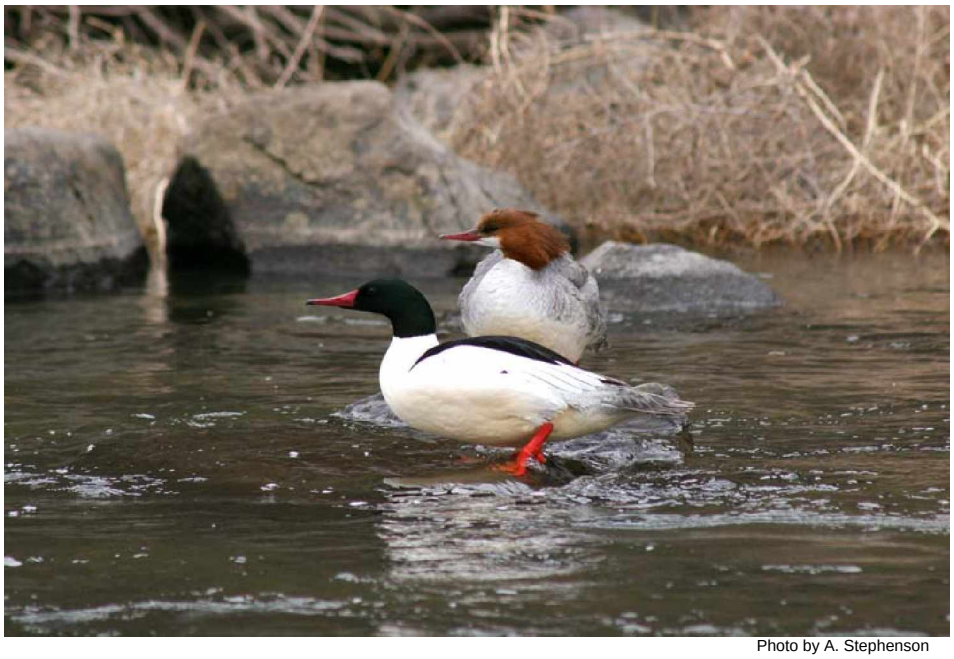
Monitoring and Evaluation of Avian Predation on Juvenile Salmonids on the Yakima River, Washington

Annual Report 2004



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ABSTRACT

Avian predation on fish contributes to the loss of migrating juvenile salmonids in the Yakima River Basin constraining natural and artificial production. The monitoring of avian predation on the Yakima River has been on-going since 1997, when the Cle Elum Supplementation and Research Facility became operational. 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 in 2002. The monitoring of avian predation on the Yakima River was continued in 2003 and 2004 by Yakama Nation Fisheries personnel.

In 2004, piscivorous birds were again monitored along river reaches, at hotspots, and at juvenile salmonid acclimation sites. Consumption by gulls at hotspots was based on direct observations of foraging success and modeled abundance. Abundance estimates of American White Pelicans and other piscivorous birds were also made at the hotspots. 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.

Species abundance at the Chandler Juvenile Fish Facility in 2004 followed the trend of 2003 with a continued increase in the number of American White Pelicans and a further decrease in the number of gulls observed at this site. Gulls remained the primary predator at Horn Rapids Dam, the other hotspot, with a slight increase over the past two years of surveys. American White Pelicans were the major consumer in the lower river, as in 2002 and 2003, and Common Mergansers remained the primary avian predator on the upper river, as in all previous years. Consumption of smolts by gulls at Chandler continued to decrease from previous years, accounting for only 10% of the total consumption at both hotspots. Consumption of smolts at Horn Rapids increased slightly over 2003 and accounted for 90% of the total consumption at hotspots. Estimated consumption of juvenile salmonids by gulls at both hotspots combined in the spring was 112,850, compared with 141,349 fish in 2003, and 279,482 in 2002. The majority of the consumption of all fish species in the upper river, 92%, was by Common Mergansers. Fish consumption by Common Mergansers ranged from 6893 kg of fish consumed in the spring to 4310 kg of fish in the summer in the upper river. The majority of the consumption in the lower river in the spring, 78%, was by American White Pelicans, who consumed 63,598 kg of fish.

INTRODUCTION

Note:

For the purposes of this document the phrase “juvenile salmonids” refers to juveniles of the following stocks: spring chinook and 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’s fish and wildlife technical publications and draft reports website, www.efw.bpa.gov/reports.aspx.

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 1995; 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 1973). 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 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 salmon stocks, spring chinook, fall chinook, coho, and summer steelhead.

An intensive monitoring effort was implemented in conjunction with the YKFP's supplementation efforts and has been an ongoing effort since 1997. The monitoring seeks to identify impacts of salmon supplementation on natural production, impacts 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 predators 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 lead to the development of an index to bird predation of juvenile salmonids within the Yakima River.

Avian Predation of Juvenile Salmonids on the Yakima River

In 1997, Dr. Steve Mathews of the University of Washington and Dave Phinney of the Washington State Department of Fish and Wildlife (WDFW), (Phinney et al. 1998), in collaboration with the YKFP, began investigations to assess the impact of avian piscivores on juvenile spring chinook populations within the Yakima River. This effort was focused on 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". 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). 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. Determining the composition of fish species consumed by piscivorous birds on the Yakima River proved problematic. Consumption estimates have relied upon observations of predation by gulls at hotspots, and daily energy requirements of avian piscivores enumerated on river reaches.

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. Yakama Nation Fisheries, the lead entity for the YKFP, joined the WACFWRU in surveying in 2002, and had continued the monitoring effort since that time. Results from these years can be obtained in the annual reports.

This research is organized into two specific time frames within which the impacts of bird predation on juvenile salmon are assessed. The first time frame, from early April to June 30, "spring", addresses the impacts of avian predators on juvenile salmon during the spring migration of smolts out of the Yakima River. The second time frame, July 1 to August 31, "summer", addresses the impacts to salmon parr and residualized coho and spring chinook in the upper reaches of the Yakima River. Dividing the survey dates into these time periods allows for all future sampling efforts to be accomplished on even numbers of 2-week blocks which best fits the consumption model.

Hotspots are defined as any sustained and localized area of intense avian predation of fish. Hotspots are 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 generalized to encompass any natural circumstance that may produce the same outcome. It was

intended that this survey method 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 flows, or new construction. In normal flow years hotspots are the result of interactions between water flow and man-made structures which lead to local areas of intensely turbulent water. The movement through such areas by migrating juvenile salmonids 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.

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 bird species. Total biomass of all fish species consumed by all piscivorous bird species was estimated, as individual fish species biomass could not be calculated.

In 2004, piscivorous birds were counted from the river banks at hotspots and from a raft or drift boat along river reaches. Consumption by gulls at hotspots 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 aerial surveys were evaluated.

METHODS

Study Location

The Yakima River Basin encompasses a total of 15,900 square kilometers in south central Washington State. The Yakima River runs 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 in 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 dominated 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, WA 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 shrub-steppe, sagebrush and irrigated agricultural lands. The middle and lower reaches of the river, from Selah to the Columbia River, exhibit a low gradient, infrequently braided river channel, and are dominated by hardwoods proximate to the river channel with arid steppe and irrigated agricultural lands abutting the shoreline.

Data Collection Methods

Hotspot Survey—Spring

In 2004, hotspot surveys were conducted on Mondays, Wednesdays, and Fridays at Horn Rapids Dam (Horn Rapids) and Chandler Pipe (Chandler). A total of 37 surveys were conducted at Chandler between April 5 and July 12. Thirty surveys were conducted at Horn Rapids between April 6 and June 30 (Table 1). The continued presence of American White Pelicans at Chandler after the main outmigration of juvenile salmonids warranted the additional surveys at that site. Both sites were generally surveyed on the same day at the same time period by two different individuals.

Observations either began on the nearest 15-minute interval after sunrise and ran for eight hours, or began at midday 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 times at Richland, WA. Depending upon the length of the day and the start time, between seven and eight 2-hour windows existed for each day.

The survey area for Horn Rapids included the area 50 meters of river above the dam 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 Chandler included 50 meters of river above the outfall pipe and 150 meters of river 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 observations were made from either inside or outside an automobile. At Chandler observations were made from a blind just downstream of the outlet pipe from the juvenile fish facility to avoid disrupting normal bird activity.

