Salmonid Species at the Time of Consumption



* Unknown salmonids were predominately composed of Chinook, coho, or sockeye smolt

* Graph incorporated 2 days of out-migration time between Rock Island Dam & Priest Rapids Dam

* n denotes the number of gull stomach samples collected for each time interval