Monitoring and Evaluation of Avian Predation on Juvenile Salmonids on the Yakima River, Washington

Annual Report 2003

Photo by Gaylord Mink

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ABSTRACT

Avian predation of fish contributes to the loss of migrating juvenile salmonids in the Yakima River Basin constraining natural and artificial production. In 1997, the Yakima Klickitat Fisheries Project (YKFP) assessed the feasibility of developing an index to avian predation of juvenile salmonids. The research that followed confirmed that Ring-billed Gulls and Common Mergansers were the primary avian predators impacting migrating smolt populations (Phinney et al. 1998).

In 1999, the Washington Cooperative Fish and Wildlife Research Unit (WACFWRU) continued the development of the index, using monitoring methods modified from Phinney et al. (1998). The monitoring of impacts to juvenile salmon along river reaches and at areas of high predator/prey concentrations, hotspots, has continued each year, with the Yakama Nation joining the WACFWRU on this project in 2002.

The monitoring of avian predation was conducted in 2003 by the Yakama Nation. Piscivorous birds were again monitored at hotspots and along river reaches. Consumption by gulls at hotspots was based on direct observations of foraging success and modeled abundance. Consumption by all piscivorous birds on river reaches was estimated using published dietary requirements and modeled abundance. Seasonal patterns of avian piscivore abundance were identified, diurnal patterns of gull abundance at hotspots were identified, and predation indices were calculated for both hotspots and river reaches.

A major shift in the primary avian predator from gulls to American White Pelicans was observed in 2003 at the Chandler Juvenile Fish Facility, one of the hotspots. Gulls remained the primary predatory at Horn Rapids Dam, the other hotspot. American White Pelicans were the major consumer in the lower river, as in 2002. Common Mergansers remained the primary avian predator on the upper river, as in all previous years surveyed. Estimated consumption by gulls at both hotspots combined in the spring was 141,349 fish. This was approximately half the number of fish consumed by gulls at this location in 2002. Consumption by Common Mergansers in 2003 ranged from 6661 kg of fish in the spring to 2963 kg of fish in the summer in the upper river.

INTRODUCTION

Note:

For the purposes of this document the phrase “juvenile salmonids” refers to juveniles of the following stocks: spring chinook, (*Oncorhynchus tshawytscha*), fall chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), and summer steelhead (*Oncorhynchus mykiss*).

For a more detailed description of previous years’ results and the statistical methods involved in this monitoring effort please refer to this project’s previous annual reports located on the Yakima Klickitat Fisheries Project’s website, www.ykfp.org or the Bonneville Power Administration website, www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/YAKIMA .

Avian Predation of Juvenile Salmon

Avian predation on juvenile salmonids can significantly constrain salmon production and has been shown to impact the survival of juvenile salmonids within both river habitats and fish culture facilities (White 1936, 1939; Mills 1967; Sealy 1973; Alexander 1979; Packhurst et al. 1987; Wood 1987a, b; Pitt et al. 1998; Derby and Lovvorn 1997). The magnitude of impact to migrating smolts by avian predators is highly variable within and across river systems. Estimations of avian consumption of juvenile salmonids within specific river systems and specific years range between 1-66% of particular runs or releases (Alexander 1979; Mace 1983; Ruggerone 1986; Wood 1987b; Kennedy and Greer 1988; Roby et al. 1998; Phinney et al. 1998). As shown repeatedly by investigations throughout North America and Europe, avian predators can consume large number of juvenile salmonids when appropriate conditions for bird and fish interactions occur (Elson 1962; Feltham 1995a; Modde and Wasowicz 1996).

Bird predation of juvenile salmonids is common throughout the Columbia River Basin, which supports some of the largest populations of piscivorous birds throughout North America and Europe (Ruggerone 1986; Roby et al. 1998). Most piscivorous birds within this basin are colonial nesting birds, including Ring-billed, Mew, California and Glaucous-winged Gulls, Caspian Terns, Double-crested Cormorants, Great Blue Herons, and American White Pelicans. These species are particularly suited to the exploitation of fluctuating prey fish densities (Alcock 1968; Ward and Zahavi 1996). Such prey fish density fluctuations can result from, but are not limited to, large migratory accumulations, hatchery releases, physical obstructions that concentrate or disorient fish, and other natural features and events which occur in complex river systems.

The advantage held by colonial birds under such conditions is hypothesized to result from unsuccessful foragers within a colony receiving cues from successful foragers as to prey type and location (Forbes 1986; Greene 1987). Such cues can lead to a rapid response by large numbers of avian predators to available concentrations of prey fishes. These behaviors, in combination with large nesting populations, can lead to high levels of consumption of migrating salmon smolts by avian predators. For example, in 1997, consumption of juvenile salmonids by a single species of avian piscivore, the Caspian Tern, from a single nesting colony within the Columbia River estuary, Rice Island, was estimated to be 6-25% of the 100 million out-migrating smolts that reached the estuary (Roby et al. 1998). In 1999, terns were relocated to a new colony on East Sand Island, where foraging took place in more marine and brackish waters. The consumption of juvenile salmonids by terns was reduced by 34% in 2000, compared to 1998, and was further reduced by 53% in 2001 and 48% in 2002 (Collis, et al. 2003).

Salmon Supplementation in the Yakima and Klickitat Rivers

The Yakima Klickitat Fisheries Project (YKFP) seeks to "test the hypothesis that new supplementation techniques can be used in the Yakima River Basin to increase natural production and to improve harvest opportunities, while maintaining the long-term genetic fitness of the wild and native salmonid populations and keeping adverse ecological interactions within acceptable limits" (Sampson and Fast 2000). This goal is to be accomplished by a combination of salmon supplementation, hatchery rearing adjustments and habitat improvements targeting four principal salmonid species, spring chinook, fall chinook, coho, and summer steelhead. The current operational level of stock specific supplementation programs varies with species.

Intensive monitoring was implemented in conjunction with the YKFP salmon supplementation efforts and has been an ongoing effort since 1997. This monitoring was designed to identify impacts of salmon supplementation on natural production, on harvest, on genetic interactions between natural and supplemented stocks, and on ecological interactions among target and non-target species. Impacts of salmon supplementation on non-target species are being assessed by comparisons of non-target species population parameters such as abundance, size-structure and distribution, and interaction indices before and after supplementation. The impacts of predation on supplemented and naturally spawning salmonid stocks are assessed by indices of predation.

It was anticipated that the interactions between supplemented salmonid stocks and key fish-eating species could impact the ultimate success of the YKFP supplementation efforts (Busack et al. 1997; Pearsons 1998). Understanding such interactions was identified as a high priority by the YKFP Monitoring Implementation Planning Team, which led to the development of an index to bird predation of juvenile salmonids within the Yakima River.

Initial Assessment of Consumption of Juvenile Salmon by Avian Piscivores—1997-1998

In 1997, Dr. Steve Mathews and Dave Phinney of the University of Washington and the Washington State Department of Fish and Wildlife (WDFW), (Phinney et al. 1998), in collaboration with the YKFP, began investigations to assess the potential of avian piscivores to impact juvenile spring chinook populations within the Yakima River. This effort was focused upon broad scale assessments of piscivorous bird abundance within rearing areas preferred by juvenile chinook, as well as abundance and feeding behavior of piscivorous birds at localized areas of intense predation referred to as “hotspots”. In 1997 and 1998, Mathews and Phinney developed field methods, surveyed river reaches and hotspots, estimated piscivorous bird abundance along river reaches and hotspots, estimated piscivorous bird consumption of juvenile salmonids at the most significant hotspots, and investigated the relationship between water flow and avian predation at hotspots.

Mathews and Phinney found that gulls were the most abundant avian predator at the hotspots. Horn Rapids Dam and the Chandler Canal Bypass Pipe were the hotspots with the most intense avian predation (Phinney et al. 1998). Gull abundance at hotspots was negatively correlated with river discharge (Phinney et al. 1998). Common Mergansers were found to be the most abundant avian predator along river reaches and the Zillah reach contained the greatest number of avian predators

Phinney et al. (1998) estimated total consumption of salmonids by birds congregating at Horn Rapids Dam and the Chandler Canal bypass to be 1.7% and 1.1%, respectively, of total juvenile salmon passage. Based upon the assumption that all fish consumed by avian piscivores were salmon and that salmon were consumed in proportion to the relative number passing, 0.52% of all spring chinook passing Horn Rapids Dam and 0.20% of all spring chinook passing Chandler Canal bypass were consumed (Phinney et al. 1998). The authors suggested that the relatively

high flows in spring of 1998 were responsible for holding avian consumption of salmon and trout at hotspots to low levels. They suggested that unusually low water levels during spring smolt migrations may facilitate a much higher level of avian predation of migrating salmon and trout. During 1999, spring flows were again higher than average and combined take by avian predators at the hotspots was 2.7% of all salmonids passing over Prosser Dam (Grassley and Grue 1999), similar to the percentage taken the year before (Phinney et al. 1998).