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

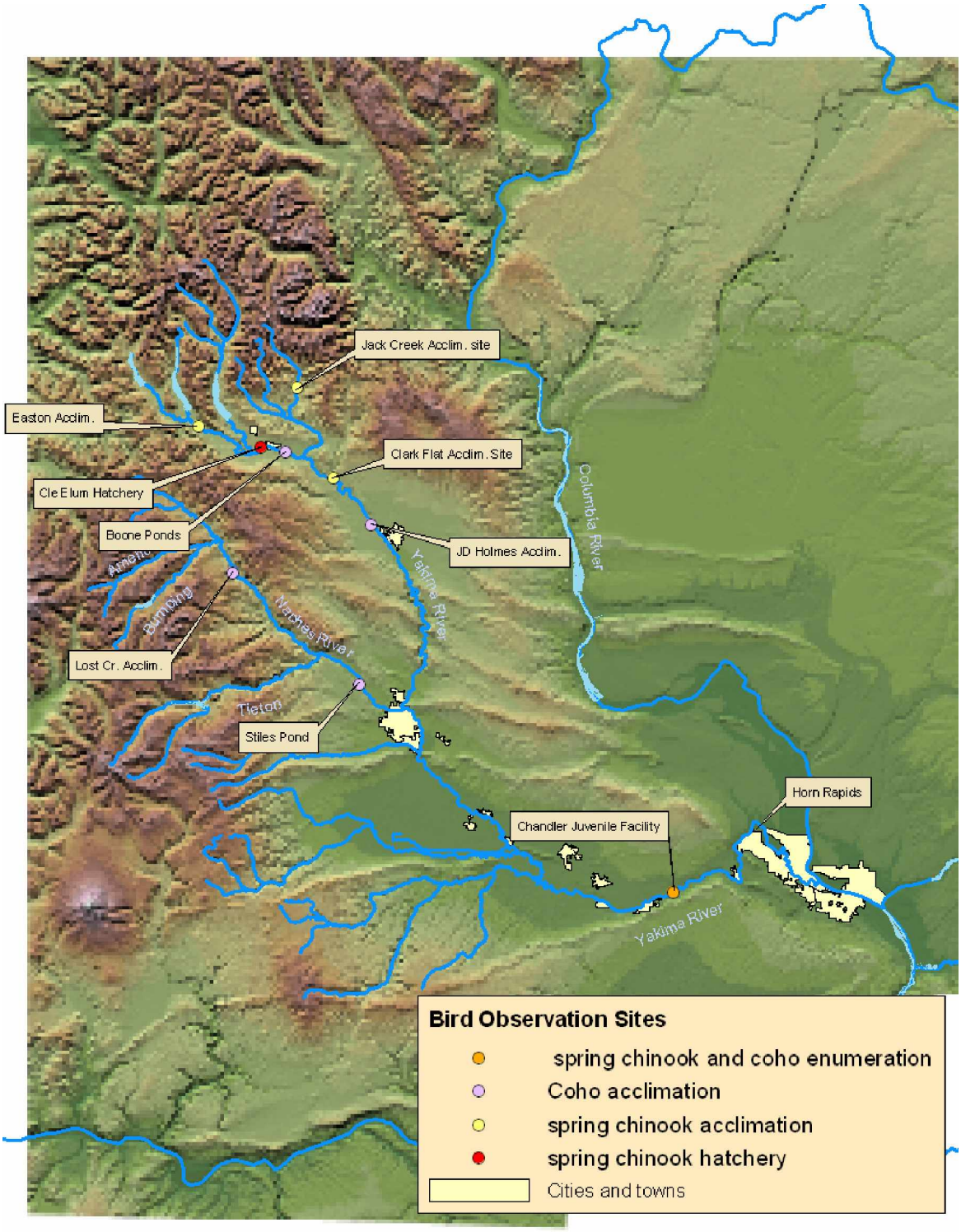


Figure 2. Map of the Yakima River Basin, Washington, with locations of river reaches.

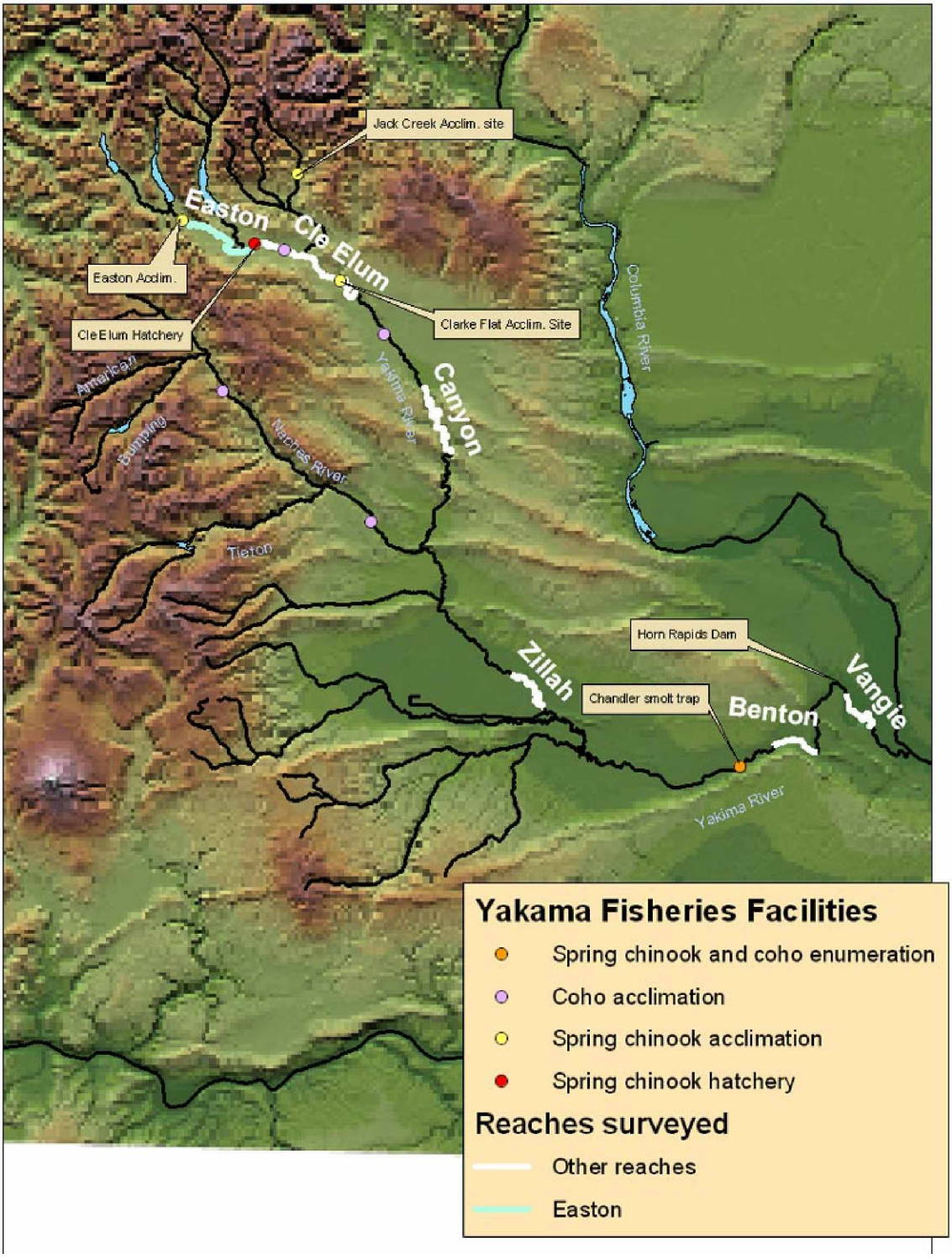


Table 1. Hotspot survey dates for Chandler and Horn Rapids in 2004.

Date	Chandler	Horn Rapids
4/5/04	X	
4/7/04	X	X
4/9/04	X	X
4/12/04	X	X
4/14/04	X	X
4/16/04	X	X
4/19/04	X	X
4/21/04	X	X
4/23/04	X	
4/26/04	X	X
4/28/04	X	X
4/30/04	X	X
5/3/04	X	X
5/5/04	X	X
5/7/04	X	X
5/10/04	X	X
5/12/04	X	X
5/14/04	X	
5/17/04	X	X
5/19/04	X	X
5/21/04	X	
5/24/04	X	X
5/26/04	X	X
5/28/04	X	X
6/2/04	X	X
6/7/04	X	X
6/11/04	X	X
6/14/04	X	X
6/16/04	X	X
6/18/04	X	X
6/21/04	X	
6/23/04		X
6/25/04	X	X
6/28/04	X	X
6/30/04		X
7/2/04	X	
7/7/04	X	
7/9/04	X	
7/12/04	X	

Leica 10x42 binoculars were used to aid in bird identification. At Horn Rapids, survey personnel stationed themselves on the windward bank of the river such that the preferred orientation of feeding gulls was towards the observer. At Chandler, 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, which improved the observer's ability to accurately monitor bird behavior.

The hotspot survey design for 2004 followed the method begun in 2001 and used in 2002 and 2003. 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 the abundance of all piscivorous birds was counted. In addition, the foraging ratios of gulls, the number feeding to total number present, and the foraging rates of gulls, the number of fish consumed per minute, 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 emerging from the river or along the river's edge were not counted as part of the foraging fraction. Although gulls sometimes utilized such rocks as 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 Sara Sohappy

Gulls and Pelicans at Horn Rapids 2004.

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

The spring river surveys included all six river reaches (Table 3). Each reach was surveyed once every 2 weeks, from April 8 through June 28 (Table 4). Reaches included Benton, Vangie, Zillah, the Canyon, Cle Elum and Easton, which accounts for approximately 37% of the Yakima River. During the summer river surveys included only the Canyon, Cle Elum and Easton reaches, which were surveyed every week from June 29 through August 28. All reaches surveyed in both the spring and summer were identical in length and location to those conducted in previous years.

