Standardized piscivorous bird monitoring protocol and results at U.S. Army Corps of Engineers' dams on the lower Columbia and Snake Rivers, 2012.

By

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EXECUTIVE SUMMARY

To minimize losses of juvenile fish to bird predation at its dams the U.S. Army Corps of Engineers has historically implemented several bird deterrents including avian line arrays and pyrotechnic hazing. Deterrents are now required by the 2008 Federal Columbia River Power System Biological Opinion at eight lower Snake and Columbia River dams. At John Day Dam, intensive pyrotechnic hazing from boats and greatly expanded avian line array helped reduce the number of foraging gulls (*Larus spp.)* from a mean of 99 per day in 2009 to only 16 per day in 2010. However, the number of gulls appeared to increase downstream at The Dalles Dam and upstream at McNary Dam. In response, a more robust standardized monitoring program was initiated with three objectives: 1) Provide site-specific training at each dam. 2) Develop and implement standard avian observation protocols in order to provide comparable avian counts between eight Army Corps dams on the Columbia and Snake Rivers. 3) Provide data collection devices or data sheets and a centralized database to standardize data collection.

Pre-season training, a written protocol, and datasheets (included in appendices) were delivered during site visits to each of the eight Projects by Portland District's Fish Field Unit (FFU) staff. Monitoring was carried out by Project Fishery Biologists or Biological Science Technicians stationed at each dam. During the Project Fisheries staffs daily duties they were asked to count and categorize the behaviors of nine species of fish eating birds at least once a day. This data report summarizes the results of the first season of monitoring after standardized counting protocols were introduced.

Bird abundance and species diversity varied not only through time but among dams with abundance peaking in May which coincides with salmonid (*Oncorhynchus spp.*) smolt and juvenile Pacific lamprey (*Entosphenus tridentatus*) peak outmigrations. The larger dams on the Columbia River, lead by McNary and The Dalles, generally had more piscivorous (fish-eating) birds than the smaller Snake River dams. Species diversity varied from project to project with gulls (*Larus spp.)* by far the most common piscivore followed by double crested cormorants (*Phalacrocorax auritus*). Interestingly, maximum bird counts were for resting gulls, cormorants, and common mergansers collected during the winter – when few juvenile salmonids are present.

Toward the effort to improve survival of juvenile salmonids and Pacific lamprey, we recommend system-wide monitoring continue, further alternative deterrent efforts be explored, and consideration be given to increasing deterrent efforts to effectively address problem avian areas at the dams. Current deterrent effort could be increased by installing additional avian lines in the spillway tailrace or having hazers work from a boat in these areas during the peak of fish outmigration, about two months minimum. Continuation of the standardized bird monitoring program is necessary to determine if increasing deterrent efforts help to decrease piscivorous bird abundance.

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INTRODUCTION

Increasing successful fish passage at Columbia and Snake River dams is an essential part in the effort to protect fish stocks passing through the hydropower system. Dams can be a focal point of predation since they tend to concentrate and disorient juvenile fish as they migrate out to the Pacific Ocean. Gulls (*Larus spp.*) and double crested cormorants (*Phalacrocorax auritus*) along with several other piscivorous waterbirds are commonly observed foraging at or near dams the on lower Columbia and Snake rivers (Ruggerone 1986, Jonas et al. 2008, Wiese et al. 2008). Many of these birds are part of nesting colonies that reside on nearby islands during the months of April to July (BRNW 2010), a time period that coincides with the salmonid smolt outmigration as well as outmigration of juvenile Pacific lamprey from the Columbia River basin to the Pacific Ocean.

In an effort to minimize smolt losses to avian predators at dams, where fish are believed to be more vulnerable to predation (Ruggerone 1986), the United States Army Corps of Engineers (USACE) implements avian deterrent programs at lower Columbia and Snake River dams (Reasonable and Prudent Alternative 48 of the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion). Several avian predation dissuasion methods have recently been used, including installation of passive dissuasion devices (e.g., avian lines or wires, spikes) and non-lethal active hazing methods using pyrotechnics or propane cannons. Determining the effectiveness of this dissuasion program in any individual year can be challenging as the number and foraging success of birds at dams is highly variable from year to year, day to day, and dam to dam. Abundance may be influenced by distance from nesting colonies, most abundant food source, and avian deterrent actions used at the dams (Zorich et al. 2010).

To date, efforts to document the impact and abundance of piscivorous water birds on juvenile salmonids and lamprey at USACE owned dams have been limited in scope or sporadically implemented. The data that has been collected has been site-specific, with methods inconsistently utilized from dam to dam. One exception to this is the data and results of Zorich et al. (2010), where a standardized, electronic data collection protocol was developed and implemented to document the number, distribution, and foraging success (fish consumption) of gulls at John Day (2009-2011) and The Dalles dams (2010-2011). Data collected from this study utilized multiple observers, at multiple sites, to collect and upload data to a centralized database. Results were comparable both within and between dams and could be accessed, managed, and analyzed real-time via a web-based portal. The success of this effort lead to a request to standardize techniques to monitor long-term bird abundance trends at the eight dams on the lower Columbia and Snake rivers and report on them in-season so hot spots could be addressed as warranted.

OBJECTIVES

Our goal was to monitor short and long term trends in piscivorous bird abundance and behavior using a standardized protocol at eight USACE dams on the lower Columbia and Snake rivers. Data was to be collected by a project biologist or biological technician during their daily duties. This data will be used to determine the number and spatial distribution of birds at each dam and to document the change in abundance over time. Using standardized methods ensures that data collected at multiple sites, by multiple observers, will be comparable between years and sites. We accomplished this goal by completing three objectives:

1) Provide site-specific training and coordination at each dam.

To take advantage of the years of accumulated knowledge at each dam, we met with project biologists to evaluate avian predation issues that are unique to each project. This includes selecting the best vantage points for data collection, defining zones, and training on how to use the data collection methods developed and tested at John Day and The Dalles dams in 2011.

2) Develop and implement standard avian observation protocols in order to provide comparable avian counts between eight Army Corps dams on the Columbia and Snake Rivers.

We implemented a standardized written protocol that included site-specific information provided by the project biologists during the field season, such as, unique zones, special situations, or other pertinent information.

3) Provide data collection devices or data sheets and a centralized database for use by project fisheries staff.

As part of developing a standardized protocol, standardized methods to collect the data were also developed including data sheets and an online data portal. Project staffs were offered the ability to either collect data via of a handheld tablet PC or hardcopy data sheets for hand entry into a web-based data portal. The data application facilitates the standardization of data collection in much the same way a paper datasheet does. The application will allow users to accurately collect uniform data on avian abundance and behavior, while minimizing personnel time and cost. The application allowed trained observers to directly upload data to a centralized database, eliminating the need for further data entry and normalizing data fields across projects. Project fisheries staff has access to manage the data from a centralized source.

Here we report on seasonal and annual trends at individual dams and the system as a whole. In addition, biologist and managers from other agencies have access to real-time summary reports via the Avian Data Portal that allow comparisons of bird distribution and activity

METHODS

SITE DESCRIPTION

The Columbia River basin drains about 250,000 square miles from the states of Washington, Oregon, Idaho, Montana, Wyoming, and Nevada as well as the Canadian provinces of British Columbia and Alberta. While there has been substantial hydropower development, this study focuses on eight large USACE hydroelectric dams on both the Columbia and Snake rivers built from 1938 – 1975. These dams are Bonneville, The Dalles, John Day, and McNary on the lower Columbia; and Ice Harbor, Lower Monumental, Little Goose, and Lower Granite on the lower Snake River (Figure 1). They are part of a larger Federal Columbia River Power System that is the primary source of electricity in the region also provides navigation, flood reduction, recreation, and are operated to facilitate successful passage of juvenile and adult anadromous fish. Further detail and aerial photographs are presented in the results sections for each dam.

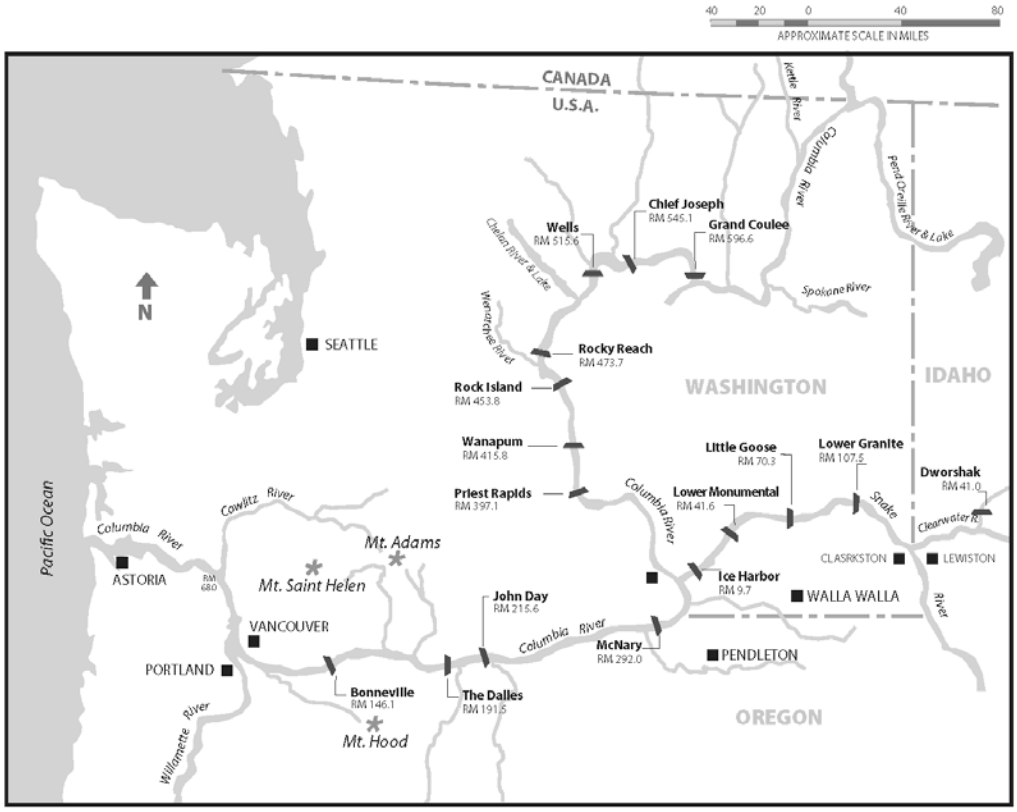

Figure 1. Map of Columbia Basin dams including the eight USACE dams monitored for fish eating birds. Map taken from the Annual Fish Passage Report (USACE 2012) and used here with the author's permission.

COORDINATION WITH PROJECTS AND TRAINING

Pre-season meetings were held at each dam with Project Fishery Biologists and Biological Science Technicians to discuss project-specific bird issues, and prepare a map dividing the forebay and tailrace areas into manageable counting zones. To accomplish these counts a standardized bird observer protocol was developed, distributed, and latter finalized with concurrence from project biologists at the individual dams.