Determination of the composition of fishes species consumed by piscivorous birds has proven problematic. Consumption estimates have relied upon observations of predation by gulls at hotspots, and daily energy requirements of avian piscivores enumerated on river reaches. Mathews and Phinney attempted a direct assessment of consumption for a single species of avian piscivores along river reaches, the Common Merganser, collecting the contents of 20 bird stomachs. Prey species composition and percent of stomachs containing identified prey items were obtained, but no length or mass estimates of prey items identified were reported.

Consumption of Juvenile Salmon by Avian Piscivores—1999 to 2002

Beginning in 1999 and continuing through 2002, the Washington Cooperative Fish and Wildlife Research Unit (WACFWRU) continued the research efforts begun by Mathews and Phinney to develop an index to bird predation of juvenile salmonids on the Yakima River. The Yakama Nation joined the WACFWRU in 2002, and took over the monitoring in 2003. Monitoring methods developed by Mathews and Phinney for river reaches and hotspots were largely adopted, with the frequency of surveys increased and some methodological alterations implemented (Grassley and Grue 2001).

This effort was again organized into two specific time frames within which impacts of bird predation on juvenile salmon were assessed. The first time frame, from early April to June 30, labeled as spring, addressed the impacts of avian predators on juvenile salmon during the spring migration of smolts out of the Yakima River. The second time frame, from July 1 to August 31, labeled as summer, addressed impacts to coho and spring chinook parr and/or residualized coho and spring chinook in the upper reaches of the Yakima River. The use of two seasons allowed for sampling efforts to be accomplished on an even number of 2-week blocks to fit the consumption model. These two time frames followed the organization and methodological designs set forward in the 1999 annual report (Grassley and Grue 2001) and are referred to within this document as “spring” and “summer”. This report and subsequent analysis is also organized into these generalized time frames in an effort to focus on impacts to particular salmonid life histories.

The abundance and consumption surveys of avian predation at the two principal hotspots, Horn Rapids Dam and Chandler Canal bypass, and the abundance surveys along six river reaches were conducted between 1999 and 2002. New efforts included the monitoring of hatchery acclimation sites by Yakama Nation (YN) personnel at the Easton and Clark Flat facilities beginning in 1999 and Jack Creek acclimation site in 2000, and well as the monitoring of the North Fork Teanaway River downstream of the Jack Creek acclimation facility. Aerial surveys along low and middle river reaches were conducted in 1999 and 2000.

Hotspot Surveys—Spring

Hotspot surveys were conducted from mid-March through May in 1999 and from early April to the end of June in 2000 through 2002. Surveys were conducted to assess the impact of localized areas of intense avian predation on the migrating spring chinook smolt population and other spring migrant juvenile salmonids. The abundance of avian piscivores was determined and behavioral based consumption of fish was estimated. These estimates were expanded across larger time frames in order to estimate seasonal impacts to migrating salmon smolts.

Hotspots were defined as any sustained and localized area of intense avian predation of fish. Hotspots can be caused by natural circumstances such as a pool of fish during extreme low water events, a by-product of hatchery operations such as open fish holding ponds, or the result of fish interacting with physical objects within the river channel such as dams, irrigation and fish bypass structures. Although the hotspot surveys were designed to address the impact of smolt concentration and disorientation caused by dams and fish bypass structures, the definition was intentionally generalized to encompass any natural circumstance that may produce the same outcome. It was intended that this survey format would be applicable to any hotspot which may emerge, especially as the physical parameters of the river change over time, such as increases or decreases in river flow, or new construction.

Within the Yakima River in normal flow years hotspots are most commonly the result of interactions between water flow and man-made structures which lead to local areas of intensely disrupted water. The movement through such areas by fish, such as migrating juvenile chinook, can lead to a temporary suspension of normal predatory avoidance behaviors due to disorientation, injury or shock. Under such circumstances, predation by avian predators may be highly efficient and intense.

Hotspot survey methods were altered beginning in the 2001 season in order to better estimate capture rates and consumption of smolts by gulls and to better deal with potential statistical bias. The new method involved acquiring time intervals between successful takes by gulls to determine consumption. This method was also used in 2002 and 2003.

River Reach Surveys—Spring and Summer

Spring river reach surveys were conducted from mid-March the end of May on the Benton, Vangie, Zillah and Cle Elum reaches in 1999. These reaches, as well as the Easton and the Canyon reaches, were surveyed from early April to the end of May in 2000 through 2002. These surveys focused on avian impacts to migrating spring chinook. Summer river reach surveys were conducted from June 1 to August 30 and consisted of the Cle Elum and Easton reaches in the upper Yakima River. The Canyon was added to the summer surveys in 2002. Summer surveys focused on impacts to spring chinook and coho parr and/or residualized spring chinook and coho. Selection of river reaches was based on a combination of factors including historical precedence, reaches utilized by Phinney et al. 1998, the degree of representation of typical habitats within the Yakima River, and the logistical constraints imposed by intermittent river access points and impassable obstructions such as dams and log-jams. River reach surveys were designed to estimate bird abundance and not directly measure consumption. Objectives related to estimating consumption by avian piscivores along river reaches were accomplished through a combination of bird abundance estimates and published daily caloric requirements for individual species. The Canyon reach was added to the spring survey schedule in 2001 and to the summer survey schedule in 2002. Also in 2002, there were more drifts on the Easton reach earlier in the spring than in 2001.

Acclimation Site Survey—Spring

YKFP supplementation efforts utilize acclimation facilities to hold and imprint salmon smolts to different waters within the Yakima River system. Acclimation sites incorporated traditional and semi-natural raceways, artificial outer channels, and volitional release regimes to facilitate the introduction of salmon smolts into waters targeted for natural production by returning adults. Acclimation site surveys were initiated in 1999 and continued each year to assess the potential for avian piscivores to be attracted to acclimation sites. These surveys were designed by the WACFWRU and implemented by YN hatchery personnel.

Aerial Surveys—Spring and Summer

Aerial bird surveys of the middle and lower Yakima River have been conducted regularly by the YN to provide broad scale census data for target species. These surveys were included in this project in 1999 and 2000 and included all piscivorous bird species that could be dependably identified. These surveys provided abundance data and confirmed that the hotspots chosen for intensive monitoring were the most active sites. In 2000, aerial surveys were paired on four days with river drifts on the Benton reach in an effort to compare the two survey methods. Aerial surveys were not conducted in 2001 or 2002.

North Fork Teanaway River Surveys—Spring and Summer

The Teanaway River is a major tributary to the upper Yakima River, entering the river at kilometer 284. Approximately 26 kilometers up the Teanaway, along the North Fork Teanaway River, the Jack Creek acclimation facility was established in 1999 as part of the YKFP's supplementation effort, with the release of 240,000 coho. Anticipating the potential for newly established acclimation facilities to attract avian piscivores, surveys were begun in 1999 to monitor any changes in piscivorous bird abundance and estimate consumption of salmonids along a reference reach of the North Fork Teanaway. Spring chinook smolt production and acclimation were begun at the Jack Creek facility in 2000 with a release of smolts in the spring. In 2000, the length of the reach surveyed was reduced. Surveys along this reach continued in the spring and summer of 2001 and 2002.

Secondary Hotspots—Spring 2002

In 2002 surveys were conducted at additional dam sites that were identified by Phinney et al. (1998) to ascertain whether or not there were additional hotspots on the Yakima River. These sites included Roza Dam, Sunnyside Dam, Wapato Dam, and Prosser Dam. Surveys at these sites indicated that none of these other sites were being heavily utilized by avian predators at that time.