All river reach 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. Surveys began between 8:00 am and 9:00 am and lasted between 2 to 6 hours depending upon the length of the reach and the water level. All surveys were conducted while actively rowing the drift boat or raft downstream to decrease the interval of time required to traverse the reach. Of the two-person survey team, 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.

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

All piscivorous birds detected visually or aurally were recorded, including time of observation, species, and sex and age if distinguishable. Binoculars, Leica 10x42, were again used to aid in identification.

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 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

Three spring chinook acclimation sites in the upper Yakima River, Clark Flat, Jack Creek and Easton, and four coho acclimation sites, Easton Pond and Holmes in the upper Yakima River Basin and Stiles and Lost Creek on the Naches River, the largest tributary of the Yakima, were surveyed for piscivorous birds in 2004. Surveys were conducted between January 20 and May 10, though dates varied for each site. Three surveys were conducted per day at the spring chinook sites, at 8:00 am, noon, and 4:00 pm. Coho sites were surveyed once to twice on the days personnel visited these sites. 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.

North Fork Teanaway River Surveys—Spring and Summer

Surveys along the North Fork of the Teanaway 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 down from Jungle Creek, noting the presence of piscivorous birds. If navigation of the river-bank was not possible, the river was crossed and surveys were continued on the opposite bank. If it was not possible to cross the river, detours were taken away from the river-bank, down stream, and paths through the underbrush were located to enable periodic return to the river-bank. Once there, a visual search up and down the stream was conducted. 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 used to aid in identification. This area was surveyed eight times between April 22 and July 29 in 2004.

Secondary Hotspot Surveys—Spring

Twenty six occasional checks were made at Prosser Dam between May 7 and July 9 to determine if there were a significant number of birds feeding below Prosser Dam or at 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 2004, based on the lack of birds seen at these sites in 2002. Observations of American White Pelicans and Common Mergansers approximately two kilometers downstream of Roza Dam were noted when passing through that area. Birds congregated in this riffle area at various times throughout the season.

Table 4. River reach survey dates for spring and summer 2004.

DATES	EASTON	CLE ELUM	TEANAWAY	CANYON	ZILLAH	BENTON	VANGIE
4/6/04	X						
4/8/04		X	---				
4/13/04				X			
4/15/04							X
4/16/04					X	X	
4/20/04	X						
4/22/04		X	X				
4/27/04				X			
4/29/04						X	X
4/30/04					X		
5/4/04	X		X				
5/6/04		X					
5/11/04				X			
5/13/04						X	X
5/14/04					X		
5/18/04	X						
5/20/04		X	---				
5/25/04				X			
5/27/04						X	X
5/28/04					X		
6/1/04	X						
6/3/04		X	X				
6/8/04				X			
6/10/04						X	---
6/11/04					X		
6/17/04		X	---				
6/18/04	X						
6/22/04				X			
6/24/04						---	X
6/25/04					X		
6/29/04	X						
7/1/04		X	X				
7/6/04				X			
7/7/04	X						
7/9/04		X	X				
7/13/04	X						
7/14/04				X			
7/15/04		X	X				
7/20/04				X			
7/21/04		X	X				
7/23/04	X						
7/27/04	X						
7/28/04				X			
7/29/04		X	X				
8/3/04				X			
8/4/04	X						
8/5/04		X	---				
8/10/04				X			
8/11/04	X						
8/12/04		X	---				
8/17/04				X			
8/18/04	X						
8/19/04		X	---				
8/24/04				X			
8/25/04	X						
8/26/04		X	---				

RESULTS AND DISCUSSION

River Reach Surveys

Avian Piscivore Abundance—Spring

In the spring of 2004, from April through June, after combining the two gulls species into a single group, 13 different piscivorous bird species were observed on the Yakima River. These included: 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, Gull species, Hooded Merganser, and Osprey. These are the same 13 species observed in previous years.

The Canyon drift exhibited the lowest concentration of piscivorous birds with only 1.39 birds per kilometer (km), while the Zillah drift had the highest concentration of birds, with 7.89 birds per km on average (Figure 3). The day with the most birds per kilometer observed was May 25th on the Zillah reach with 17.2 birds per km. When gulls are excluded from these counts, the only reaches that are largely affected are the Benton and Vangie reaches, the two lowest reaches on the river. Osprey, Great Blue Heron, and Belted Kingfisher were the only species found on all six reaches in the spring, and Common Mergansers were again seen on all reaches except the Vangie reach. Common Mergansers were most abundant in the upper most reaches of the river on the Easton and Cle Elum reaches as has been the case in all previous years surveyed (Figure 3).

Common Mergansers are of particular importance because of their known utilization of salmon smolts as forage (White 1957; Wood 1986; Wood and Hand 1985) and their relatively high abundance within the upper reaches of the Yakima River. In 2004, Mergansers were again encountered most frequently on the Easton and Cle Elum reaches, with 2.55 birds per km and 1.81 birds per km observed, respectively (Figure 3). They represented 90% of all piscivorous birds counted within the Easton reach, 86% within the Cle Elum reach during spring and 50% in the Canyon. In the lower three reaches, Common Mergansers accounted for only 17% of all avian piscivores observed on the Zillah reach, 2% on the Benton reach, and were not observed on the Vangie reach at all.

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, and 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 birds observed on any reach, with ten of the 13 species, occurring at some point during the spring survey season. Figure 11 shows prevalence of American White Pelicans and gulls in the lower three reaches of the river and the prevalence of Common Mergansers in the upper three reaches of the river.

Figure 3. Spring abundance, birds per km, of all avian piscivores by reach, April 6 to June 29, 2004. Error bars represent standard deviation.

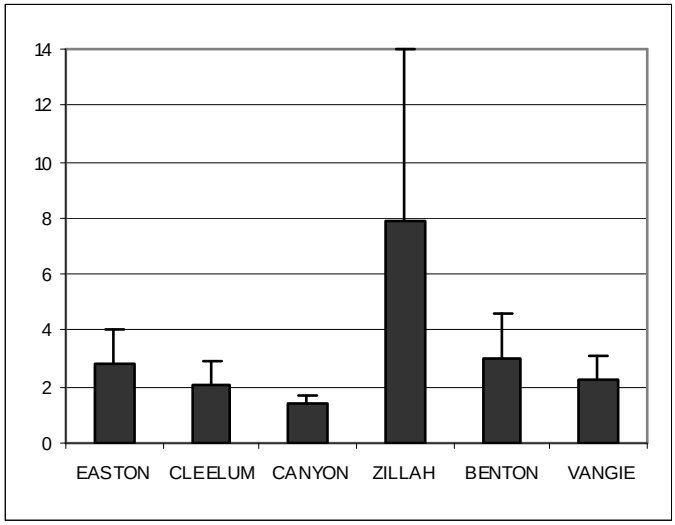


Figure 4. Spring abundance, birds per km, of Common Mergansers by reach, April 6 to June 29, 2004. Error bars represent standard deviation.

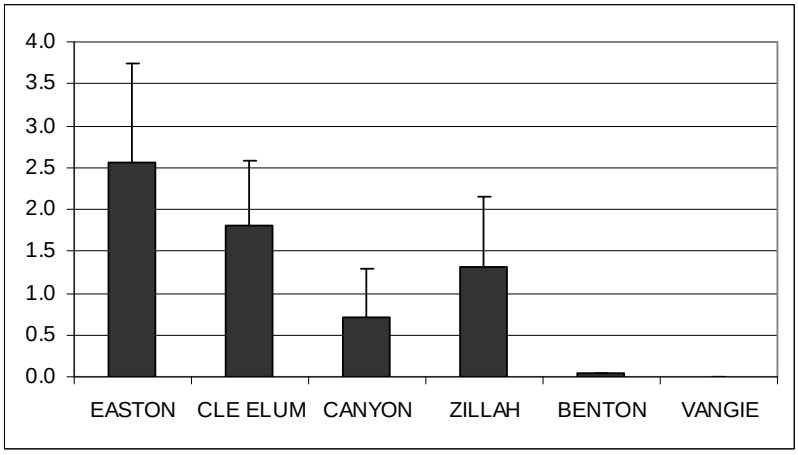


Figure 5. Average spring avian piscivore abundance per kilometer on the Benton river reach, April 6 to June 25, 2004. Error bars represent standard deviations.

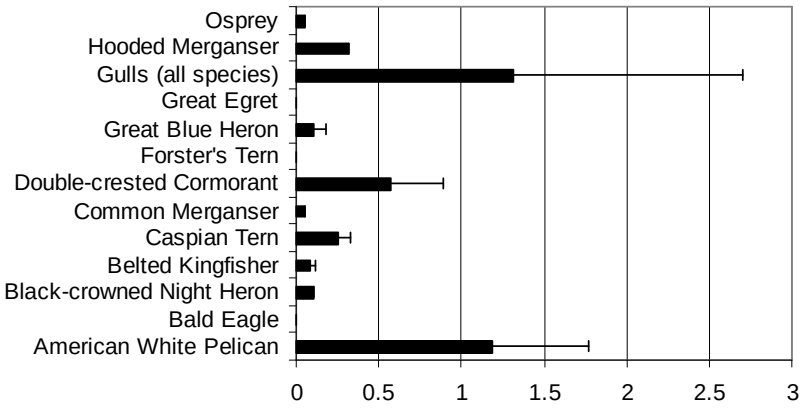


Figure 6. Average spring avian piscivore abundance per kilometer on the Vangie river reach, April 6 to June 25, 2004. Error bars represent standard deviations.