As a result of these meetings a list of the nine most common fish eating bird species was developed. The piscivorous birds that were counted are: American white pelican (*Pelecanus erythrorhynchos*), Bald eagle (*Haliaeetus leucocephalus*), Caspian tern (*Sterna caspia*), common mergansers (*Mergus merganser*), double-crested cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea Herodias*), grebes (*Podicipedidae spp.*), gulls, and osprey (*Pandion haliaetus*). The abbreviation for common bird names used in graphs and tables in this report follows that of Klimkiewicz and Robbins (1978):

AWPE = American White Pelican
BAEA = Bald Eagle
CATE = Caspian Tern
COME = Common Merganser
DCCO = Double Crested Cormorant
GBHE = Great Blue Heron
GULL = any gull species*
OSPR = Osprey
GREBE = Clark's or Western Grebe

**Gulls typically not identified to species for reporting purposes due to the difficulty in identifying individual species of active birds over a wide observational distance.*

Most near dam areas are too large to be seen by one observer from one location. Therefore sites were divided into zones which covered, at a minimum, from the upstream to the downstream boat restricted zones of each dam. The entire observed area at each site was measured with Google Earth Pro using the polygon measuring tool and reported in square kilometers and square miles. An instantaneous scan was used to count the number of birds of each species or genus in each zone (forebay, spillway tailrace, powerhouse tailrace, juvenile outfall pipe, etc), time, and classifying behavior.

While not always possible due to work load, it was requested that all zones be observed within one hour of each other, at least once a day from 1 April to 30 September. Here we report on the time frame between 1 April and 31 July as this is when there is the greatest overlap with migrating salmonids.

A standardized bird observer protocol was developed to document the number, distribution, and behavior of piscivorous birds during the smolt outmigration period (see APPENDIX A. Avian Observer Protocol). As part of the written protocol, guidelines specific to each species were established to help classify bird behavior as foraging, resting, scavenging, or simply flying by. Data was also collected on dam operations such as whether spill was occurring, if surface fish passage was in operation (removable spillway weirs, ice trash chutes, or corner collector at Bonneville), whether fish in juvenile collection systems were being bypassed back to the river, and if the US Department of Agriculture (USDA-WS) bird hazer was on site.

DATA COLLECTION

Bird count data collection was accomplished by one of two methods. Data was collected on traditional paper datasheets then manually entered into an on-line data portal or collected electronically on tablet PC's (xTablet T7200 by MobileDemand) then synced to the data portal wirelessly. Electronic data entry reduces data entry errors and decreases the time required for data entry. One round of collecting bird counts from all predetermined zones defines a session (Appendix A). The goal is for projects to complete at least one session of bird counts per day within the hour (to reduce double counting).

To streamline and standardize the data collection process, a mobile application was developed for use with rugged tablet PC's. The application allowed users to consistently and accurately record data on bird abundance and behavior, while minimizing personnel time and costs. A Microsoft Windows-based application was loaded on hand-held data loggers/computers enabled with wireless communications that allow users to synchronize (transfer) their data from the field to a centralized database - a secure (i.e., password protected) web-based data portal and analysis hub for all project data. Authorized project personnel had access to the data via the web portal in order to add, edit, graph, and manage project data. In addition, regional resource managers such as US Fish and Wildlife Service, NOAA Fisheries, the States of Washington, Oregon, and Idaho will have access to near real-time summary graphics that allow comparisons of bird distribution and predation activity both within and among the different hydroelectric projects.

A bird count data sheet was developed and sent to projects that elected to collect their bird data on paper (see APPENDIX B. Avian Observer Data Sheet). Bonneville, McNary, Lower Monumental, Little Goose, and Lower Granite dams collected their bird counts using this form or a modified version. These projects entered their bird data into the portal manually.

Tablet PC's equipped with the bird count software were used at The Dalles, John Day, and Ice Harbor dams. This data was collected electronically and synced to the portal via wireless technology and was instantaneously available for review and analysis.

DATA ANALYSIS

Graphs and tables presented here are based on daily or seasonal mean bird counts. We estimated daily bird abundance by calculating the daily mean for each observation zone and then summing these means to yield a daily mean count for the site. If only one count was taken during a day it is reported as the mean, (see results for each project). Seasonal mean counts refer to April 1 – July 31, although weekly means are also displayed for the entire year (see APPENDIX C. YEARLY BIRD COUNTS). To estimate the seasonal mean per day per sight we summed the counts for each observation zone, divided by the number of days observed, and then summed these values.

RESULTS

ALL PROJECTS

Bird counts were highly variable from project to project but commonly peaked in May which typically coincides with salmonid smolt and juvenile lamprey outmigrations (Zorich et al. 2011 and 2012). Gulls were by far the most abundant and widespread predator, and the larger dams on the Columbia River generally had more piscivorous (fish-eating) birds than the smaller Snake River dams with the exception of Bonneville Dam.

The number of birds varied not only through time but from dam to dam with The Dalles and McNary having consistently more foraging birds, typically gulls, than the other dams (Figure 2). Foraging bird numbers generally increased in April, peaked in May, decreased until early June, and sometimes bounced back in late June or early July (Figure 3).

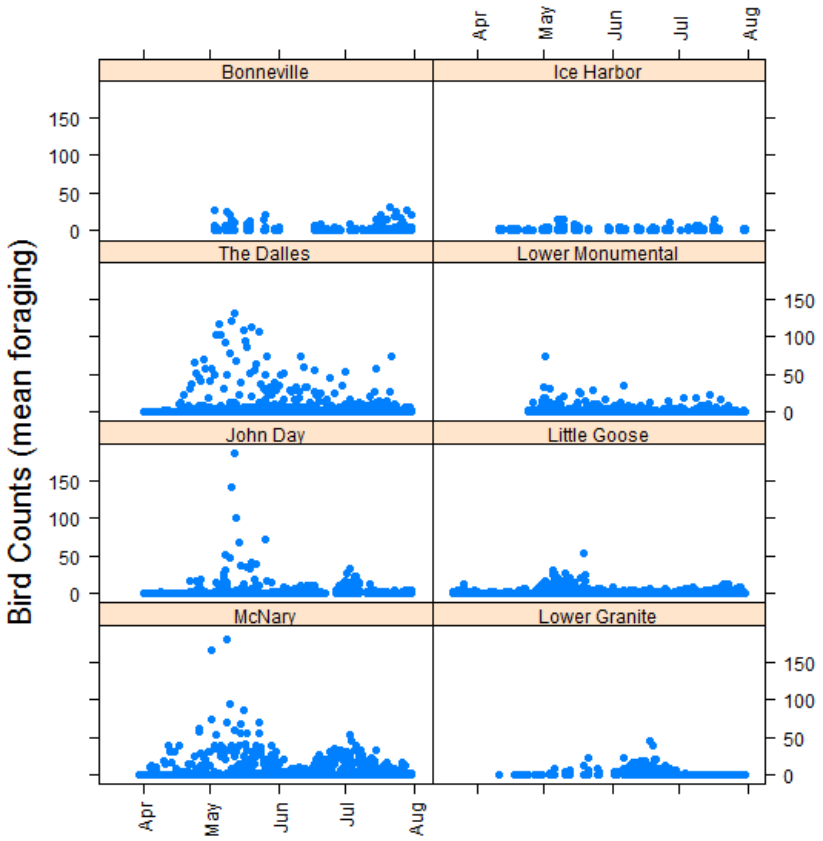

Figure 2. Timing and abundance of foraging birds at eight USACE dams in 2012. Project means have been calculated for each day from one to three counting sessions depending on the project.

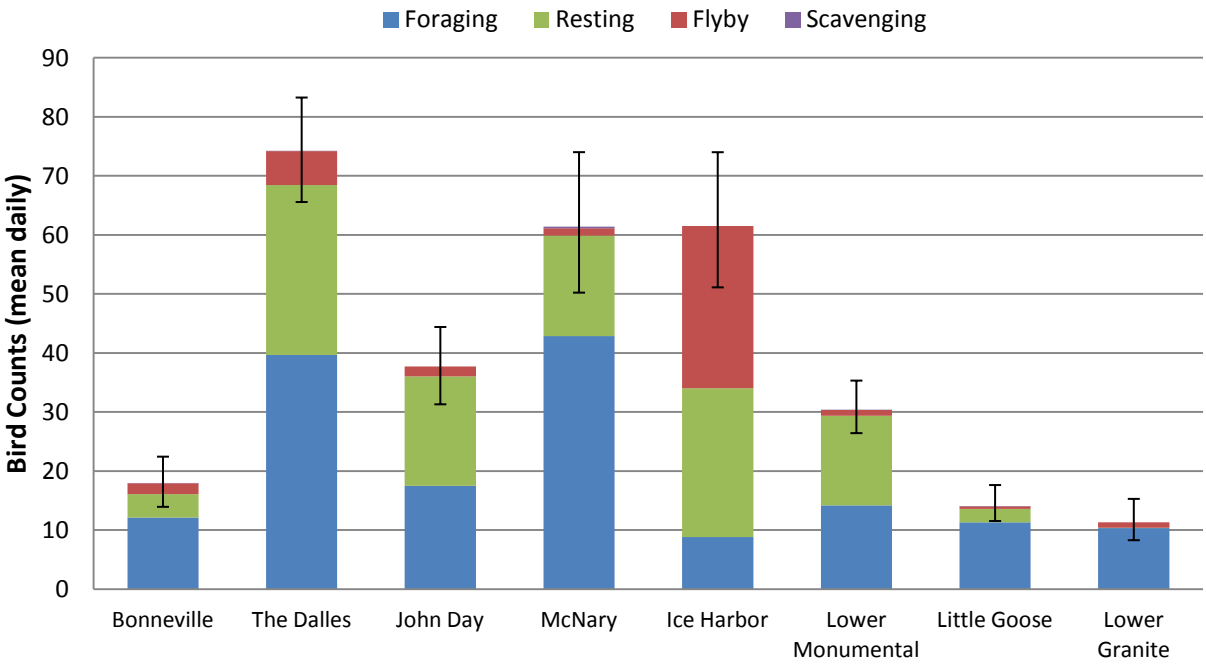

Figure 3. Seasonal daily mean bird counts by behavior April through July, 2012 (with 95% CI bars). Bonneville Dam counts are May through July, 2012 and their juvenile fish outfall (JFOF) was not counted.

Species diversity varied from project to project with gulls being the most common piscivore followed by double crested cormorants. Seasonal daily mean gull counts (i.e., average number of gulls observed per day from 1 April to 31 July) ranged from a high of 55.9 at The Dalles to a low of 4.2 at Lower Granite (Table 1). Double crested cormorants were the second most prevalent species and were commonly counted at The Dalles, Ice Harbor and Lower Monumental dams. Among all projects their seasonal daily means ranged from 0.01 at John Day to 16.8 at The Dalles where the birds were found resting in the electrical transmission towers in the forebay. Unique to Ice Harbor was the large number of American white pelicans resting at Eagle Island and occasionally foraging in the tailrace. Osprey, great blue heron, and common mergansers were occasionally present at some projects, but there were typically only a few individuals of each at any given time.