Summary

From 1999 through 2002, piscivorous birds were counted from the river banks at hotspots and from a raft or drift boat along river reaches. Consumption by gulls was based on direct observations of foraging success and modeled abundance. Consumption by all piscivorous birds along river reaches was estimated using published dietary requirements and modeled abundance. A second-order polynomial equation was used to interpolate abundances on days when surveys were not conducted. Seasonal patterns of avian piscivore abundance were identified, diurnal patterns of gull abundance at hotspots were identified, predation indices were calculated for hotspots and summer river reaches, and the efficacy of aerial surveys for estimating bird abundance within river reaches was evaluated (Grassley and Grue 2001).

The primary avian predators for all four years, 1999 through 2002, were California and Ring-billed Gulls at hotspots and Common Mergansers within the upper river reaches. The estimated take by gulls at hotspots, presumed to be 100 % salmonids, between April 22 and May 30 was 4,084

fish at Chandler and 12,636 fish at Horn Rapids Dam in 1999. Combined take was 2.7% of the salmonids passing over Chandler Dam or 0.9 % of all smolts estimated passing or being released from the Chandler Dam area during the 1999 smolt migration season. The estimated take by gulls at hotspots between April 8 and June 30, 2000, was 30,340 fish at the Chandler Bypass Outfall and 133,135 fish at Horn Rapids Dam. Combined take was approximately 6% of the salmonids passing over or being released from the Chandler Dam area during the 2000 smolt migration season. The estimated take by gulls at Chandler in 2001 was 132,848 fish and 37,035 at Horn Rapids, representing a shift in consumption at these two sites over the previous year. In 2002, consumption estimates for gulls at these sites were 84,203 fish at Horn Rapids, and 195,279 fish at Chandler, or approximately 10% of hatchery released smolts passing or being released from Chandler.

Estimated take by Common Mergansers in the upper reaches of the Yakima River in the summer was 2,068 kg in 1999, 4,866 kg in 2000, 3843 kg in 2001, and 1925 kg in 2002 (Major et al. 2002, Stephenson et al. 2003).

Photo by Ann Stephenson

Common Mergansers on the Upper Yakima River.

METHODS

Study Location

The Yakima River Basin encompasses a total of 15,900 square kilometers in south central Washington State, running along the eastern slopes of the Cascade mountain range for a total length of approximately 330 kilometers (Figures 1and 2). The terrain and habitat varies greatly along its length, which begins at 2,440 meters elevation at the headwaters and ends at 104 meters elevation at the mouth where it enters the Columbia River near the City of Richland, WA.

The upper reaches of the Yakima River, above the town of Cle Elum, are high gradient areas predominated by mixed hardwood-conifer forests in association with a high degree of river braiding, log jams and woody debris. Reaches from Cle Elum to Selah, near the mouth of the Yakima River Canyon, are areas of intermediate gradient with less braiding and more varied terrain, including mixed conifer and hardwoods proximate to the river channel, frequent canyon type geography, and increasingly frequent arid steppe, sagebrush and irrigated agricultural lands. The middle and lower reaches of the river, from Selah to the mouth of the Yakima at the Columbia River, exhibit a low gradient, infrequently braided river channel, and are dominated principally by hardwoods proximate to the river channel with arid steppe and irrigated agricultural lands abutting the shoreline.

Data Collection Methods

Hotspot Survey—Spring

In 2003, hotspot surveys were conducted systematically, on Mondays, Wednesdays, and Fridays at Horn Rapids and Chandler Pipe. A total of 36 surveys were conducted at Chandler Pipe and at Horn Rapids Dam for the 2003 field season, which occurred between April 7 and June 30 (Table 1). For the first five weeks of surveying, both sites were surveyed on the same day for one or two sequential windows by one individual. For the remainder of the season, both sites were generally surveyed on the same day for the same three windows by different individuals. The first and last windows were dropped from the surveys in 2003 due to logistical constraints, and because past surveys revealed that these were the times of little to no activity by gulls.

Observations on survey days either began on the nearest 15-minute interval after sunrise and ran for eights hours, or began at midday, eight hours after the nearest 15-minute interval after sunrise, and ended on the nearest 15-minute interval before sunset. This allowed for observations during all periods of the day, to account for the diurnal patterns of avian piscivores. Regionally calibrated tables obtained from the National Oceanic and Atmospheric Administration were used to determine sunrise and sunset. Depending upon the length of day and the start time, between seven and eight 2-hour windows existed for each day.

The survey area for Horn Rapids Dam included the area 50 meters above and 150 meters below the dam. The buoy located above the dam was not included within the survey area, therefore any birds resting upon the buoy were not included in abundance counts. The survey area for the Chandler Canal Bypass outfall included 50 meters above the outfall pipe and 150 meters below the outfall pipe. All birds resting upon the shoreline lateral to the specified area at both hotspots were included in the abundance counts.

Observations at both sites were made from the shore. At Horn Rapids Dam observations were made from either inside or outside an automobile. At Chandler Canal Bypass observations were made from behind tall grass near the shore just downstream of the outlet pipe, to avoid disrupting normal bird activity.

Figure 1. Map of the Yakima River Basin, Washington with locations of acclimation sites and hotspots.

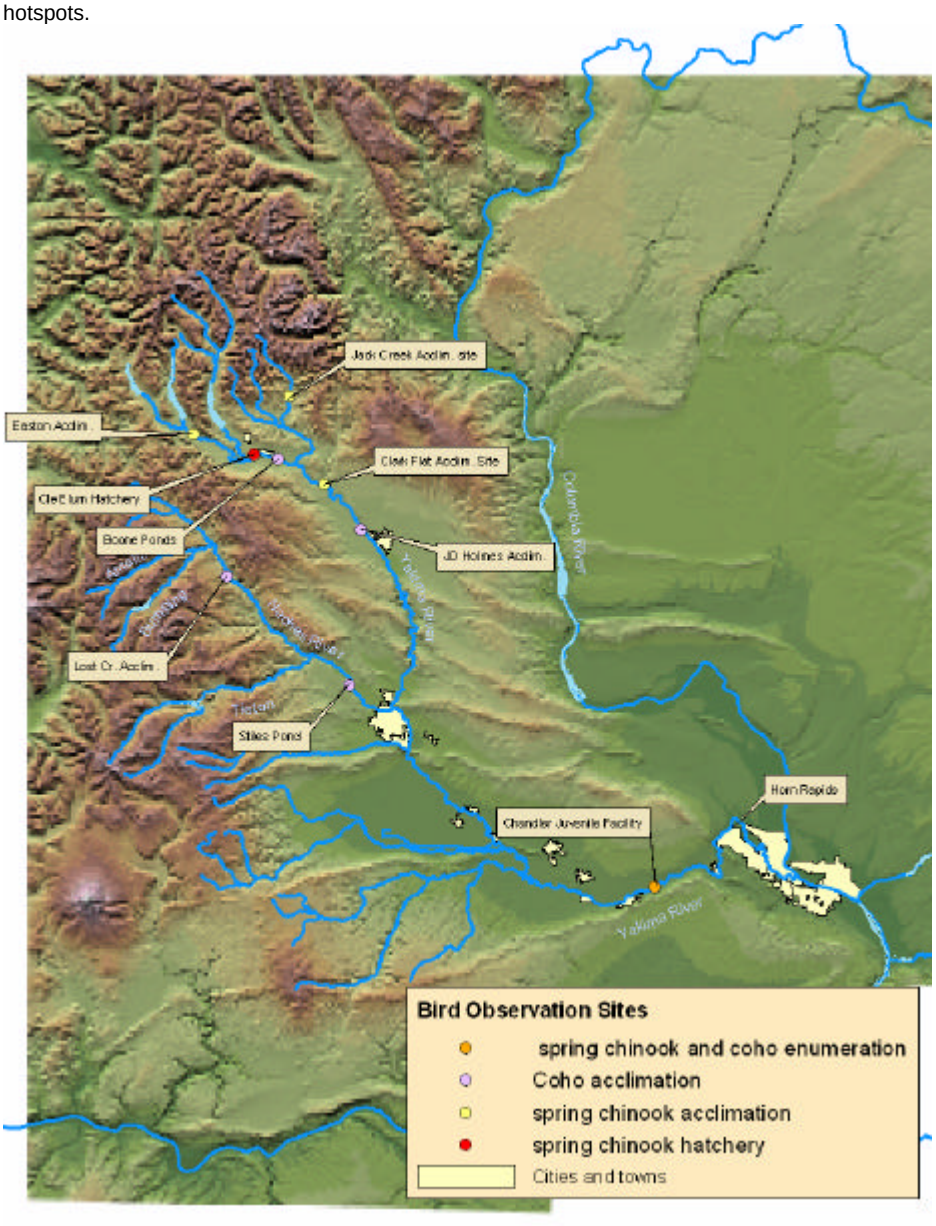


Figure 2. Map of the Yakima River Basin, Washington, with locations of river reaches.