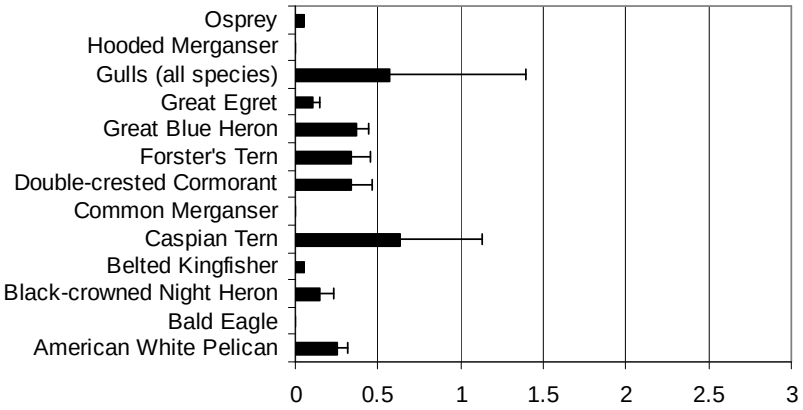
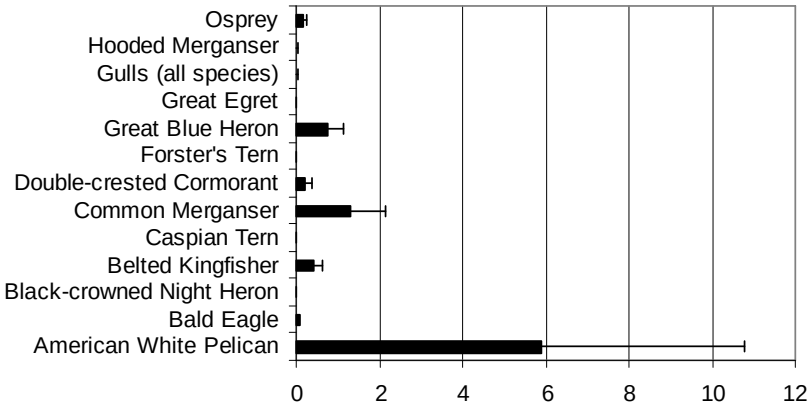


Figure 7. Average spring avian piscivore abundance per kilometer on the Zillah river reach, April 6 to June 26, 2004. Error bars represent standard deviations.



Please Note the differences in scale.

Figure 8. Average spring avian piscivore abundance per kilometer on the Canyon river reach, April 6 to June 25, 2004. Error bars represent standard deviations.

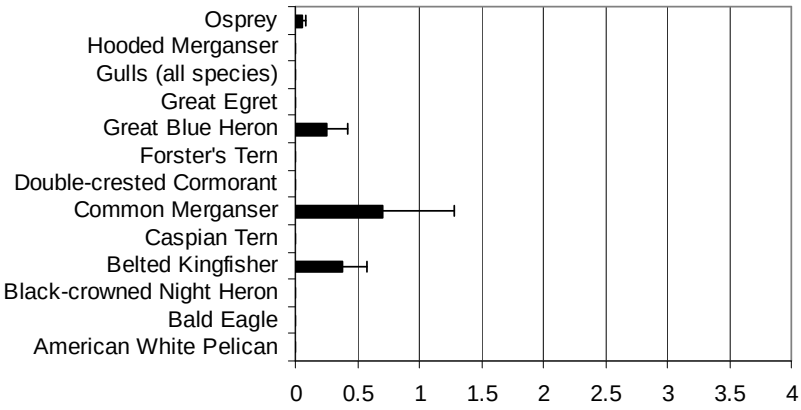


Figure 9. Average spring avian piscivore abundance per kilometer on the Cle Elum river reach, April 6 to June 25, 2004. Error bars represent standard deviations.

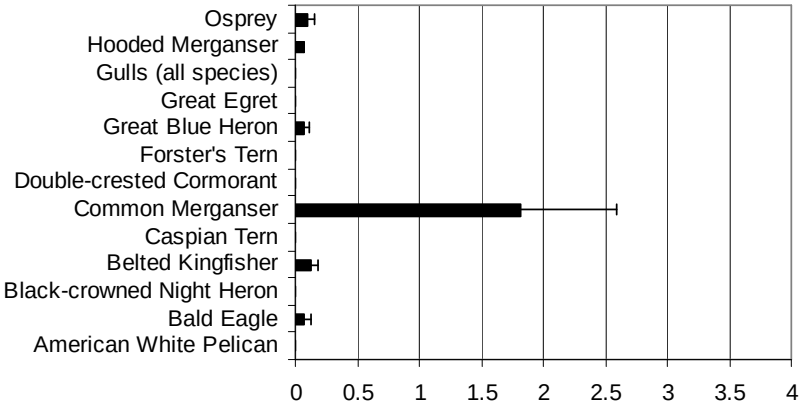


Figure 10. Average spring avian piscivore abundance per kilometer on the Easton river reach, April 6 to June 25, 2004. Error bars represent standard deviations.

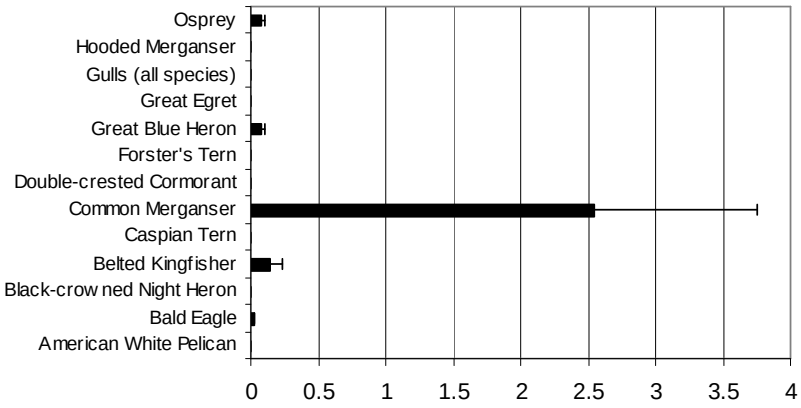
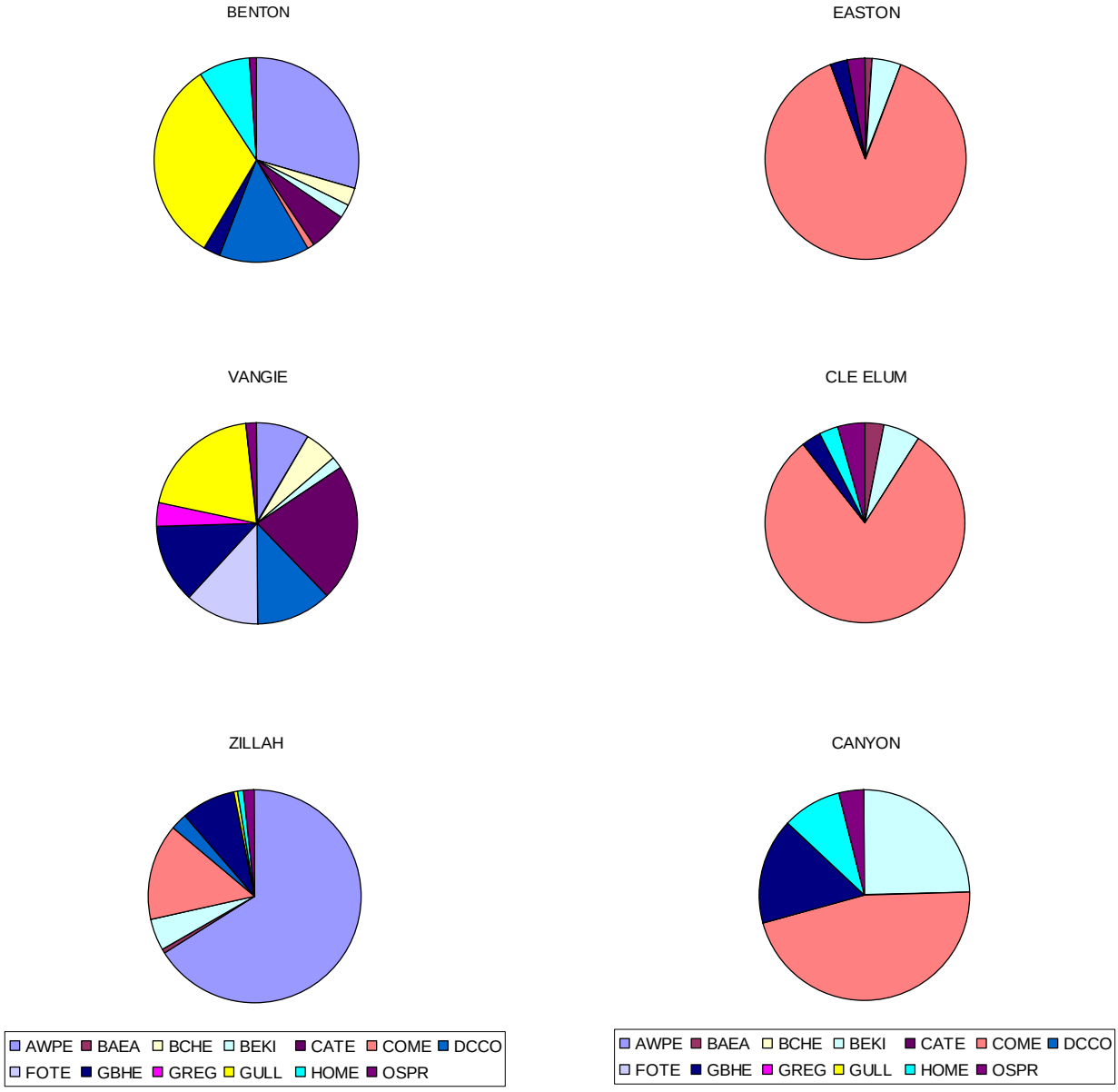