It should be noted that piscivorous birds are present at the dams throughout the year, but the species composition, including species of gull, changes seasonally. Project biologist's from Lower Granite, Little Goose, Ice Harbor, John Day, Bonneville, and The Dalles dams, who continued to monitor piscivorous birds through the 2012/13 winter reported an increase in the number of resting birds, primarily gulls, but also double crested cormorants and common mergansers (The Dalles Dam). The largest winter gathering of birds occurred in the John Day forebay and on the forebay's navigation lock wing wall which were visited by thousands of resting gulls during early November.

Table 1. Seasonal daily means for each species at each site from April 1 to July 31, 2012. All behaviors combined. Maximum counts are included in parenthesis.

SPECIES	Bonneville*	The Dalles	John Day	McNary	Ice Harbor†	Lower Monumental‡	Little Goose	Lower Granite†
AWPE	0.0 (0)	0.0 (2)	0.5 (30)	**8.3** (58)	**20.9** (76)	3.3 (27)	0.6 (13)	**6.9** (88)
CATE	0.0 (0)	0.0 (0)	0.0 (3)	3.7 (50)	0.6 (4)	3.1 (37)	0.1 (4)	0.0 (0)
GULL	**12.9** (91)	**55.9** (451)	**22.2** (396)	**40.6** (378)	**24.2** (122)	**12.8** (104)	**10.5** (135)	**4.2** (40)
DCCO	1.1 (8)	**16.8** (79)	0.0 (1)	0.6 (19)	**15.8** (42)	**10.9** (44)	2.6 (22)	0.2 (4)
GBHE	0.4 (2)	0.2 (5)	0.1 (2)	0.0 (1)	0.1 (1)	0.0 (1)	0.0 (1)	0.0 (1)
OSPR	2.4 (9)	0.7 (5)	0.0 (4)	0.3 (3)	0.0 (1)	0.1 (1)	0.1 (2)	0.0 (1)
COME	0.0 (2)	0.0 (9)	0.0 (2)	0.0 (4)	0.0 (0)	0.0 (0)	0.1 (7)	0.0 (0)
GREBE	1.2 (12)	0.5 (93)	**14.8** (51)	**7.9** (61)	0.1 (1)	0.2 (3)	0.0 (1)	0.0 (0)

AWPE = American White Pelican, CATE = Caspian Tern, GULL = any gull species, DCCO = Double Crested Cormorant, GBHE = Great blue heron, OSPR = Osprey, COME = Common Merganser, GREBE = Clark's or Western Grebe. During this time frame bald eagles were only counted twice, both at Little Goose Dam, two flying by in April and one foraging in July.
*Bonneville counts are May through July 31, 2012 and do not include the juvenile fish outfall.
†Ice Harbor and Lower Granite counts are April 11 through July 31, 2012.
‡Lower Monumental counts are April 24 through July 31, 2012.

BIRD COUNTS BY PROJECT

BONNEVILLE

Bonneville Dam is located at river kilometer 234 (river mile 146.1). The monitored area consists of twelve zones that cover 0.82 square km (0.32 square miles). It is surrounded by steep forested mountains on both banks and receives the most precipitation of these projects. Most juvenile fish migrating out from the Columbia River basin must pass through Bonneville Dam, including several salmonid ecologically significant units (ESU's) listed as threatened or endangered under the Endangered Species Act (NOAA 2008). Powerhouse II has screened turbine intakes that are designed to guide fish into a bypass system away from the turbines and deposits them back into the river at the juvenile fish outfall (JFOF) 3.2 km (2 miles) downstream (Figure 4).

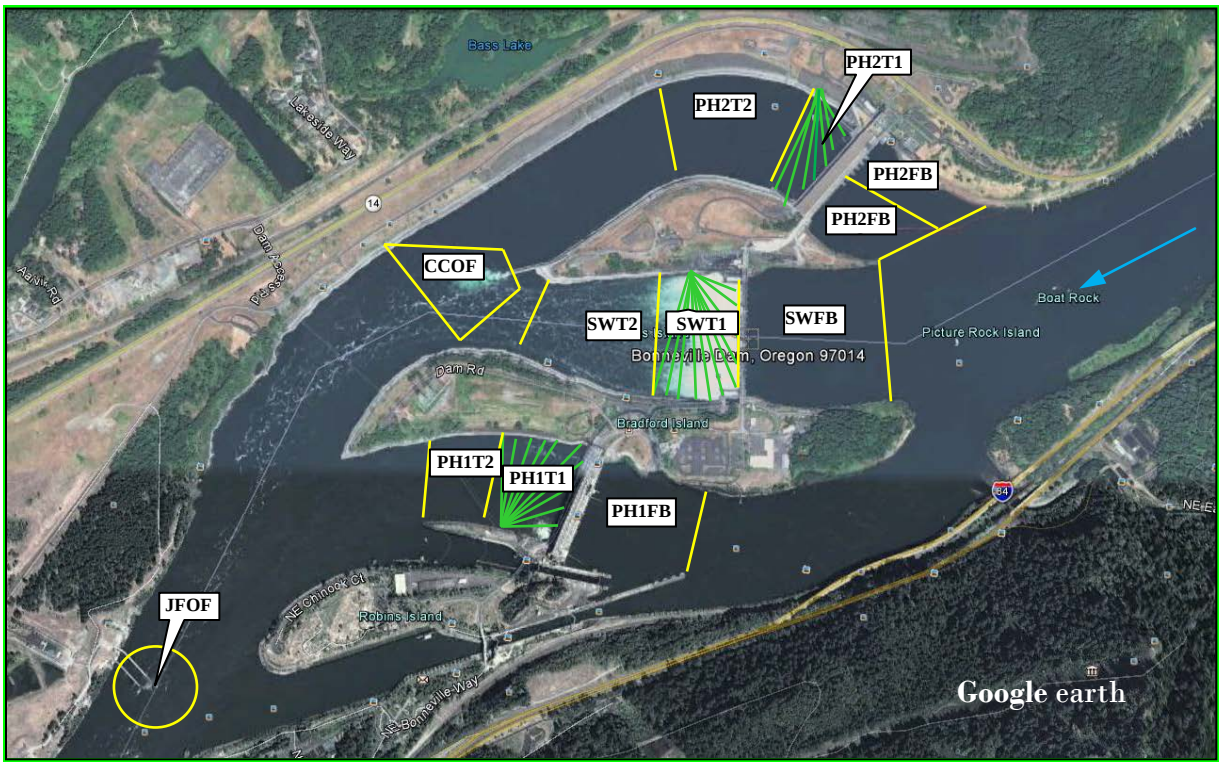

Figure 4. Zone map of Bonneville Dam used in 2012. Yellow lines delineate the zones, green lines represent the avian deterrent lines (not exact number), and the blue arrow indicates flow direction.

Project biologists at Bonneville performed bird counts on 51 of the 122-day season, typically once a day. Bonneville reported some of the lowest mean counts of piscivorous birds, ranked sixth highest in seasonal mean daily bird count and fifth highest in the number of foraging birds (Figure 3). However, monitoring here was not complete. It was shorter in duration by six weeks (beginning in May) including a two week gap in June and the juvenile fish outfall (JFOF) was not monitored. By May bird counts were already beginning to peak with a maximum daily count of 93 on May 10 (Figure 5). Therefore, these results may be biased low and comparison to other dams is given only in a ranked sense.

Six of the nine monitored piscivorous species were counted at Bonneville Dam in spring and summer of 2012. Gulls were the most common, 12.9 per day ranking Bonneville fifth of the eight dams. Missing were American white pelicans, Caspian terns, and common mergansers. If the JFOF had been monitored we would expect the gull estimate to be higher. Here and at other inland projects gulls were likely California gulls (*Larus californicus*) and have been collected for diet studies (Zorich et al. 2010 and 2011). Ospreys were the next most common at 2.4 per day which is more than three times that of any other project (Table 1). There were two active osprey nests in the electrical transmission towers above powerhouse I.

All four behaviors were displayed at Bonneville with foraging cataloged 65.2% of the time, resting 22.6%, flyby 11.0%, and scavenging (mostly from sea lion eating adult salmon or sturgeon) 1.3% of the time. Foraging behavior peaked in May and again in late July (Figure 6).

Birds were distributed throughout Bonneville's twelve count zones but foraging was focused on the spillway tailrace zone two (SWT2) downstream from the avian deterrent lines (Figure 7). This zone had the highest seasonal mean, 8.0 birds, predominately due to foraging gulls. Gulls would forage on the north side of zone SWT2 just downstream of the choppy white water caused by the spill. Resident ospreys were found most often foraging in the calmer waters of the forebays or downstream of the powerhouses (Table 2). They were also frequently spotted foraging inside fishways though that is not included in these results. Grebes were commonly sighted in the powerhouse forebays, though not in large numbers, and cormorants were usually seen resting on floating debris booms in the forebay of powerhouse II.

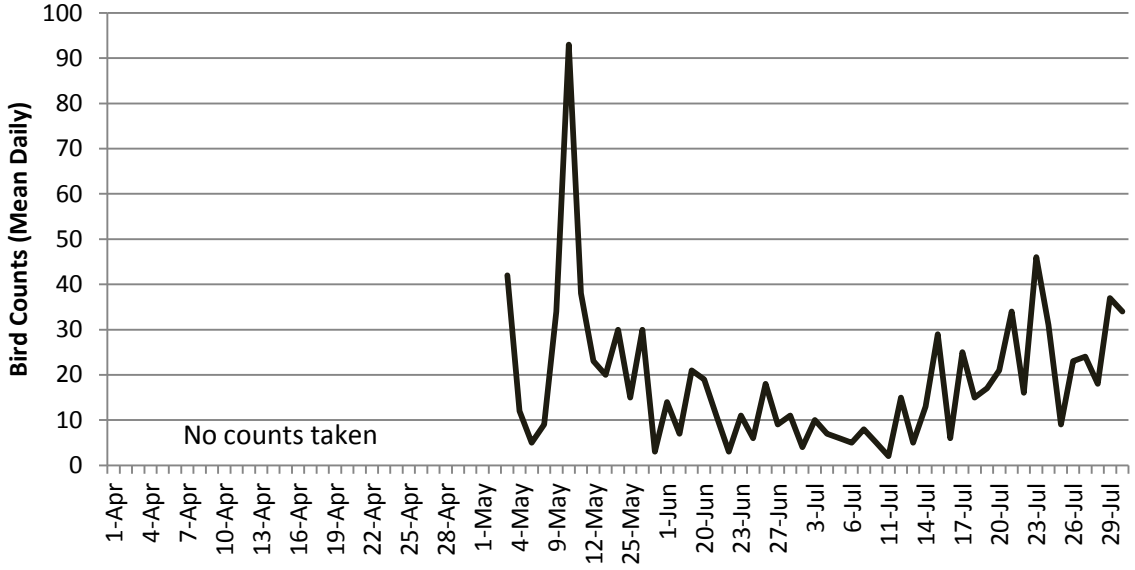

Figure 5. Mean daily bird counts at Bonneville Dam during the primary smolt outmigration period. Counts reported here are for May 3 through July 31, 2012.