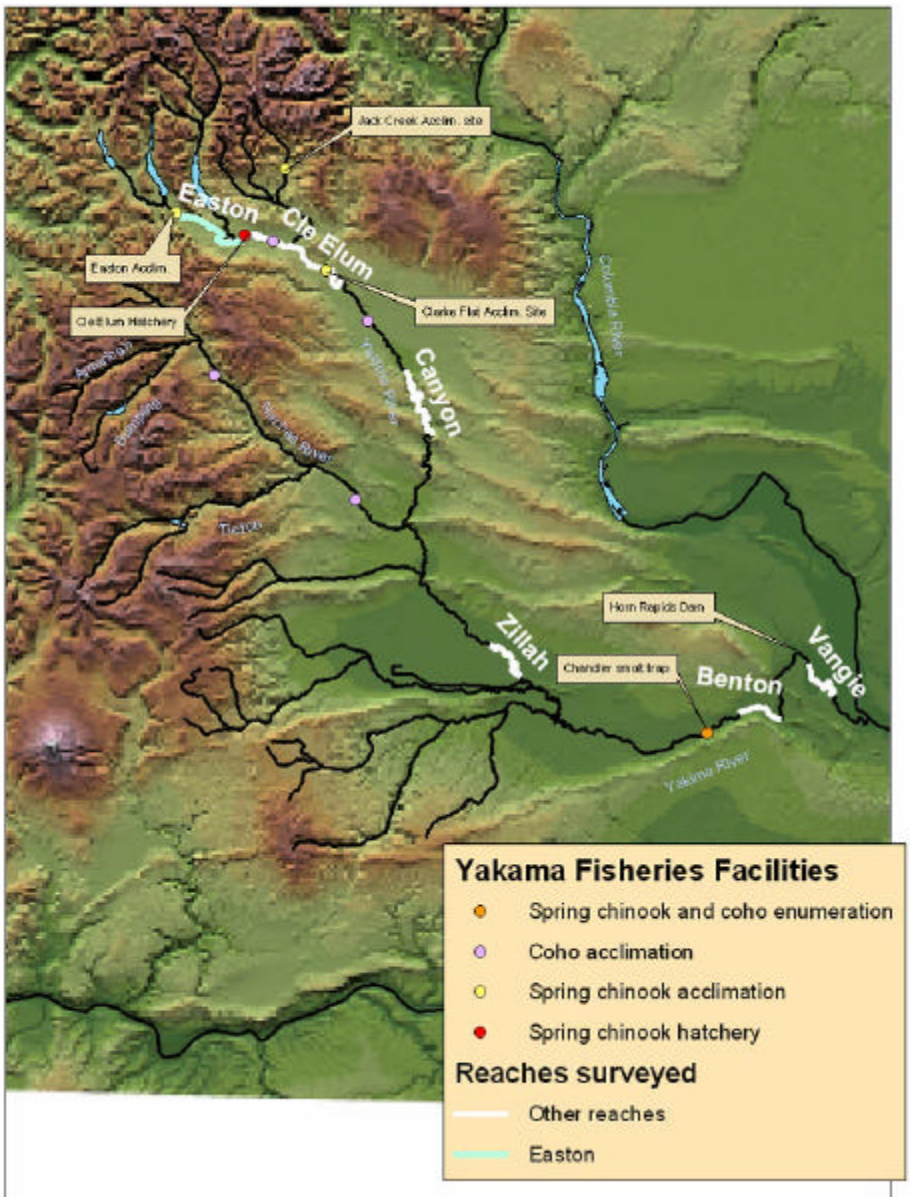


Table 1. Hotspot survey dates for Chandler Canal Bypass Pipe and Horn Rapids Dam in 2003.

Date	Chandler Pipe	Horn Rapids
04/07/03	X	X
04/09/03	X	X
04/11/03	X	X
04/14/03	X	X
04/16/03	X	X
04/18/03	X	X
04/21/03	X	X
04/23/03	X	X
04/25/03	X	X
04/28/03	X	X
04/30/03	X	X
05/02/03	X	X
05/05/03	X	X
05/07/03	X	X
05/09/03	X	X
05/12/03	X	X
05/14/03	X	X
05/16/03	X	X
05/19/03	X	X
05/21/03	X	X
05/23/03	X	X
05/26/03		
05/28/03	X	X
05/30/03	X	X
06/02/03	X	X
06/04/03	X	X
06/06/03	X	X
06/09/03	X	X
06/11/03	X	X
06/13/03	X	X
06/16/03		X
06/17/03	X	
06/18/03	X	X
06/20/03	X	X
06/23/03	X	X
06/25/03	X	X
06/27/03	X	X
06/30/03	X	X

Binoculars, Leica 10x42s, were used to aid in bird identification. At Horn Rapids Dam, survey personnel stationed themselves on the windward bank of the river such that the preferred orientation of feeding gulls was towards the observer. At the Chandler Canal Bypass outfall, altering the side of the river from which observations were made was not feasible. However, the distance from one side of the river to the other was considerably less than at Horn Rapids Dam, which improved the observer's ability to accurately monitor bird behavior.

The hotspot survey design for 2003 followed the method used in 2001 and 2002. Each day was divided into 2-hour survey windows, consisting of three 15-minute abundance and feeding blocks. Between each of these three blocks was a 15-minute period of no observation, unless a feeding interval was still being measured, in which case the observation period was extended into the next 15 minutes. This 75-minute cycle of blocks was followed by a 45-minute rest period before a new 2-hour window was begun. Within each 15-minute survey block, in addition to the abundance of all piscivorous birds being counted, the foraging ratios, (the number feeding to total number present), and the foraging rates, (fish consumed per minute), of gulls were determined (Table 2). Any gull flying within the study area was considered foraging. Gulls within the study area foraging on terrestrial prey items, such as insects, seeds, plants, were not considered feeding, but were included in total abundance counts. Gulls sitting or standing on rocks in the river or along the river's edge were not counted as part of the foraging fraction. Although gulls sometimes used such rocks for fishing platforms, more frequently such platforms were used for loafing and other non-foraging activities. It was not feasible to distinguish foraging gulls standing on rocks from those loafing.

The gull chosen to be observed for foraging rate was the first individual observed consuming a fish within the study area. Once a gull was chosen it was followed continuously until a second successful capture occurred or a maximum of 30 minutes had passed. Initial successful feeding attempts were those in which a foraging bird captured a fish by plunging from the air into the water. Second takes were counted regardless of the means of capture. This accounted for the very rare instance in which the second successful take by a gull was accomplished by stealing from another bird or jumping from an exposed rock or log into the water to catch a fish. Past surveys where a gull was randomly chosen for observation did not provide enough foraging intervals.

Photo by WACFWRU

Gulls at Chandler Outfall Pipe.

Table 2. Hotspot survey period design.

Window	Block	Activity
1	1 Observation (15-minute)	Abundance of all piscivorous birds and ratio of gulls present to gulls foraging determined at beginning of block. First gull observed successfully capturing a fish followed continually until second successful capture. Time of foraging interval recorded. Abundance of all piscivorous birds and ratio of gulls present to gulls foraging determined at end of block
1	Rest (15-minute)	Any ongoing foraging interval was continued into this period until a second successful capture or the end of the 15-minute rest period. If there was no interval ongoing then no data were collected.
1	2 (15-minute)	Same activities as block 1.
1	Rest (15-minute)	Same as previous rest period.
1	3 (15-minute)	Same as blocks 1 and 2.
1	Rest (45-minute)	Any ongoing foraging interval was continued into the first 15-minutes of this period and ended according to the above criteria. The observer then rested for 30 minutes with no data collection activity.
2	1 (15-minute)	Repeat as Window 1.

Reach Surveys—Spring and Summer

Spring river surveys included six different river reaches (Table 3). Each reach was surveyed once every 2 weeks, from April 8 through June 27 (Table 4). These reaches included Benton, Vangie, Zillah, the Canyon, Cle Elum and Easton. During the summer river surveys included only the Canyon, Cle Elum and Easton reaches, which were surveyed every week from July 1 through August 28. All reaches surveyed were identical in length and location to those conducted in previous years.