Figure 11. Birds per km by species for each reach in the spring 2004.



Avian Piscivore Abundance—Summer

Due to increasing water temperatures and drop in water level occurring in the lower river in the summer, monitoring efforts are shifted to summer parr and residential salmonid smolts in the upper part of the river during the summer. Drifts were limited to the Easton, Cle Elum and Canyon reaches. Common Merganser, Belted Kingfisher, Great Blue Heron, and Osprey were again found on all three reaches, but Common Mergansers again remain the most abundant piscivorous bird species along these stretches of the river (Figures 14-17).

Figure 12. Summer abundance of all avian piscivores by reach, July 1 to August 31, 2004. Error bars represent standard deviation.

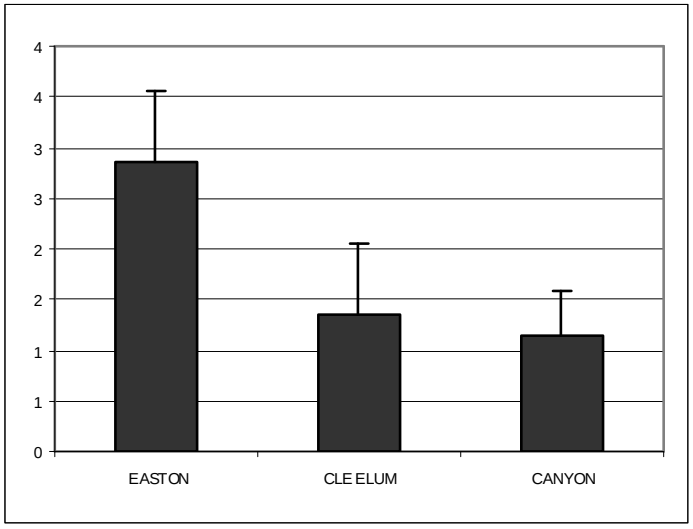


Figure 13. Summer abundance of Common Mergansers by reach, July 1 to August 31, 2004. Error bars represent standard deviation.

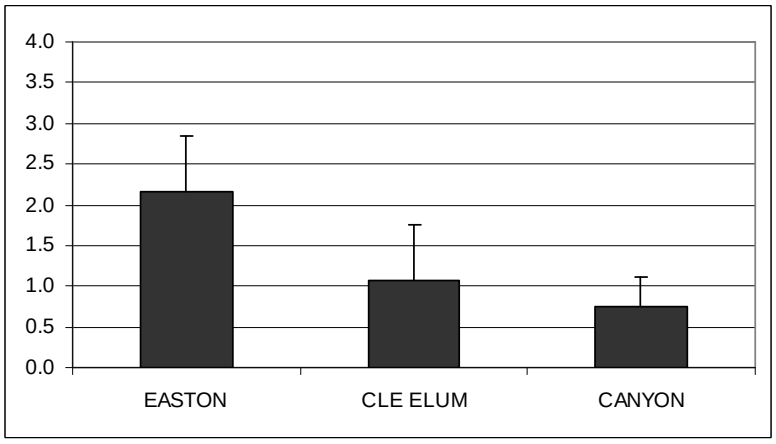


Figure 14. Average summer avian piscivore abundance per kilometer on the Canyon river reach, July 1 to August 31, 2004. Error bars represent standard deviations.

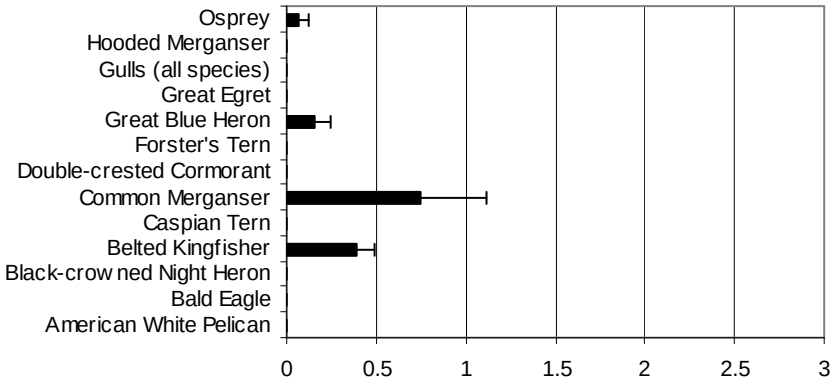


Figure 15. Average summer avian piscivore abundance per kilometer on the Cle Elum river reach, July 1 to August 31, 2003. Error bars represent standard deviations.

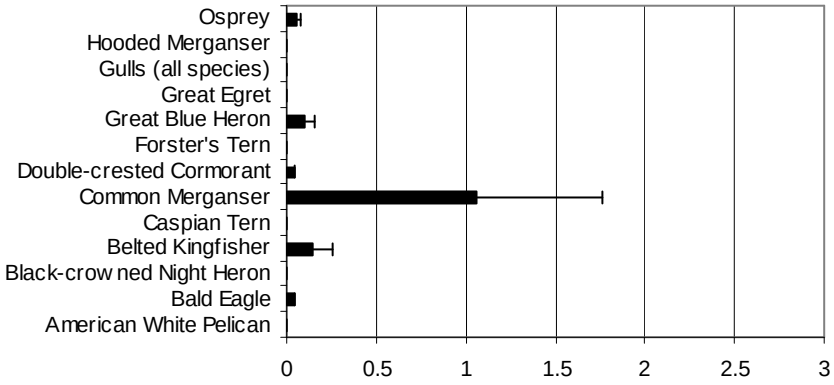


Figure 16. Average summer avian piscivore abundance per kilometer on the Easton river reach, July 1 to August 31, 2003. Error bars represent standard deviations.

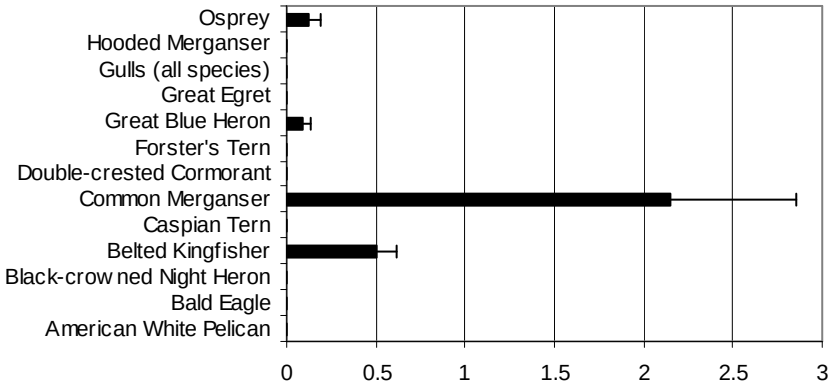
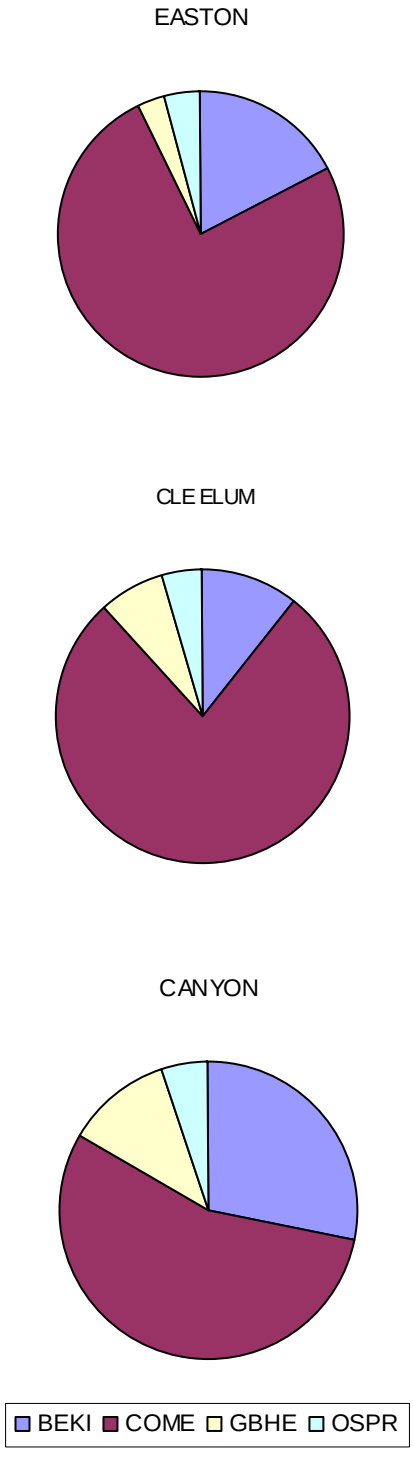