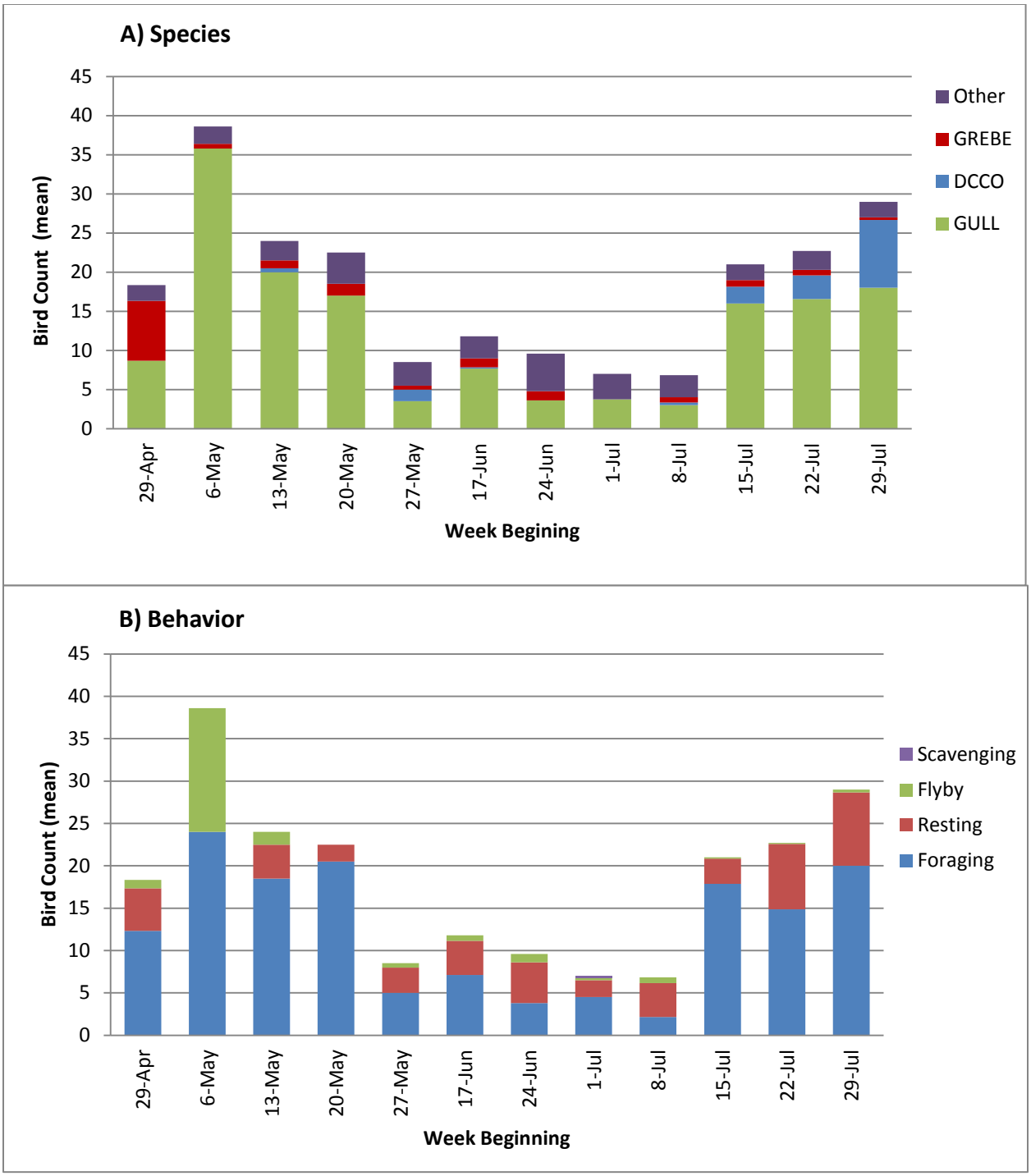

Figure 6. Timing, abundance, diversity, and behavior of nine fish eating birds at Bonneville Dam May 3 through July 31, 2012. A) The most numerous species; GULL = any gull species, DCCO = double crested cormorant, GREBE = western or Clark's grebes, Other = remaining six monitored species. B) Behavior of the birds in graph A.

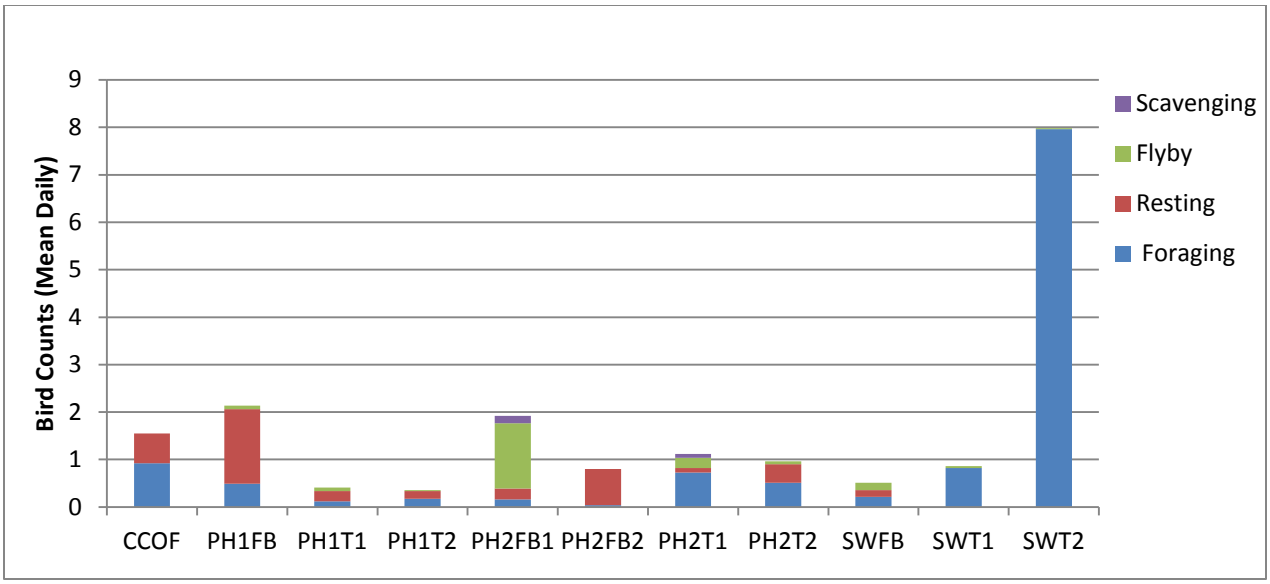

Figure 7. Spatial distribution of birds by zone and behavior at Bonneville Dam, seasonal daily mean for May 3 through July 31, 2012. Note that the juvenile fish outfall (JFOF) was not counted.

Table 2. Seasonal daily mean bird counts by zone and species at Bonneville Dam (all behaviors), May 3 through July 31, 2012. The juvenile fish outfall (JFOF) was not monitored.

Species	CCOF	JFOF	PH1FB	PH1T1	PH1T2	PH2FB1	PH2FB2	PH2T1	PH2T2	SWFB	SWT1	SWT2
American White Pelican	0	na	0	0	0	0	0	0	0	0	0	0
Bald Eagle	0	na	0	0	0	0	0	0	0	0	0	0
Caspian Tern	0	na	0	0	0	0	0	0	0	0	0	0
Common Merganser	0	na	0	0	0	0	0	0	0	0	0	0
Double Crested Cormorant	0	na	**0.1**	0	0	0	**0.8**	**0.1**	**0.1**	0	0	0
Great Blue Heron	0	na	**0.1**	**0.2**	0	0	0	0	0	**0.1**	0	0
Grebe	0	na	**1.0**	0	0	**0.2**	0	0	0	0	0	0
Gull	**1.5**	na	**0.7**	0	**0.1**	**1.3**	0	0	**0.4**	**0.1**	**0.9**	**8.0**
Osprey	0	na	**0.2**	**0.2**	**0.1**	**0.1**	0	**0.9**	**0.5**	**0.3**	0	**0.1**

THE DALLES

The Dalles Dam is located at Columbia River kilometer 308 (river mile 191.5) and is the second largest of the eight dams (Figure 8). The monitored area consisted of eight zones that cover 1.75 square km (0.68 square miles). It is located on a large bend in the river next to The Dalles, OR who's population was 13,620 in 2010 (U.S. Census), and is near agricultural lands, a county landfill, and a regional landfill. It is also about 21.5 rkm (13.4 miles) downstream from the gull colony at Miller Island's rocks.

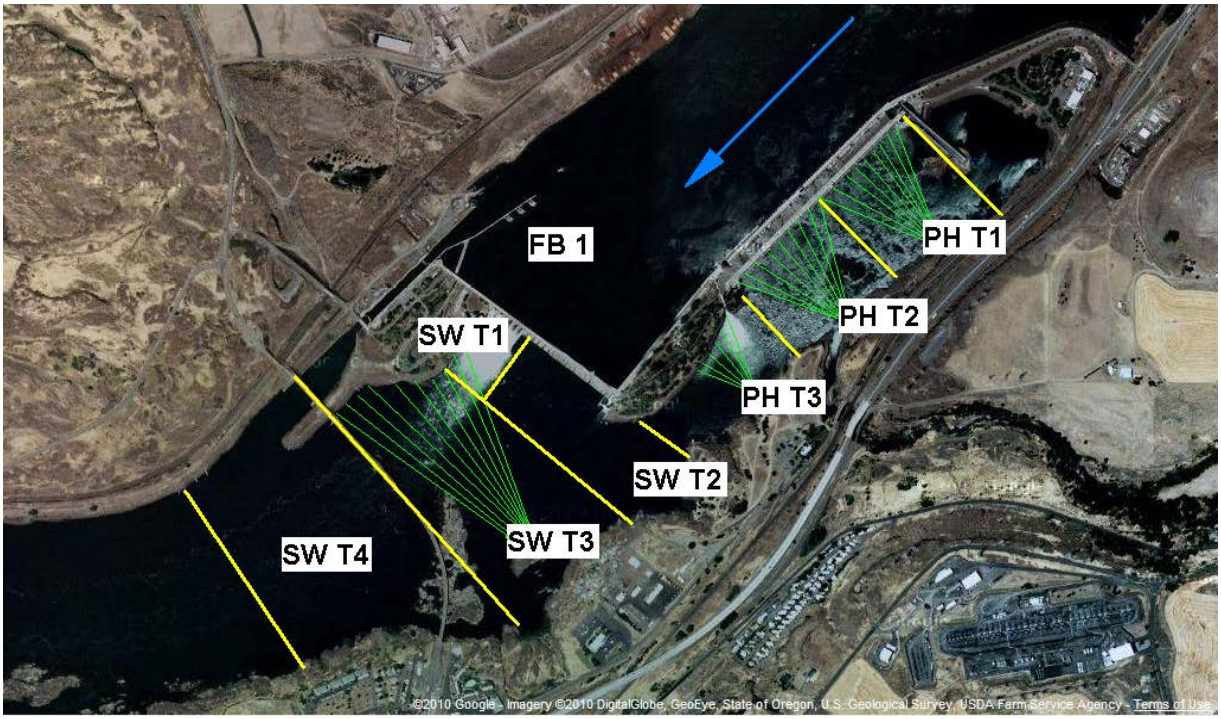

Figure 8. Zone map for The Dalles Dam in 2012. Yellow lines delineate the zones, green lines represent the avian deterrent lines (not exact number), and the blue arrow indicates flow direction.