Surveys were conducted by a two-person survey team from a 16 foot Lavro drift boat on all reaches except Easton, which was surveyed from a two-person raft. Most surveys began between 8:00 am and 9:00 am and lasted between 2 to 6 hours, depending upon length of reach, water level and wind speed. All surveys were performed while actively rowing the drift boat or raft down stream to decrease the interval of time required to traverse the reach. One person rowed the boat while the other person identified and recorded birds. Team members alternated between rowing and bird identification duties approximately every hour. All piscivorous birds that were detected visually or aurally were recorded.

Table 3. River reach start point, end point and total length (km) surveyed for piscivorous birds.

Name	Start	End	Length	Strata
Vangie	1.6 km above Twin Bridges	Van Giesen St Hwy Bridge	9.3	3
Benton	Chandler Canal Power Plant	Benton City Bridge	9.6	3
Zillah	US Hwy 97/St. Hwy 8 Bridge	Granger Bridge Ave Hwy Bridge	16.0	3
Canyon	Ringer Road	Lmuma Recreation Site	20.8	2
Cle Elum	South Cle Elum Bridge	Thorp Hwy Bridge	28.3	1
Easton	Easton Acclimation Site	South Cle Elum Bridge	29.3	1
North Fork Teanaway	Mouth of Jungle Creek	3.5 km downstream	3.5	5

Information recorded included time of observation, species, and sex and age if they were distinguishable. Binoculars, Leica 10x42, were used to aid in identification. All birds positively identified by the rower were included, although the team member responsible for bird identification at the time of the encounter made final decisions for uncertain or potential repeat identifications, that is, double counting.

All piscivorous birds encountered on the river by survey personnel were recorded at the point of initial observation. Most birds observed were only slightly disturbed by the presence of the survey boat and were quickly passed. Navigation of the survey boat to the opposite side of the river away from encountered birds minimized escape behaviors. If subsequent to the encounter the bird attempted to escape from the survey boat by moving down river a note was made that the bird was being pushed. Birds being pushed were usually kept in sight until passed by the survey boat. Passage usually occurred when the river widened sufficiently to let the pushed bird pass to the side of the survey boat.

If the bird being pushed down river moved out of sight of the survey personnel, a note was made, and the next bird of the same species/age/sex to be encountered within the next 1000 meters of river was assumed to be the pushed bird. If a bird of the same species/age/sex was not encountered in the subsequent 1000 meters, the bird was assumed to have departed the river or passed the survey boat without detection, and the next identification of a bird of the same species/age/sex was recorded as a new observation.

Acclimation Site Surveys—Spring

Beginning on January 15th and continuing through May 12th, piscivorous bird surveys were conducted by YN hatchery personnel at the Clark Flat, Jack Creek and Easton Spring Chinook acclimation sites. Surveys were conducted when fish were present at these sites. Fish were held at different times and lengths of time at each site due to weather conditions. Jack Creek was surveyed from February 10 to May 12, Easton from February 13 to March 29, and Clark Flat from January 15 to April 20. Three surveys were conducted at each site during the day, one at 8:00 am, one at noon, and one at 4:00 pm. All piscivorous birds within the acclimation facility, along the length of the artificial acclimation stream, and 50 meters above and 150 meters below the acclimation stream outlet, into the main stem of the Yakima River or N. Fork Teanaway, were identified and recorded within their respective zones. Surveys were conducted on foot by hatchery personnel.

In 2003, surveys were also conducted at four Coho Acclimation sites. Easton Pond and Holmes on the Yakima River were surveyed between February 18 and April 3, and Stiles and Lost Creek on the Naches River, the largest tributary of the Yakima, were surveyed between February 28 and April 13 and 16, respectively. These sites were surveyed between one and four times per day when hatchery workers would visit these sites for other duties.

North Fork Teanaway River Surveys—Spring and Summer

The survey reach included the river and its banks from the Jungle Creek/North Fork Teanaway confluence down river past the Jack Creek acclimation site continuing downstream for approximately 3.5 km. One to two surveyors moved downstream noting the presence of piscivorous birds. All piscivorous birds detected visually or aurally were recorded including time of observation, species of bird, and sex and age if distinguishable. A pair of Leica (10x42) binoculars was utilized to aid in identification. This area was surveyed ten times between May 6 and August 20, 2002, approximately once every two weeks.

Secondary Hotspot Surveys—Spring

Nineteen occasional surveys were made at Prosser Dam between April 9 and June 30, to determine if there were a significant number of birds feeding at dam or the head of the canal, where fish are susceptible to predation due to upwelling.

No secondary surveys were conducted at the four other dams on the Yakima River in 2003, based on the minimal number of birds seen at these sites in 2002.

Table 4. River reach survey dates for spring and summer 2003. Dashed line demarcates spring and summer periods.

DATE	EASTON	CLE ELUM	TEANAWAY	CANYON	BENTON	VANGIE	ZILLAH
8-Apr	X						
10-Apr		X					
15-Apr				X			
17-Apr					X	X	
18-Apr							X
22-Apr		X					
24-Apr	X						
29-Apr				X			
1-May					X	X	
2-May							X
6-May		X	X				
8-May	X						
13-May				X			
15-May					X	X	
16-May							X
20-May	X						
22-May		X					
27-May				X			
29-May					X	X	
30-May							X
3-Jun	X						
5-Jun		X					
10-Jun				X			
12-Jun					X	X	
13-Jun							X
16-Jun	X						
19-Jun		X	X				
24-Jun				X			
26-Jun					X	X	
27-Jun							X
1-Jul				X			
2-Jul		X	X				
3-Jul	X						
8-Jul				X			
9-Jul		X	X				
10-Jul	X						
15-Jul				X			
16-Jul		X	X				
17-Jul	X						
22-Jul				X			
24-Jul	X						
25-Jul		X	X				
29-Jul				X			
30-Jul			X				
31-Jul	X						
5-Aug				X			
6-Aug		X	X				
7-Aug	X						
11-Aug				X			
12-Aug		X	X				
13-Aug	X						
19-Aug				X			
20-Aug		X	X				
21-Aug	X						
26-Aug				X			
27-Aug		X	X				
28-Aug	X						

Results and Discussion

River Reach Surveys

Avian Piscivore Abundance— Spring

In the spring of 2003, from April through June, 14 different piscivorous bird species were observed on the Yakima River. These included the American White Pelican, Bald Eagle, Black-crowned Night Heron, Belted Kingfisher, Caspian Tern, Common Merganser, Double-crested Cormorant, Forster's Tern, Great Egret, Great Blue Heron, California Gull, Ring-billed Gull, Hooded Merganser, and Osprey. These are the same species that were observed in 2002.

The Canyon exhibited the lowest concentration of piscivorous birds, with only 1.23 birds per kilometer (km). The Zillah drift had the highest number of birds per km the reaches, with 5.3 birds per km on average (Figure 2). The day with the most birds per kilometer was on the Vangie reach, with 10.2 birds per km on June 26th. When gulls are excluded from abundance counts, the only reaches that are largely affected are the Benton and Vangie reaches, the two lowest reaches on the river. This indicates that gulls are mostly utilizing the lower reaches of the Yakima River. Osprey, Great Blue Heron, and Belted Kingfisher were found on all six reaches in the spring, and Common Mergansers were seen on all reaches except the Vangie reach. Common Mergansers were again most abundant in the upper most reaches of the river on the Easton and Cle Elum reaches (Figure 3).

Common Mergansers are of particular importance because of their known utilization of salmon smolts as forage (White 1957; Wood 1985) and their relatively high abundance within the upper reaches of the Yakima River. Mergansers were encountered most frequently on the Easton and Cle Elum reaches, 2.24 birds/km and 1.90 birds/km respectively (Figure 3). They represented 72% of all piscivorous birds counted within the Easton reach and 78% of all piscivorous birds counted within the Cle Elum reach during spring. In the Canyon, Common Mergansers accounted for about half, 51%, of all piscivorous birds observed. In the lower three reaches, Common Mergansers accounted for only 2% of all avian piscivores observed on Benton, 26% on Zillah, and were not observed on Vangie.