Figure 17. Birds per Km by species for each reach summer 2004



Avian Piscivore Consumption—Spring

For the purposes of these surveys, 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 one is made up of the upper most reaches of the Yakima, including the Easton and Cle Elum reaches, Stratum two 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 of all fish species consumed in Stratum I in the spring of 2004 was 86.9 kg/km, 38.6 kg/km in Stratum 2, and 411.2 kg/km in Stratum 3. In the spring, Common Mergansers accounted for 67% of the consumption in Stratum 1, 69% of Stratum 2, and 6% of Stratum 3. Due to their high daily dietary requirements, 1.34 kg per day, American White Pelicans accounted for 78% of the total consumption in Stratum 3 in the spring, up from 68% of the consumption in 2003

Avian Piscivore Consumption—Summer

The mean biomass of all fish species consumed by avian piscivores in the summer was 57.4kg/km in Stratum one, and 24.4 kg/km in Stratum two. Common mergansers accounted for 90% of the total consumption in the summer in Stratum 1, and 69% in Stratum 2.

North Fork Teanaway River Surveys—Spring and Summer

Bird species seen along the North Fork of the Teanaway during surveys in 2004 included 13 Belted Kingfisher, 26 Common Merganser, and one Great Blue Heron. A minimal amount of fish was consumed on this section of the Teanaway, 2.7 kg of fish in the spring and 5.4 kg in the summer. The difference in consumption between the two seasons can be accounted for by the presence of one large brood of Common Mergansers, 21 juveniles and one female, seen during the summer. Only 40 individual piscivorous birds total were seen during these surveys, confirming that the Jack Creek Acclimation Site has not become a major attractant for fish eating birds either during the release of smolts or during the birds' breeding season.

Hotspot Surveys—Spring

Avian Piscivore Abundance

The average daily number of gulls at Chandler remained low throughout the 2004 survey season. Gull numbers peaked on April 21st at 7.5 gulls on average per day and then again on July 2 at 7.3 gulls per day. Gull numbers at Horn Rapids were consistently higher than at Chandler and peaked at 43.3 gulls per day on May 24th.

Figure 18. Average daily gull abundance at Chandler.

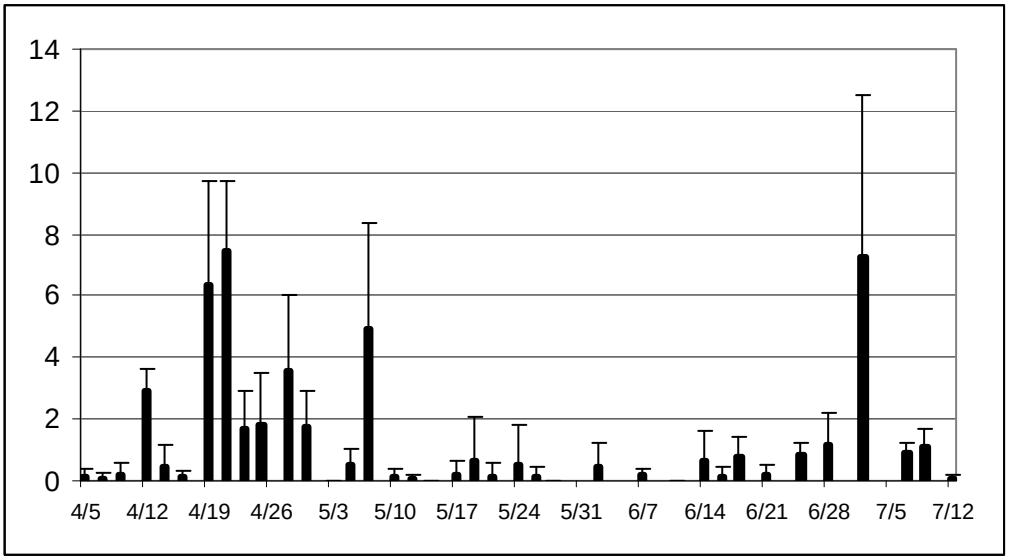
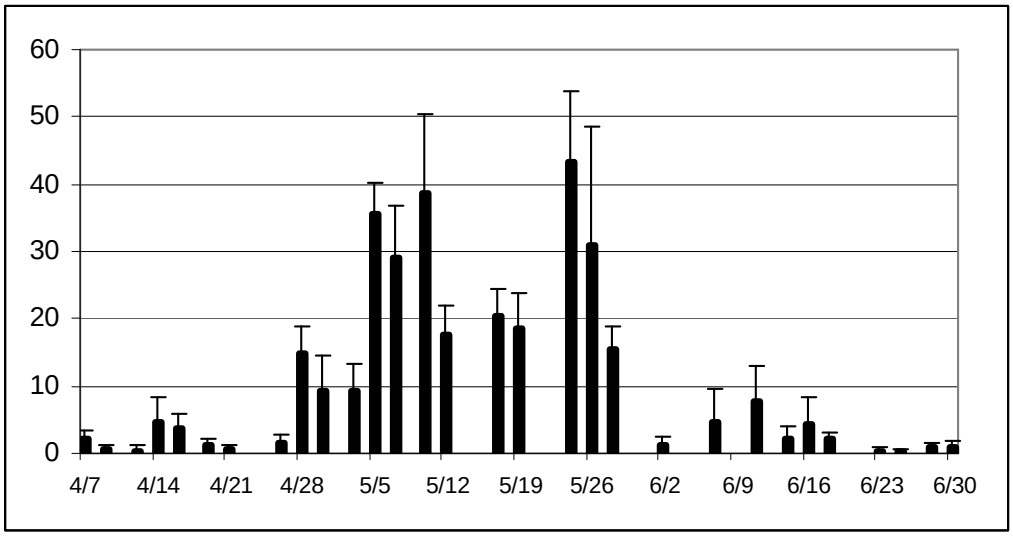


Figure 19. Average daily gull abundance at Horn Rapids

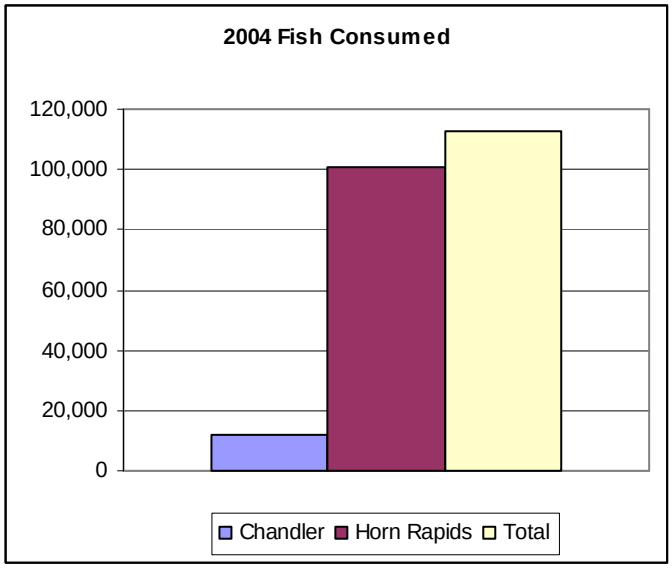


Note difference in scale.