Project biologists conducted bird counts twice a day every day of the 122 day season from April 1 through July 31. The Dalles reported the highest seasonal daily mean bird count of 74.1 (Table 1) and the second highest seasonal daily mean foraging count of all eight sites (Figure 2). Bird counts peaked during May and again in July with a large number of birds flying by in late June (Figure 9).

All four behaviors were observed at The Dalles Dam. Of these, foraging accounted for 53.4%, resting 38.9%, flyby 7.7%, and scavenging <0.1%. Scavengers were observed eating scraps from tribal fishermen cleaning their catch. Early in the season foraging was the main behavior, but in July resting birds were counted more often (Figure 10).

Birds were not evenly distributed but were more concentrated in three of the eight count zones. The highest bird counts were collected on the spillway side of the dam downstream of the The Dalles US-197 bridge (SWT4). Gulls foraged heavily in this zone (Figure 11). The majority of resting birds in the forebay (FB1) were double crested cormorants, often perched on the electrical transmission towers near the Washington shore (Table 3). Grebes were scarce but could occasionally be found in the forebay. Resident ospreys were counted in various zones throughout the season as two active osprey nests are located at the dam (Table 3).

Five of the nine bird species of interest were counted during the season. Of these, gulls (likely California gulls see Zorich et al. 2010) were the largest group of piscivorous birds at the dam with a seasonal daily mean of 55.9 (Table 3). Double crested cormorants were the next most abundant bird with a seasonal daily mean of 16.8. During the winter, common mergansers were numerous (see Appendix C).

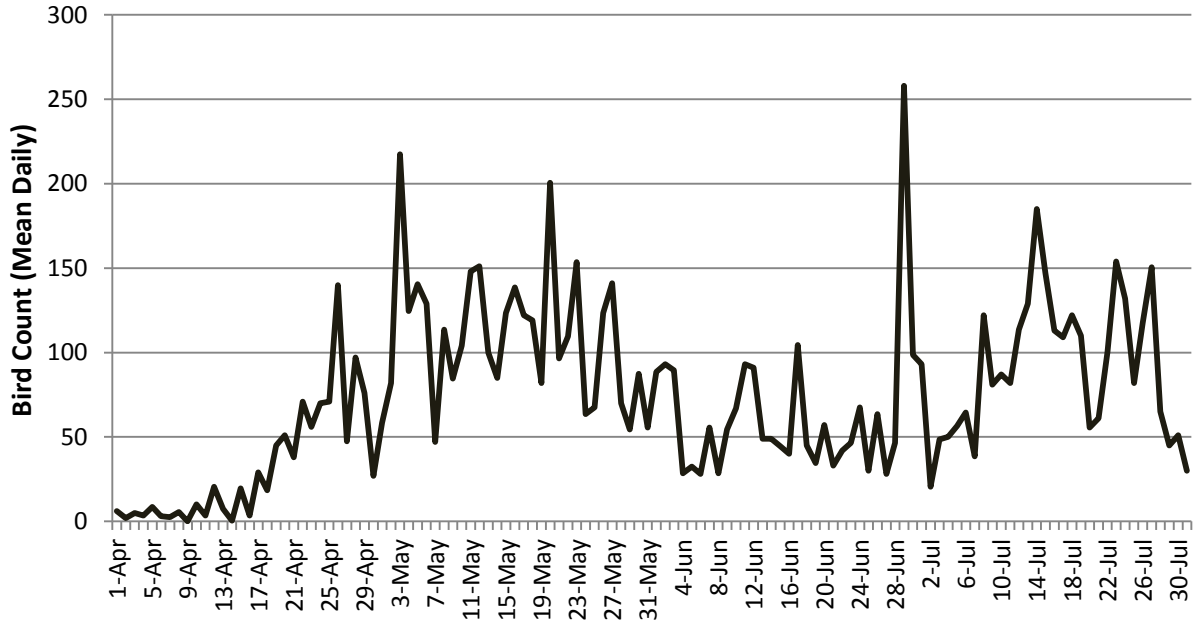

Figure 9. Mean daily bird counts at The Dalles Dam during primary smolt outmigration, April 1 through July 31, 2012.

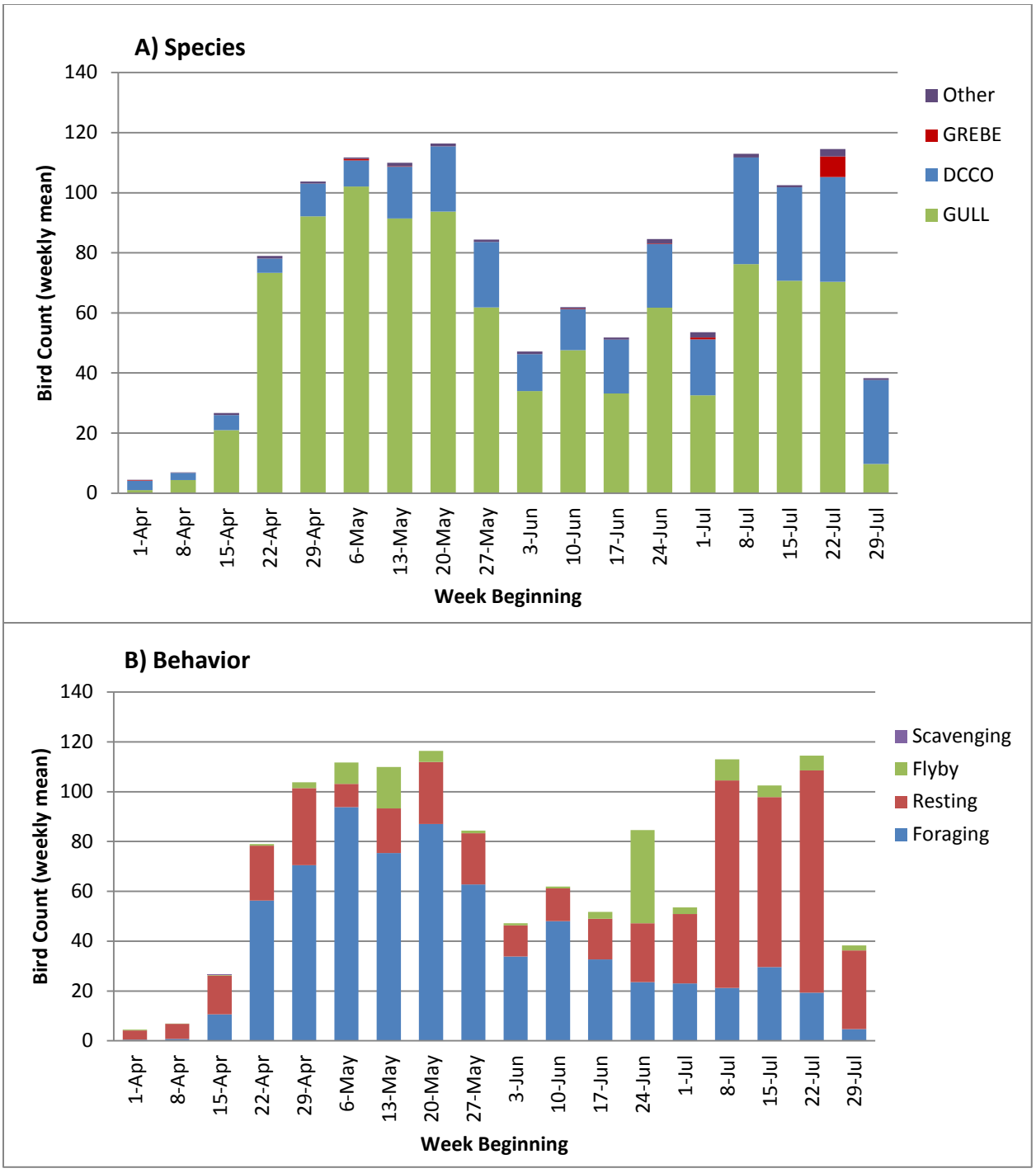

Figure 10. Timing, abundance, diversity, and behavior of nine fish eating birds at The Dalles Dam April 1 through July 31, 2012. A) The most numerous species; GULL = any gull species, DCCO = double crested cormorant, GREBE = western or Clark's grebes, Other = remaining six monitored species. B) Behavior of the birds in graph A.

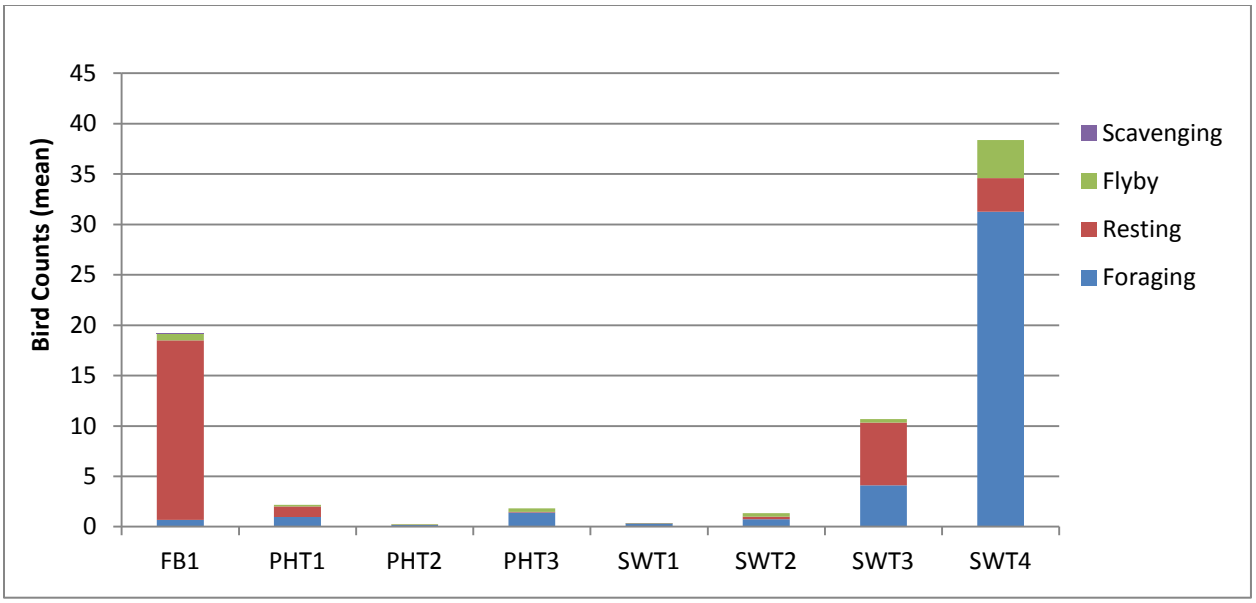

Figure 11. Spatial distribution of birds by zone and behavior at The Dalles Dam, seasonal daily mean for April 1 through July 31, 2012. FB1 = forebay, PHT1 to 3 = powerhouse tailrace zones, SWT1 to 4 = spillway tailrace zones. PHT1, PHT2, SWT1, and SWT2, are adjacent to dam.