The distribution of bird species over all six reaches during the spring was highly variable (Figures 5 to 10). The lower sections of the river had a greater diversity of species with ten species occurring on Vangie, nine on Benton and eight on Zillah. Six species were found on Easton and Cle Elum, and five species were seen in on the Canyon. The Vangie reach had the greatest diversity of bird species observed on any reach, with ten of the 14 species occurring at some point during the spring survey season.

Figure 3. Spring abundance of all avian piscivores by reach, April 7 to June 30, 2003. Error bars represent standard deviation.

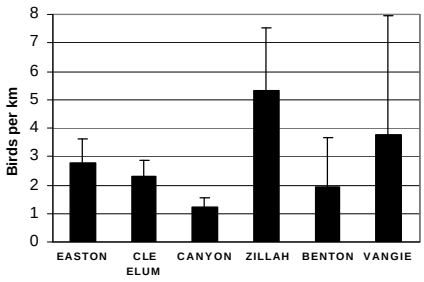


Figure 4. Spring abundance of Common Mergansers by reach, April 7 to June 30, 2003. Error bars represent standard deviation.

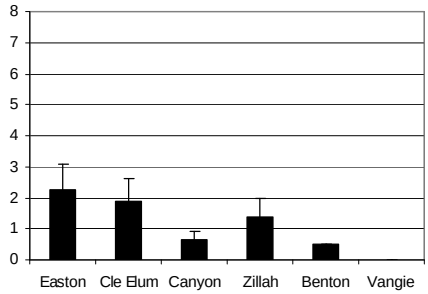


Figure 5. Average spring avian piscivore abundance per kilometer on the **Benton** river reach, April 7 to June 30, 2003. Error bars represent standard deviations.

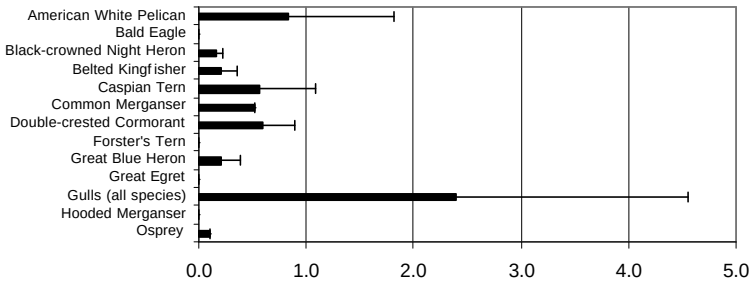


Figure 6. Average spring avian piscivore abundance per kilometer on the **Vangie** river reach, April 7 to June 30, 2003. Error bars represent standard deviations.

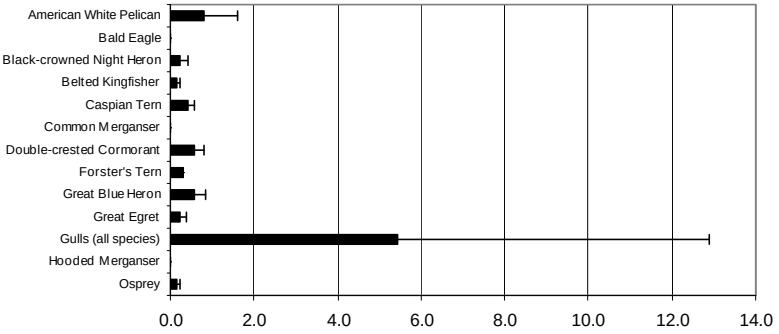
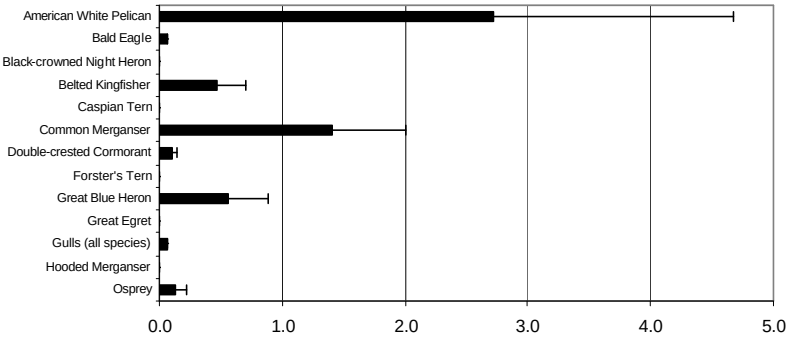


Figure 7. Average spring avian piscivore abundance per kilometer on the **Zillah** river reach, April 7 to June 30, 2003. Error bars represent standard deviations.



Please Note the differences in scale.

Figure 8. Average spring avian piscivore abundance per kilometer on the **Canyon** river reach, April 7 to June 30, 2003. Error bars represent standard deviations.

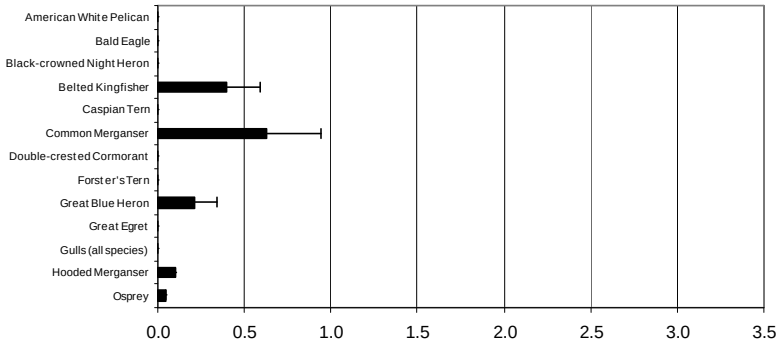


Figure 9. Average spring avian piscivore abundance per kilometer on the **Cle Elum** river reach, April 7 to June 30, 2003. Error bars represent standard deviations.

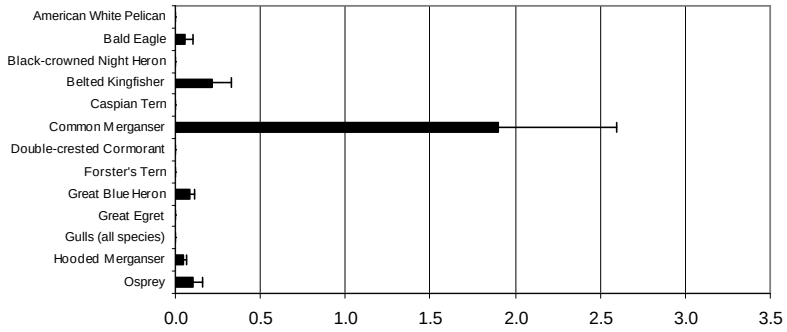
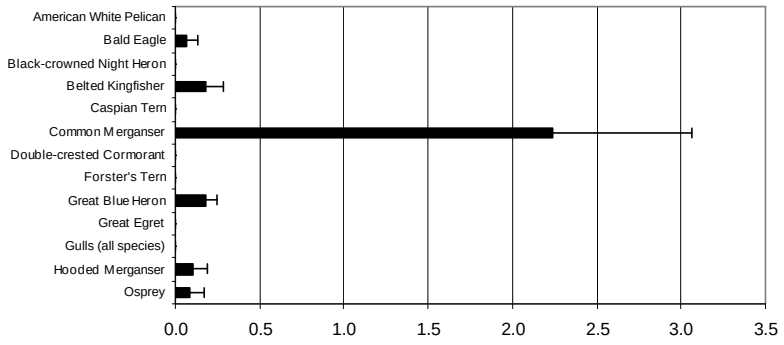


Figure 10. Average spring avian piscivore abundance per kilometer on the **Easton** river reach, April 7 to June 30, 2003. Error bars represent standard deviations.



Avian Piscivore Abundance— Summer

Due to the increase in water temperatures and the drop in water levels in the lower river in the summer, monitoring efforts were shifted to summer parr and resident salmonids in the upper portions of the river. Drifts were limited to the Easton, Cle Elum and Canyon reaches. Common Merganser, Belted Kingfisher, Great Blue Heron, and Osprey were found on all three of these reaches. The Easton reach contained the greatest number of piscivorous birds in the summer (Figure 11). Common Mergansers were by far the most abundant piscivorous bird species found in the upper Yakima River in the summer. Common mergansers also occurred most frequently on the Easton reach (Figure 12).

Figure 11. Summer abundance of all avian piscivores by reach, July 1 to August 31, 2003. Error bars represent standard deviation.