Consumption by Gulls

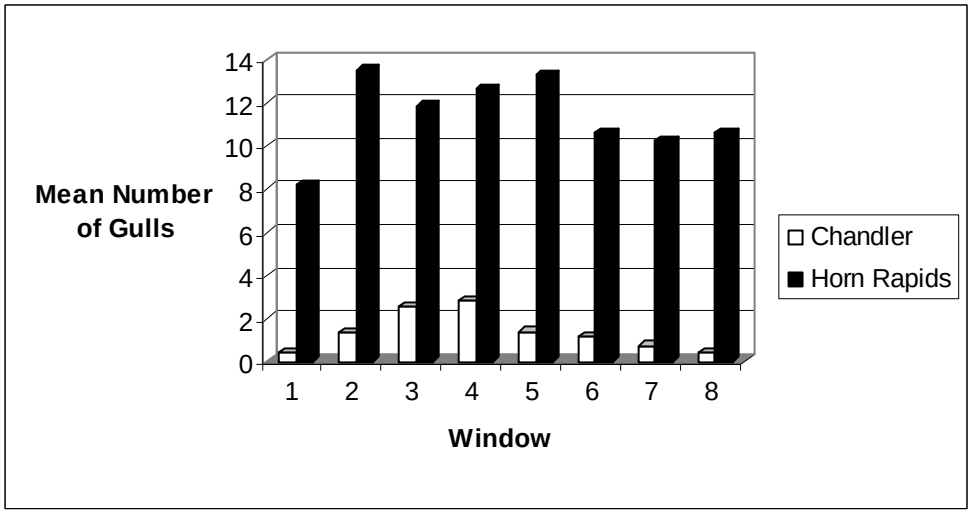
During the 2004 hotspot survey season 11,977 individual fish, assuming 100% salmonid smolts based on direct observation, were consumed by gulls at Chandler and 100,873 smolts at Horn Rapids for a total of 112,850 smolts at both hotspots (Figure 20). This accounted for 3.5% of all juvenile salmonids, both hatchery and wild, passing through or being released from Chandler in 2004.

Figure 20. The number of salmonids consumed by gulls at hotspots in 2004.



The number of gulls at Chandler increased as the day progressed, peaking in the seventh and eighth hours after sunrise at 2.81 gulls per window. The number of gulls at Horn Rapids was low initially, increased, then fluctuated slightly throughout the day. (Figure 21). Numbers one through eight represent two-hour survey periods beginning the first 15 minutes after sunrise.

Figure 21. Diurnal pattern of gull abundance at Chandler and Horn Rapids.



Other piscivorous bird species observed at Chandler included the American White Pelican, Great Blue Heron, Caspian Tern, Black-crown Night Heron, Double Crested Cormorant, and Common Mergansers. These species as well as Great Egret and Osprey were observed at Horn Rapids. American White Pelicans were observed much more frequently at both hotspots than during any other previous year's surveys, especially at Chandler.

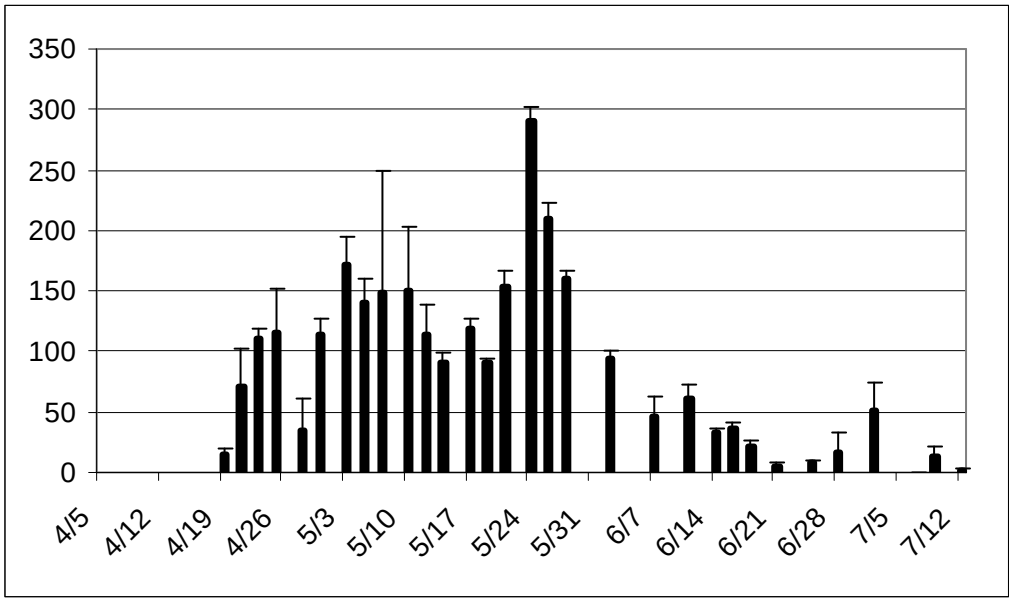
American White Pelicans

Historically, American White Pelicans were known to occur in Washington State (Dawson and Bowles, 1909). They are currently listed as a State Endangered species in the state of Washington. The only currently known breeding site in Washington is on Badger Island on the Columbia River, below the confluence of the Snake and Columbia Rivers, downstream from the mouth of the Yakima. These colonial nesters are known to travel 50-80 km in search of food, so some of the birds observed on the Yakima River could be coming from this colony (Motschenbacher 1984). Bands that were recovered from three pelicans on the lower Yakima River in recent years were found to have come from British Columbia, eastern Montana, and the Klamath National Wildlife Refuge (Tracy Hames, personal communication).

There was again a dramatic increase in the number of American White Pelicans (*Pelecanus erythrorhynchos*) found at Chandler between 2003 and 2004 as was seen between 2002 and 2003. Pelicans were first observed to reoccur 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, below the Yakima Canyon to the mouth, 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 at Chandler. Instances of klepto-parasitism, where pelicans stole the fish the gulls had caught, were observed. As the water levels decreased and more rocks were exposed, more loafing sites became available. In 2004 pelican numbers continued to increase while gull numbers decreased. Although two low pressured sprinklers were run at Chandler near the outfall pipe in 2004 to deter birds, they had no effect on the number of birds at this site. The birds became habituated to the sprinklers and could easily avoid them.

In 2004, pelicans returned in greater numbers and earlier in the year then in 2003. The average number of pelicans per day peaked on May 24 at 291 birds (Figure 22).

Figure 22. Average Daily Number of American White Pelicans at Chandler in 2004.



Aerial photo of American White Pelicans at Chandler May 26, 2004

Aerial Surveys

Four aerial surveys were conducted over the Yakima River between March and September of 2004. All surveys included the mouth of the Yakima River in Richland upstream to the town of Yakima. One survey extended into the lower reaches of the Yakima Canyon and the September survey included Badger Island on the Columbia River, a 10 minute flight from the mouth of the Yakima. Aerial surveys of the Yakima River were divided into 12 geographic reaches extending from the mouth of the Yakima to Easton. These reaches were based on aerial surveys conducted on the Yakima River in the past. Reaches surveyed in 2004 generally included reaches one through six. Surveys usually began around 8:30 am and lasted approximately three hours.

Figure 23. Aerial survey reaches.

Reach	From	To
1	Mouth	Horn Rapids Dam
2	Horn Rapids Dam	Benton City
3	Benton City	Prosser Dam
4	Prosser Dam	Mabton Bridge
5	Mabton Bridge	Union Gap
6	Union Gap	Selah Gap
7	Selah Gap	S. end Yakima Canyon
8	S. end Yakima Canyon	N. end Yakima Canyon
9	N. end Yakima Canyon	Clark Flat
10	Clark Flat	Indian John Hill
11	Indian John Hill	Cle Elum Hatchery
12	Cle Elum Hatchery	Easton

Aerial surveys were conducted mainly to look at the abundance and distribution of American White Pelicans along the Yakima River from its mouth to the town of Yakima. Geographic barriers make it difficult to fly into the Yakima Canyon, which is why most surveys ended in back in Yakima. Other piscivorous birds besides pelicans that were observed included: Bald Eagle, Belted Kingfish, Common Merganser, Double-crested Cormorant, Great Blue Heron, Great Egret, Gulls and Osprey. Ninety-one percent of the birds observed were American White Pelicans and five percent were gulls. The majority of the pelicans observed, 88%, were in reach 5 between Mabton bridge and Union Gap, 6% in reach 4 and 2% in reaches 3 and 1. Pelicans were often observed in backwaters and ponds off the main-stem river. Aerial surveys allow for one hundred percent of the lower Yakima River to be surveyed.

American White Pelicans adjacent to the lower Yakima River 2004.

American White Pelican Carcasses

In 2004, a total of five pelican carcasses where recovered by Yakama Nation Fisheries personnel from the Yakima River between the end of April and the end of June. One carcass was found on May 5th at Chandler. The other four were found in or near the lower Yakima River. Of the five birds, only two had fish contents in their digestive systems. One contained a near intact chiselmouth, and the other contained a sucker with its head mostly digested.

Jim Stephenson with American White Pelican.

Chiselmouth removed from American White Pelican carcass.

Acclimation Site Surveys—Winter/Spring

Again in 2004 only a minimal number of birds were seen at the Spring Chinook Acclimation Sites. A total of 92 Belted Kingfisher were seen at Clark Flat and Jack Creek, accounting for 65% of the birds seen at these two sites. Other birds observed were Bald Eagles, Great Blue Heron, Common Mergansers, Golden Eagles (possibly juvenile Bald Eagles), and three American White Pelicans at Clark Flat, the furthest upstream citing of this species. The spring chinook acclimation sites have not become a major attractant for piscivorous birds.

At the Coho acclimation sites, the majority of the birds observed were Common Mergansers, accounting for 92% of the observations, with the remainder of the birds being Belted Kingfisher, Great Blue Heron, Bald Eagle, Golden Eagle Hooded Merganser, and one Osprey. One coho acclimation site, Boone Pond in the upper Yakima, attracted an exceptionally large number of Common Mergansers, 1406 individuals.