Table 3. Seasonal daily mean bird counts by zone and species at The Dalles Dam (all behaviors), April 1 through July 31, 2012.

Species	FB1	PHT1	PHT2	PHT3	SWT1	SWT2	SWT3	SWT4
American White Pelican	0	0	0	0	0	0	0	0
Bald Eagle	0	0	0	0	0	0	0	0
Caspian Tern	0	0	0	0	0	0	0	0
Common Merganser	0	0	0	0	0	0	0	0
Double Crested Cormorant	**15.9**	**1.5**	0	0	0	**0.2**	**0.1**	**0.2**
Great Blue Heron	0	**0.1**	0	0	0	0	0	0
Grebe	**0.5**	0	0	0	0	0	0	0
Gull	**3.8**	**0.5**	**0.2**	**1.9**	**0.4**	**1.1**	**11.3**	**41.2**
Osprey	**0.3**	**0.2**	0	**0.1**	0	**0.1**	0	0

JOHN DAY

John Day Dam is located at Columbia River rkm 348 (river mile 216). Here the monitored area was divided into ten zones covering 1.94 square km (0.75 sq mi). The powerhouse at John Day is equipped with screens that divert juvenile fish away from the turbines and through the juvenile bypass system on the south shore (Figure 12). John Day Dam is 15.3 km (9.5 miles) upstream from Miller Island's rocks where a colony of California and ring-billed gulls nest.

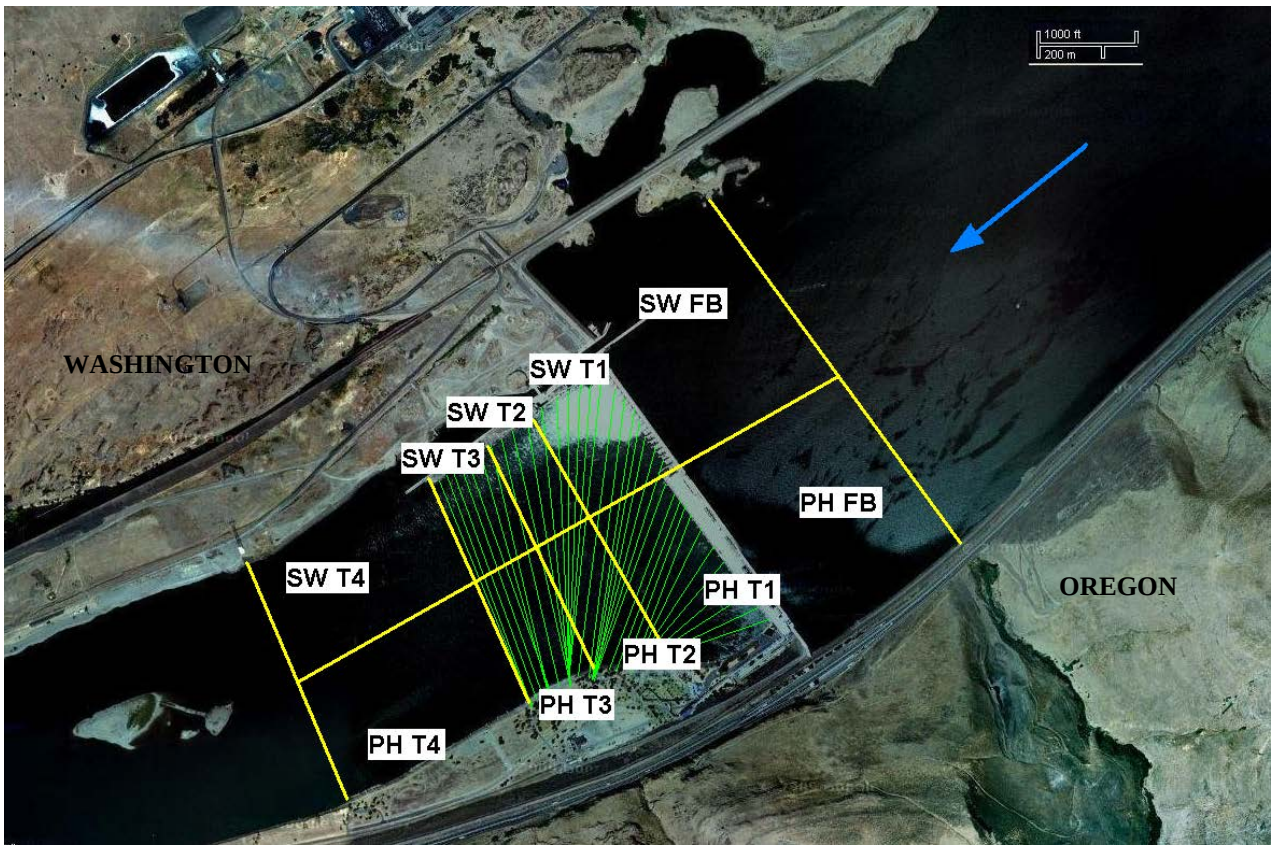

Figure 12. Zone map used at John Day Dam in 2012. Yellow lines demarcate zones and green lines represent the avian deterrent lines (not exact number), and the blue arrow indicates flow direction.

Project biologists conducted bird counts twice a day everyday of the 122 day season from April 1 through July 31. John Day was ranked the fourth highest in overall seasonal mean daily bird counts and third highest in seasonal mean daily foraging birds (Table 1). Bird counts at the dam peaked in early May and again in early July (Figure 13). Daily mean counts reached a high of 210 on May 12. Maximum counts here were not as protracted as maximum counts at The Dalles Dam.

Three of the four behaviors were recorded at John Day Dam (Figure 14). Of these, foraging accounted for 49.0%, resting 46.9%, and flyby 4.0%. Foraging counts peaked in early May and again in early July while resting counts peaked in mid July. No scavenging was observed. John Day had a large number of resting birds, mainly gulls, in the fall and winter months (see Appendix C).

Bird activity at John Day Dam was minimal in all but two of its ten count zones (Figure 15 and Table 4). Foraging birds, primarily gulls, occurred most in the SWT4 zone which is one of two tailrace zones unprotected by the avian deterrent array and furthest downstream of the spillway. Resting grebes were responsible for the largest portion of mean daily bird counts in the powerhouse forebay zone (PHFB). American white pelicans also foraged at the dam in various zones.

Eight of the nine bird species were counted at John Day Dam from April 1through July 31(Table 4). Only the bald eagle did not make an appearance during this time period. Four of those (gulls, grebes, great blue heron, and American white pelicans) were observed throughout the season (Table 4). Of these, gulls (primarily California gulls) were the largest group of piscivorous birds at the dam with a seasonal mean of 22.2. Grebes were the next most abundant with a seasonal mean of 14.7. Many of these birds rested in large groups on downstream islands just outside the count zones. The other two species were observed much less frequently.

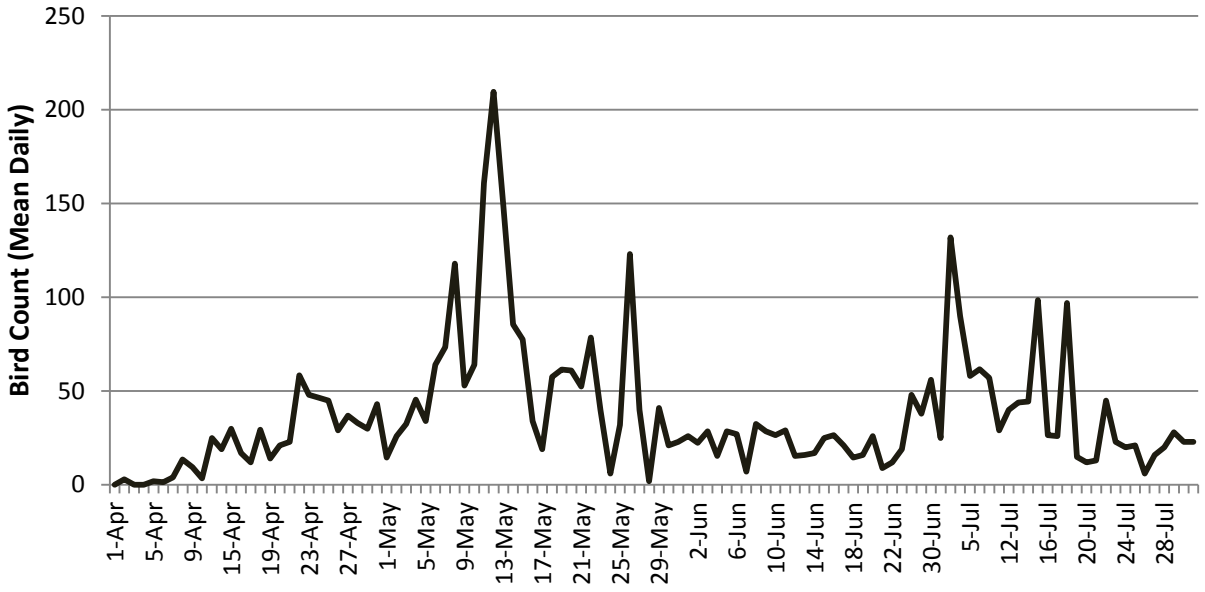

Figure 13. Mean daily bird count at John Day Dam during primary smolt outmigration, April 1 through July 31, 2012.