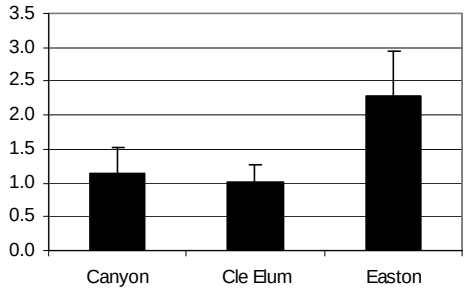


Figure 12. Summer abundance of Common Mergansers by reach, July 1 to August 31, 2003. Error bars represent standard deviation.

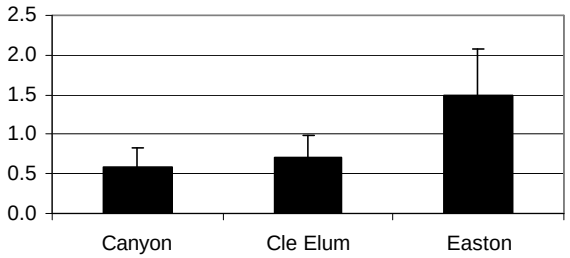


Figure 13. Average summer avian piscivore abundance per kilometer on the **Canyon** river reach, July 1 to August 31, 2003. Error bars represent standard deviations.

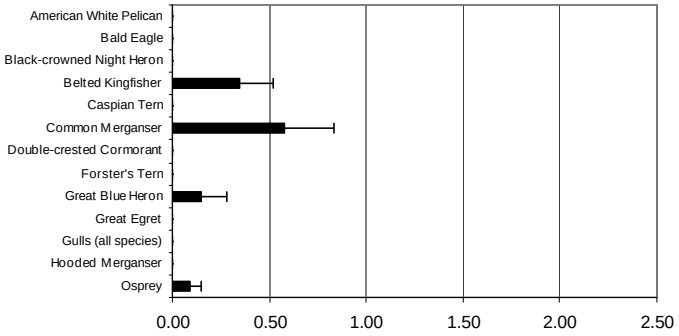


Figure 14. Average summer avian piscivore abundance per kilometer on the **Cle Elum** river reach, July 1 to August 31, 2003. Error bars represent standard deviations.

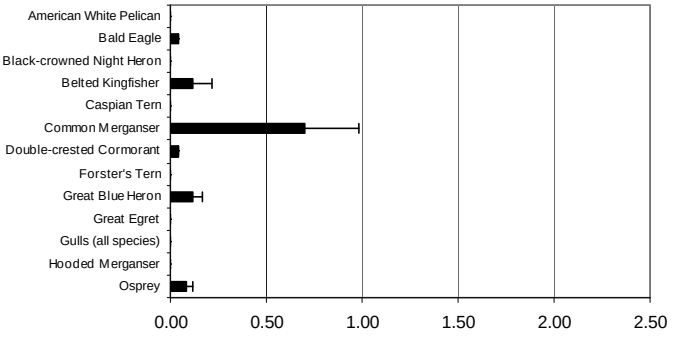
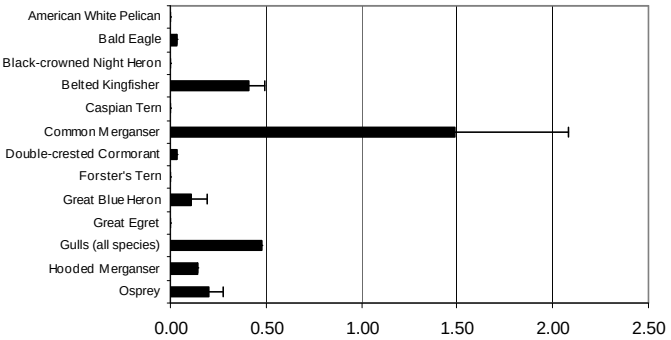


Figure 15. Average summer avian piscivore abundance per kilometer on the **Easton** river reach, July 1 to August 31, 2003. Error bars represent standard deviations.



Avian Piscivore Consumption—Spring

The Yakima River was divided into three main strata based on geographic differences with one or more of the river reaches used to calculate the kilograms of fish consumed by birds in that strata. Stratum 1 is made up of the upper most reaches of the Yakima, including the Easton and Cle Elum reaches, Stratum 2 consists of the Yakima Canyon, and Stratum three is made up of the area downstream of the Yakima Canyon to its confluence with the Columbia, represented by the Zillah, Benton, and Vangie reaches. Mean biomass consumed in Stratum 1 in the spring of 2003 was 87.5 kg/km, 30.2 kg/km in Stratum 2, and 246.5 kg/km in Stratum 3. In the spring, Common Mergansers accounted for 91% of the consumption in Stratum 1, 80% of Stratum 2, and 10% of Stratum 3. Due to their high daily dietary requirements, 1.34 kg per day, American White Pelicans accounted for 69% of the total consumption in Stratum 3 in the spring, an increase of almost 20% over 2002.

Avian Piscivore Consumption—Summer

The mean biomass of fish consumed by avian piscivores in the summer, July 1 through August 31, 2003, was 43.2 kg/km in Stratum 1, and 24.1 kg/km in Stratum two. Common Mergansers were again the major consumer in these two strata in the summer, where they accounted for 82% of the consumption in Stratum 1 and 60% of the consumption in Stratum 2. Summer consumption accounted for 33% of the total consumption for the entire season in Stratum 1, and 44% of the total consumption in Stratum 2. Overall, more fish were consumed in the spring than in the summer for these two strata.

North Fork Teanaway River Surveys—Spring and Summer

Bird species and abundances observed along the North Fork of the Teanaway in 2003 included five Belted Kingfisher, 21 Common Merganser, one Great Blue Heron, and one Osprey. An estimated 9.6 kg of fish were consumed during the spring and .83 kg in the summer. The difference in consumption between seasons can be accounted for by the presence of a large brood of Common Mergansers, 20 juveniles and one female, seen during the spring. Only 28 piscivorous birds were seen over all, reaffirming that the Jack Creek Acclimation Site has not become a major attractant for fish eating birds, either during the release of smolts, or later in the summer.

Hotspot Surveys—Spring

Avian Piscivore Abundance

The average daily gull numbers at Chandler remained at 25 birds per day until the end of April, peaked on May 9th at 67 birds per day, and then remained low for the rest of the season (Figure 16). Gull numbers at Horn were low all season, peaking at 27 gulls per day on May 28th (Figure 17).

Figure 16. Average gull abundance at Chandler. Error bars represent standard deviations.

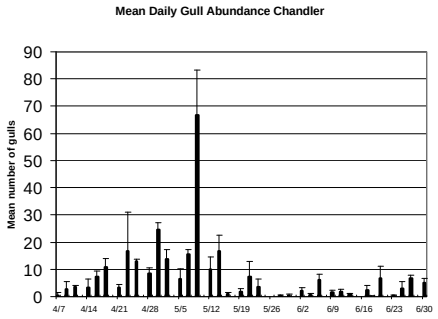
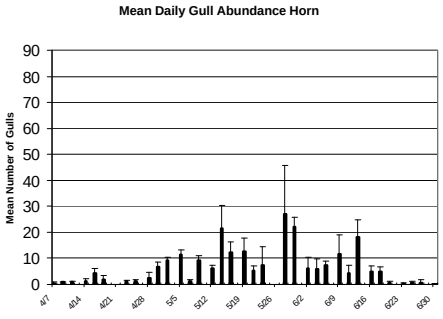


Figure 17. Average gull abundance at Horn Rapids. Error bars represent standard deviations.



Consumption by Gulls

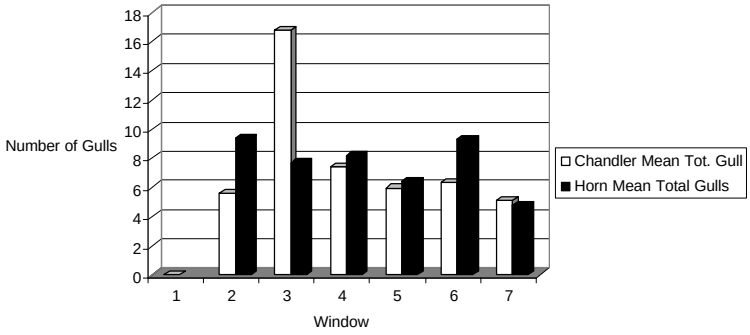
Throughout the 2003 hotspot survey season, an estimated 78,436 fish were consumed by gulls at Chandler, compared with 195,279 fish consumed in 2002. This major decrease in the consumption of fish by gulls can potentially be accounted for by the major increase in the number of American White Pelicans seen at this site. Pelicans were observed harassing and stealing fish from gulls. Pelicans were also observed occupying most of the loafing sites at lower water levels.