Summary

Consumption of Juvenile Salmonids by Avian Piscivores—2004

In 2004, surveys were again conducted at the two hotspots, Chandler and Horn Rapids, along the six river reaches and the North Fork of the Teanaway, and at three spring chinook and four coho acclimation sites. In addition, four aerial surveys were conducted in 2004 as well.

In 2004, Common Mergansers continued to be the major avian predator in the upper Yakima River. In the lower Yakima River the number of American White Pelicans continued to increase and were the major avian consumer along the lower three river reaches. There was also another dramatic increase in the number of pelicans seen at Chandler in 2004, where they have displaced gulls as the main predator at that site, as in 2003. Gulls remained the major avian predator at Horn Rapids Dam, though pelicans were observed at this site in 2004 as well. The spring chinook acclimation sites have not been a major attractant for piscivorous birds, while one coho acclimation site, Boone Pond on the upper Yakima, attracted a large number of Common Mergansers. Aerial surveys show the prevalence of pelicans in the lower Yakima River, often in backwater areas just off the mainstem Yakima River.

Multi-year analysis

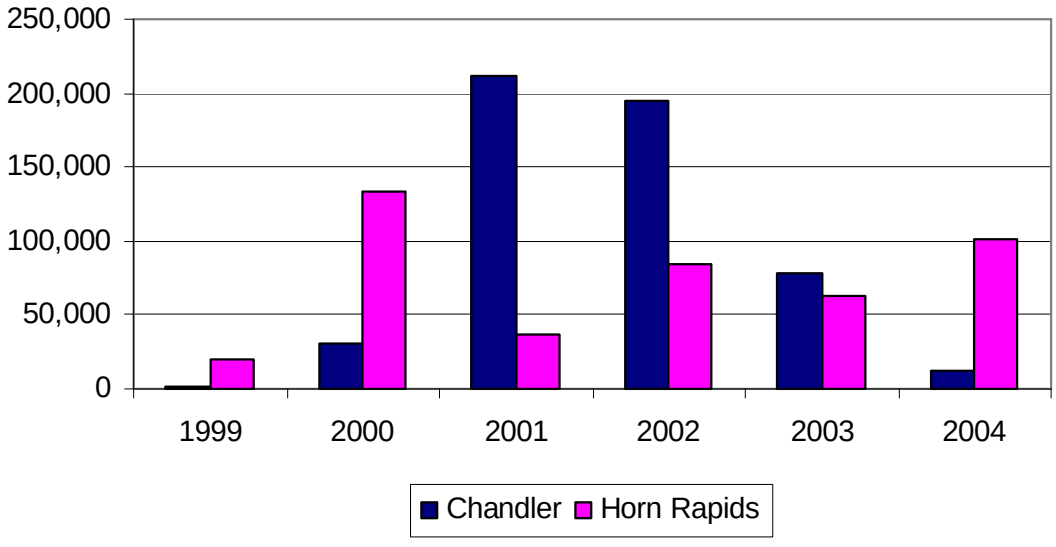
Consumption by Gulls

The two hotspots have been monitored for smolt consumption by gulls since 1999. The number of smolts consumed at Chandler increased between 1999 and 2001, but decreased substantially in both 2003 and 2004, the same time American White Pelicans showed up in increasing numbers. It should be noted that the survey method was modified in 2001. Table 6 and Figure 24 show the number of smolts consumed at each site from 1999 through 2004 (Major et al. 2002; Stephenson et al. 2003; Stephenson and Fast 2004).

Table 5. Number of smolts consumed at hotspots 1999 through 2004.

Year	Chandler	Horn Rapids	Total
1999	2157	19,406	21,563
2000	30,340	133,135	163,475
2001	211,914	36,258	248,172
2002	195,279	84,202	279,481
2003	78,436	62,913	141,349
2004	11,977	100,873	112,850

Figure 24. Number of smolts consumed at hotspots 1999 through 2004.



Abundance of gulls and pelicans at Chandler 2004

Figure 25 shows the decrease in the number of gulls at Chandler between 2002 and 2004, and Figure 26 shows the increase in American White Pelicans during this same time frame. Pelicans may be moving into a niche that gulls have abandoned, or they may be forcing the gulls out of the area.

Figure 25. Average daily gull abundance Chandler 2002 to 2004.

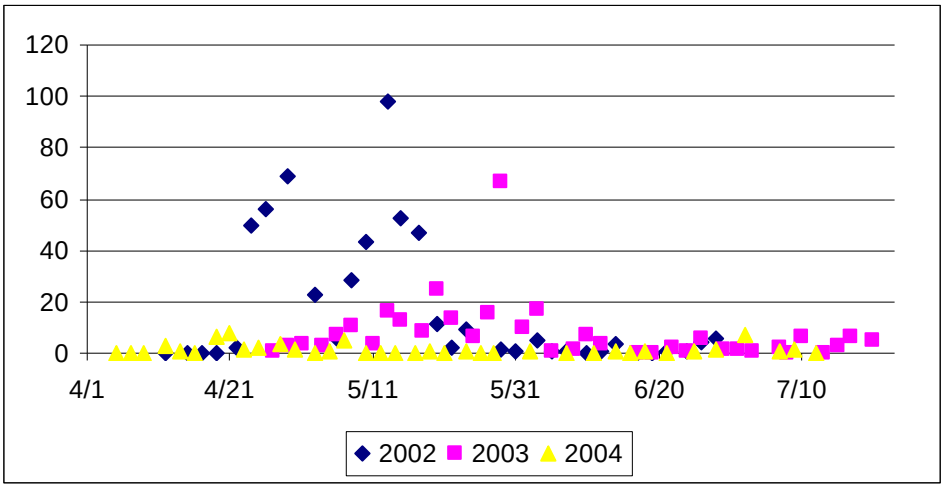
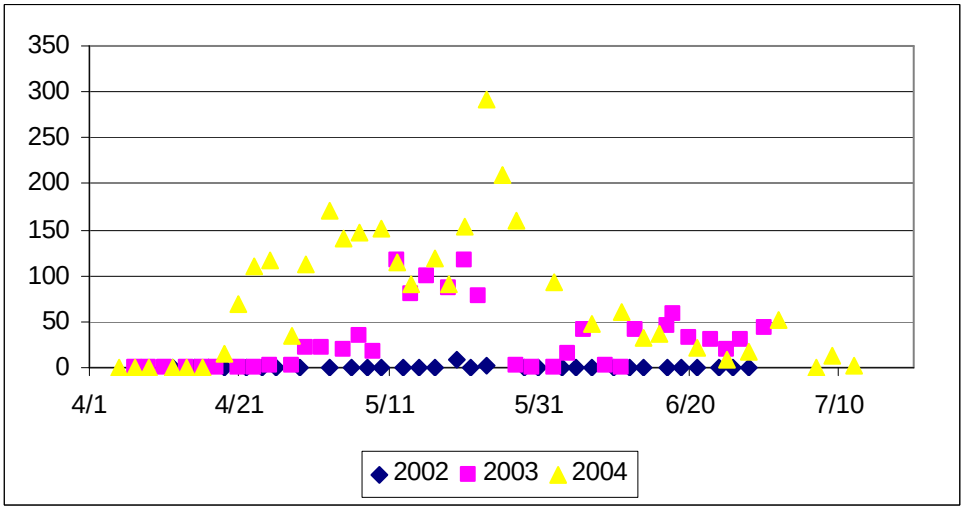


Figure 26. Average daily American White Pelican abundance Chandler 2002 to 2004.



Note difference in scale.

River Reach Avian Piscivore Consumption – 1999-2004

Bird consumption of fish in Stratum I and II in the both the spring and summer has not increased as dramatically as consumption in Stratum III, the lower Yakima River, in the spring (Figure 27). This increase in consumption can be accounted for by the increase in the number of American White Pelicans observed in this section of river in the last few years, due to their high dietary requirement of 1.3 kg of food per day.

Figure 27. Multi-Year fish consumption Strata I, II, and III.

Table 6. Piscivorous bird species encountered on the Yakima River 2004.

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*)

Table 7. Daily Intake of Piscivorous Birds (Major et al. 2003)

Species	Species	Daily Intake (kilograms)	Daily Intake (pounds)
AMBI	American Bittern	0.087	0.192
AWPE	American White Pelican	1.339	2.952
BCNH	Black Crown Night Heron	0.138	0.304
BEKI	Belted Kingfisher	0.059	0.130
CATE	Caspian Tern	0.231	0.509
COME	Common Merganser	0.455	1.003
DCCO	Double Crested Cormorant	0.499	1.100
FOTE	Forsters Tern	0.057	0.126
GTBH	Great Blue Heron	0.415	0.915
GNBH	Green Heron	0.034	0.075
GREG	Great Egret	0.145	0.320
GULL	All Gull Species	0.094	0.207
HOME	Hooded Merganser	0.24	0.529
OSPR	Osprey	0.35	0.772

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A. Stephenson

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