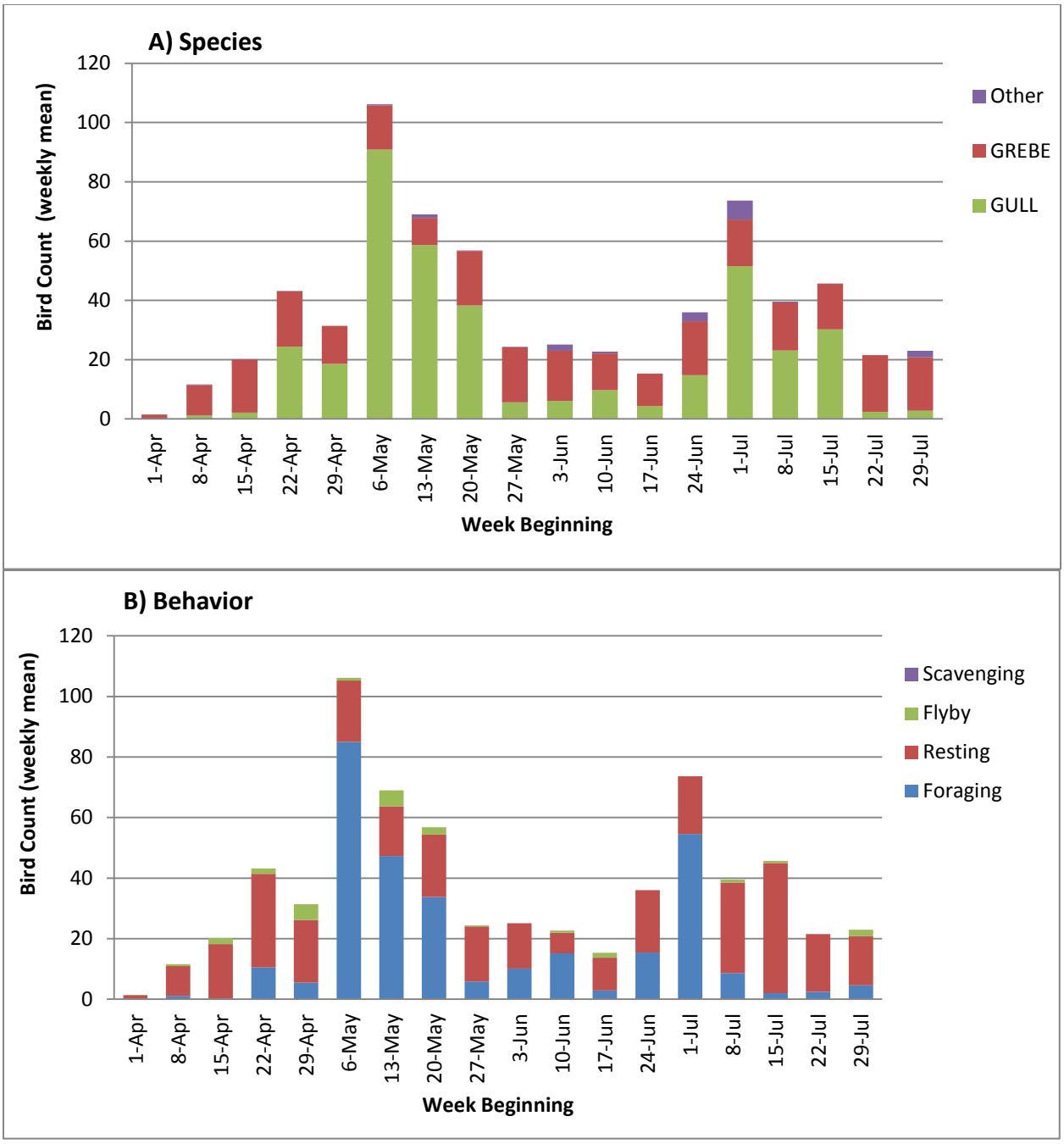

Figure 14. Timing, abundance, diversity, and behavior of nine fish eating birds at John Day Dam April 1 through July 31, 2012. A) The most numerous species; GULL = any gull species, GREBE = Western or Clark's Grebes, Other = remaining seven monitored species. B) Behavior of the birds in graph A.

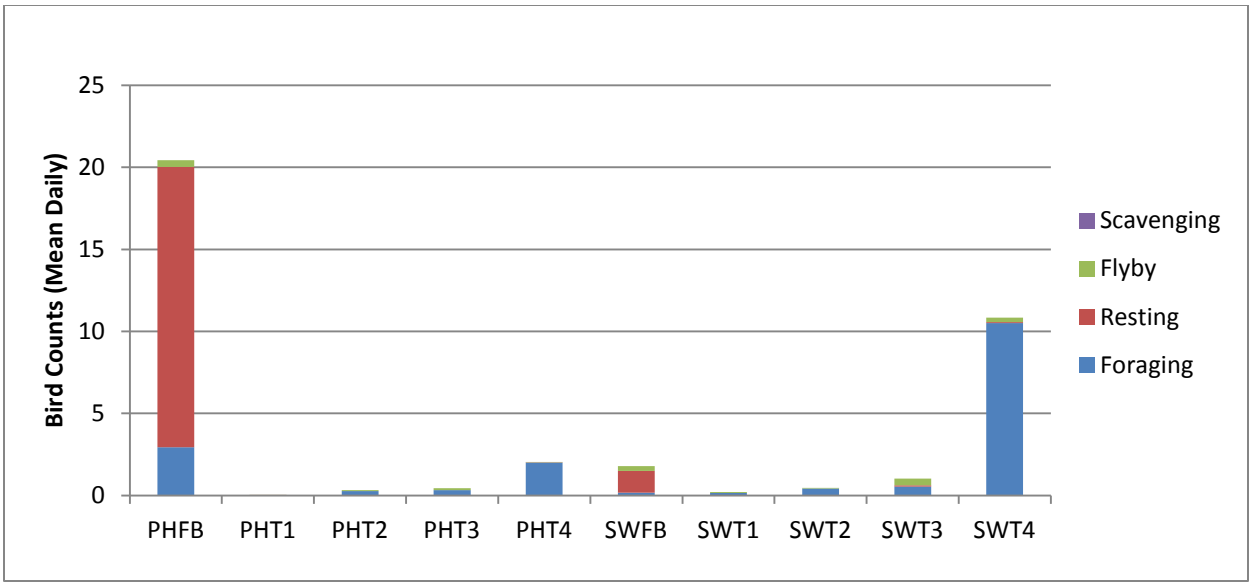

Figure 15. Spatial distribution of birds by zone and behavior at John Day Dam, seasonal daily mean for April 1 through July 31, 2012. SWFB = spillway forebay, PHFB = powerhouse forebay, SWT1 to SWT4 = spillway tailrace zones, PHT1 to PHT4 = powerhouse tailrace zones.

Table 4. Seasonal daily mean bird counts by zone and species at John Day Dam (all behaviors), April 1 through July 31, 2012.

Species	PHFB	PHT1	PHT2	PHT3	PHT4	SWFB	SWT1	SWT2	SWT3	SWT4
American White Pelican	**0.1**	0	0	0	**0.1**	0	0	**0.1**	**0.1**	**0.1**
Bald Eagle	0	0	0	0	0	0	0	0	0	0
Caspian Tern	0	0	0	0	0	0	0	0	0	0
Common Merganser	0	0	0	0	0	0	0	0	0	0
Double Crested Cormorant	0	0	0	0	0	0	0	0	0	0
Great Blue Heron	**0.1**	0	0	0	0	0	0	0	0	0
Grebe	**14.7**	0	0	0	0	0	0	0	0	0
Gull	**5.6**	0	**0.3**	**0.4**	**1.9**	**1.7**	**0.2**	**0.4**	**0.9**	**10.7**
Osprey	0	0	0	0	0	0	0	0	0	0

MCNARY

McNary Dam is located at Columbia River rkm 470 (river mile 292). McNary is the last Corps dam on the lower Columbia River. The powerhouse at McNary is equipped with screens that divert juvenile fish away from the turbines and through a juvenile bypass system on the south shore. The outfall pipe is located 0.6 km downstream of the dam. The dam is surrounded by agricultural and wetland areas, it is also close to populated areas such as the cities of Umatilla and Hermiston, Oregon. The monitored area was divided into four zones which covered 1.42 square km (0.55 sq mi) (Figure 16).

Figure 16. Zone map used at McNary Dam in 2012. Yellow lines demarcate zones, green lines represent the avian deterrent lines downstream of the powerhouse (not exact number), and the blue arrow indicates flow direction.

Project biologists monitored bird numbers and behavior once a day everyday from April 1 through July 31 and beyond. McNary had the second highest seasonal mean bird count, at 62.6 (Table 1), and highest mean foraging count of all eight projects (Figure 3). Most bird activity occurred the first half of May. During this time mean daily bird counts reached a high of 405 on May 2 (Figure 17).

All four behaviors were catalogued at McNary Dam. Foraging was the main behavior; being recorded 69.8% of the time, resting 27.3%, flyby 2.0%, and scavenging 0.9%. Although foraging and resting activity tapered off at the end of May, foraging behavior peaked again from mid June to mid July.

Seven of the nine piscivorous bird species of interest were counted at McNary Dam. Of these, gulls were the primary fish eating bird to forage near the dam and were present throughout the season. While grebe counts peaked in April and gull counts hit their peak in May, American white pelicans and Caspian terns began appearing in late June and continued to be observed through July (Figure 18). Resident osprey and common mergansers were counted less frequently during the season. Great blue heron and bald eagles were not observed during the spring period.

All but one of McNary's four count zones had moderate to substantial bird activity (Figure 19). Gulls were the most numerous foragers observed at the spillway and juvenile outfall zones, followed by American white pelicans, and Caspian terns, while grebes were exclusively found resting and foraging in the forebay (Table 5). Activity in the powerhouse tailrace zone was minimal.

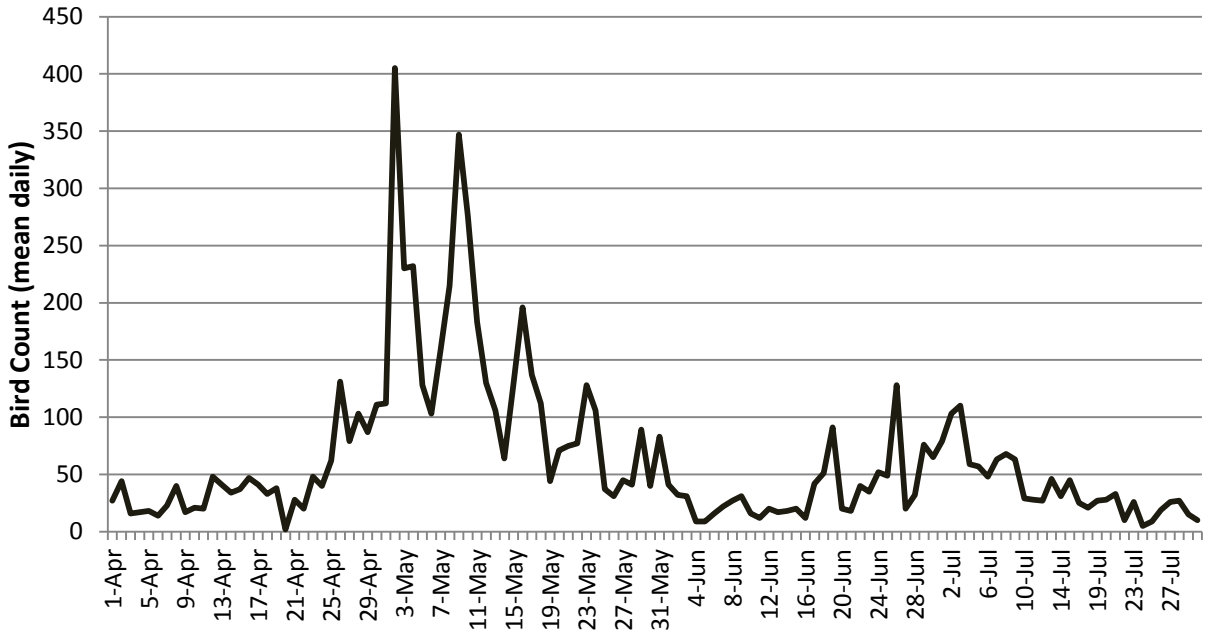

Figure 17. Mean daily bird count at McNary Dam during primary smolt outmigration, April 1 through July 31, 2012.