The number of fish consumed by gulls in 2003 at Horn Rapids was 62,913, compared to 84,203 fish consumed in 2002. The number of gulls at Horn Rapids also decreased in 2003, but were not displaced by American White Pelicans as at Chandler.

Diurnal Use by Gulls

No clear diurnal pattern of gull use emerged at either hotspot. Gull numbers peaked in the third window after sunrise at Chandler, and were roughly equal during the second and sixth windows after sunrise at Horn (Figure 18). Data was not collected during the first and eighth windows due to logistical constraints. Past years showed greatly reduced numbers during these time periods.

Figure 18. Diurnal pattern of gull abundance at Chandler and Horn Rapids. Numbers 1 through 8 represent 2-hour survey periods beginning the first 15 minutes after sunrise.

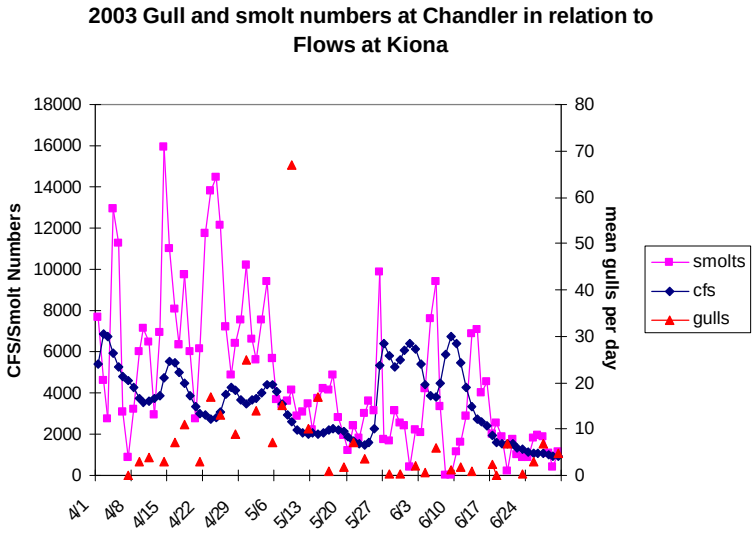


Other species observed at Chandler included: American White Pelican, Great Blue Heron, Caspian Tern, Black-crown Night Heron, Double Crested Cormorant, Great Egret, and Osprey. Other species observed at Horn Rapids included: Double Crested Cormorant, American White Pelican, Caspian Tern, Great Blue Heron, Osprey, Black Tern, Forster's Tern, and Belted Kingfisher.

Chandler Gulls, Smolts and River Flows

Gull numbers at Chandler remained relatively low all season, making it difficult to establish clear patterns between the number of smolts passing Chandler and the number of gulls present. The day with the highest mean daily average of gulls in mid-May does appear to follow an increase in smolt numbers, though it should be noted that the smolt numbers here do not include the release of fall chinook from Chandler. The same case can be applied to gull numbers in relation to river levels at Kiona, located downstream of Chandler near the town of Benton City, though gulls numbers do slightly increase as flows decrease at the end of June.

Figure 19. Gull and smolt numbers in relation to river flow at Chandler.



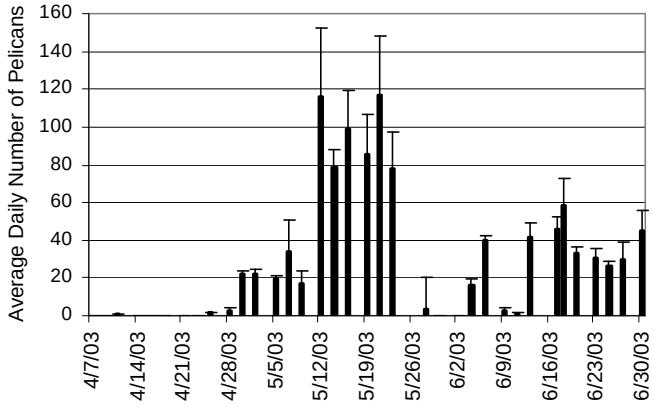
American White Pelicans

Historically, American White Pelicans were known to have occurred in Washington state (Dawson and Bowles, 1909). They are currently listed as a State Endangered species, but are not federally list as endangered. The only currently known breeding colony in Washington State is on Badger Island on the Columbia River. These colonial nesters are known to travel 50-80 km in search of food, so some of the birds on the Yakima River could be coming from this colony (Motschenbacher 1984). Bands that were recovered from three pelicans in the lower Yakima River were found to have come from British Columbia, eastern Montana, and the Klamath NWR (Tracy Hames, personal communication).

There was a dramatic increase in the number of American White Pelicans (*Pelecanus erythrorhynchos*) at Chandler in 2003 from the previous years surveyed. Pelicans were first observed in the lower Yakima River in the mid to late 1980s, and have been increasing in the areas upstream of Prosser since 1994 (Tracy Hames, personal communications). Pelicans were first seen during river reach surveys by the WCFWRU along the lower reaches of the Yakima River in 2001. Based on the model of avian consumption developed by the WCFWRU, pelicans in the lower Yakima River, Stratum 3, accounted for about half of the total fish biomass depredated by piscivorous in 2001 and 2002.

Pelicans were first recorded during hotspot surveys at Chandler in 2000. The average number of pelicans seen in a single day increased from .5 birds per day in 2002 to 35 birds per day in 2003. As the numbers of pelicans increased, they began to displace gulls at foraging and loafing sites. Instances of klepto-parasitism, where pelicans stole the fish the gulls had caught, were observed. As water levels decreased and more rocks were exposed, more loafing sites became available. As pelican numbers increased gull numbers significantly decreased. Although two low pressured sprinklers were run at Chandler near the outfall pipe in 2003 to deter birds, they had little to no effect on the number of birds at this site. The birds became habituated to the sprinklers and easily avoided or ignored them.

Figure 20. Average Daily Number of American White Pelicans at Chandler in 2003.



Acclimation Site Surveys—Winter/Spring

A total of 152 birds of five different species were observed at the spring chinook acclimation sites. 67% of the birds observed were Belted Kingfisher, and the remaining observations were of Bald Eagles, Hooded Mergansers, Great Blue Herons, and one Black-crowned Night Heron. The spring chinook acclimation sites do not appear to be a major attractant for piscivorous birds. At the coho acclimation sites, 84% of the birds observed were Common Mergansers, with the remainder being Belted Kingfisher, Great Blue Heron, Bald Eagle, Double-crested Cormorant, Hooded Merganser, and Great Egret. The coho acclimation site at Easton Pond attracted an exceptionally large number of Common Mergansers.

Summary

In the upper Yakima River Common Mergansers continue to be the major avian predator on fish. A steady increase in the number of American White Pelicans was observed on the lower Yakima River over the last few years. Pelicans were the major avian consumer along these river reaches. 2003 also saw a dramatic increase in the number of Pelicans seen at Chandler, on of the hotspots, over 2002 and preceding years, to the point where they have displaced gulls as the major predator. Gulls remained the major avian predator at Horn Rapids Dam. The spring chinook acclimation sites have not been a major attractant for piscivorous birds, though one coho acclimation site was attracting a large number of Common Mergansers.

Table 5. Piscivorous bird species encountered on the Yakima River 2003.

American White Pelican (*Pelecanus erythrorhynchos*)
Bald Eagle (*Haliaeetus leucocephalus*)
Belted Kingfisher (*Ceryle alcyon*)
Black-crowned Night Heron (*Nycticorax nycticorax*)
California Gull (*Larus californicus*)
Caspian Tern (*Sterna caspia*)
Common Merganser (*Mergus merganser*)
Double-crested Cormorant (*Phalacrocorax auritus*)
Forster's Tern (*Sterna forsteri*)
Great Blue Heron (*Ardea herodias*)
Great Egret (*Ardea alba*)
Hooded Merganser (*Laphodytes cucullatus*)
Osprey (*Pandion haliaetus*)
Ring-billed Gull (*Larus delawarensis*)

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