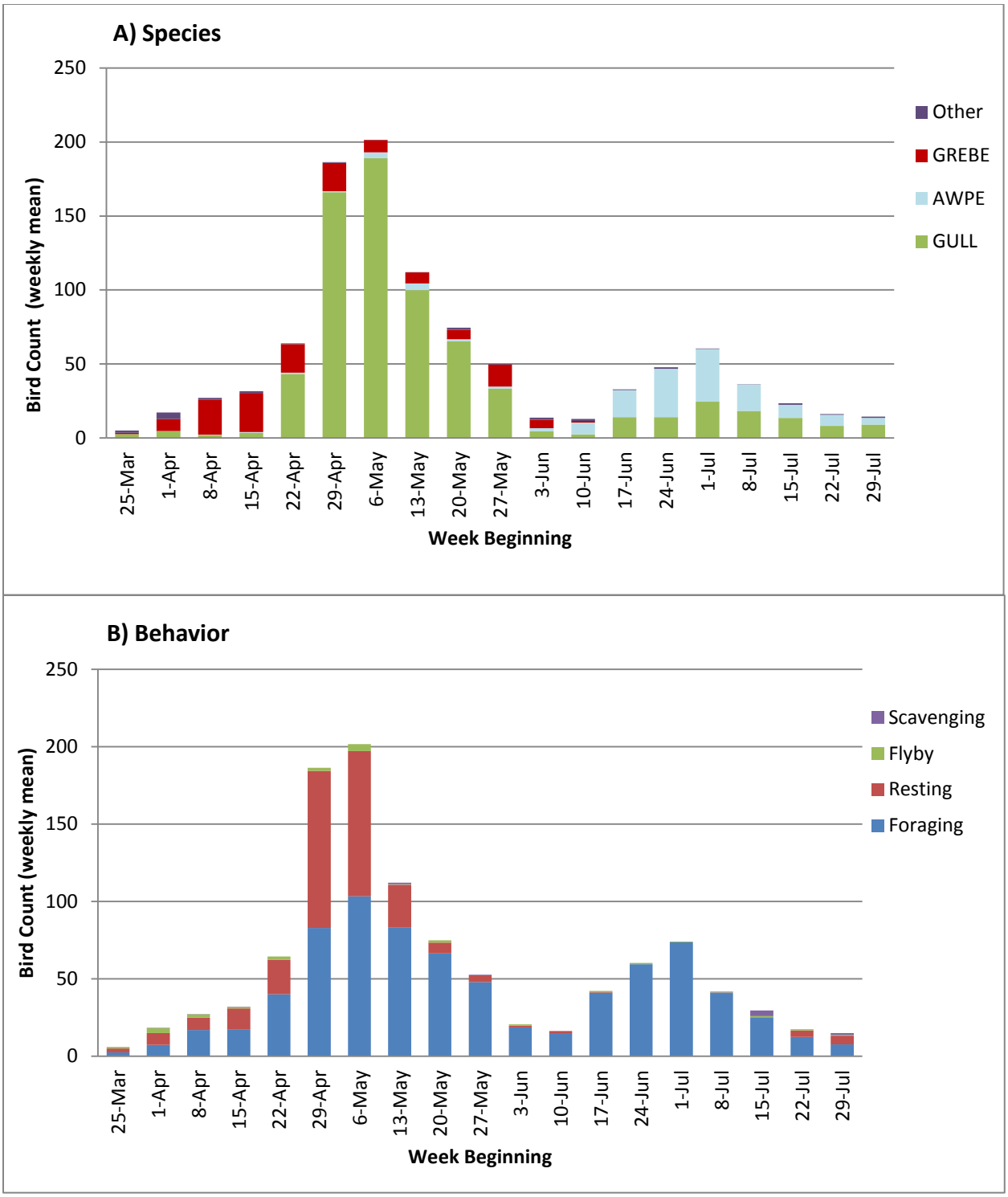

Figure 18. Timing, abundance, diversity, and behavior of nine fish eating birds at McNary Dam April 1 through July 31, 2012. A) The most numerous species; GULL = any gull species, AWPE = American white pelican, GREBE = western or Clark's grebes, Other = remaining six monitored species. B) Behavior of the birds in graph A.

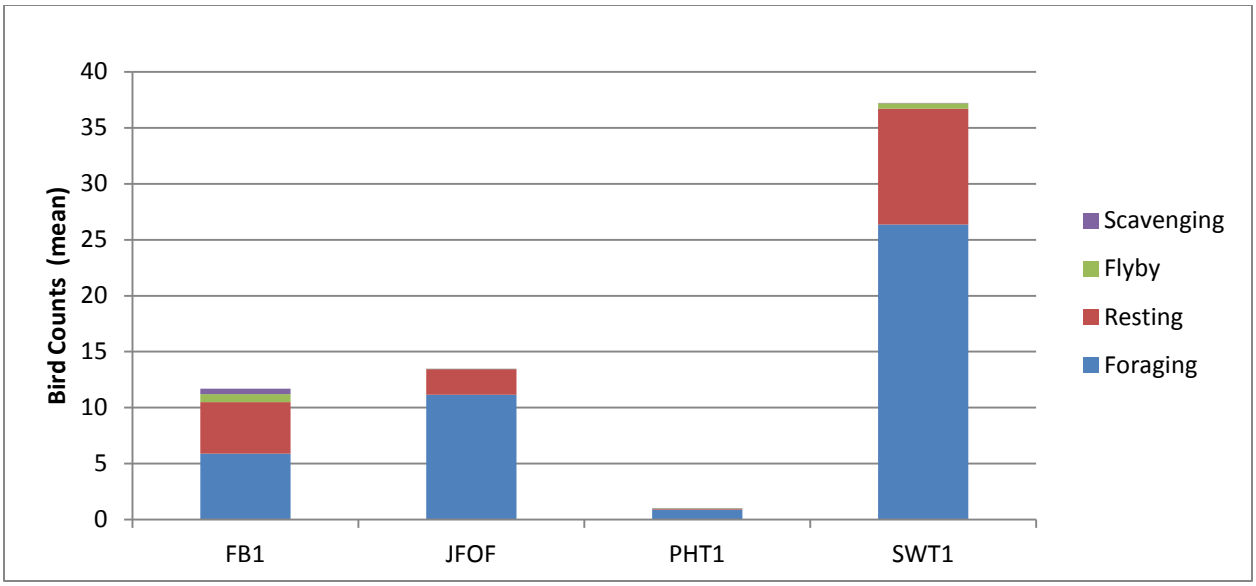

Figure 19. Spatial distribution of birds by zone and behavior at McNary Dam, seasonal daily means for April 1 through July 31, 2012. FB1 = forebay, JFOF = juvenile fish outfall, PHT1 = powerhouse tailrace, SWT1 = spillway tailrace.

Table 5. Seasonal daily mean bird counts by zone and species at McNary Dam (all behaviors), April 1 through July 31, 2012.

Common Name	FB1	JFOF	PHT1	SWT1
American White Pelican	**0.3**	**0.3**	**0.7**	**7.2**
Bald Eagle	0	0	0	0
Caspian Tern	**0.2**	**0.5**	**0.1**	**2.9**
Common Merganser	0	0	0	0
Double Crested Cormorant	**0.1**	**0.1**	0	**0.4**
Great Blue Heron	0	0	0	0
Grebe	**8.2**	0	0	0
Gull	**1.7**	**12.6**	**0.2**	**26.7**
Osprey	**0.3**	0	0	0

ICE HARBOR

Ice Harbor Dam is located on the Snake River rkm 15.6 (river mile 9.7). It's the first of several dams on the Snake River, a tributary of the Columbia River. The powerhouse is equipped with screens that divert juvenile fish away from turbine units to a juvenile bypass on the south shore (Figure 20). The dam is close to Burbank, Washington and the larger metropolitan area of the Tri Cities. It is surrounded by agricultural lands made up of mainly orchards. The monitored area was divided into eight zones and encompassed 0.74 sq kilometers (0.29 sq mi).

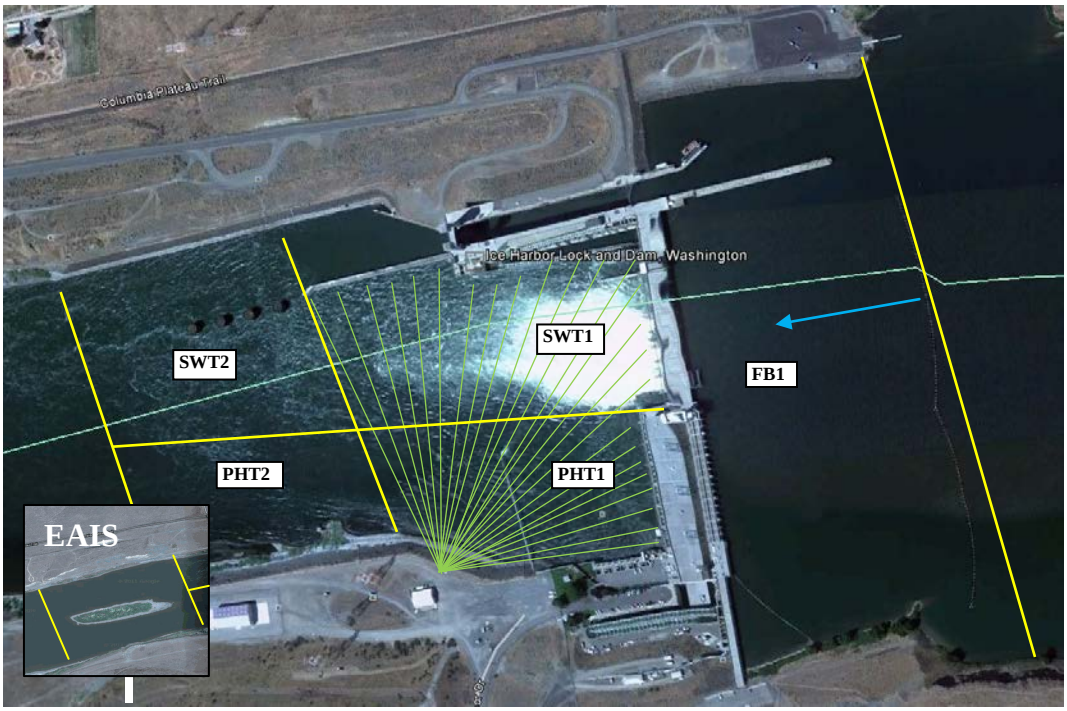

Figure 20. Zone map used at Ice Harbor Dam in 2012. Yellow lines demarcate zones, green lines represent the avian deterrent lines (not exact number), and the blue arrow indicates flow direction. Insert shows the Eagle Island Zone 1.1 km downstream of dam.

Project biologists monitored bird numbers and behavior from April 11 to July 31. Bird counts were taken once a day for 50 of the 122 day season. Ice Harbor had the third highest seasonal daily mean bird count (61.5) and the lowest mean daily foraging count of all eight dams (Figure 3). Daily bird counts peaked in early May reaching a maximum count of 178 before tapering off at the end of the month (Figure 21).

Three of the four behaviors were recorded at Ice Harbor Dam (Figure 22). Foraging behavior was observed 14.3% of all counts, resting 41%, and flyby 44.7% (the highest of any dam). Scavenging was not observed. Birds moving to and from Eagle Island account for the higher number of flybys. The project chose to include Eagle Island as an important part of its bird monitoring effort due to historical observations of piscivorous birds in this area.

Ice Harbor Dam had fewer foraging birds than the other dams (April – July 2012) and moderate species richness with six of the nine piscivorous birds found here. American white pelicans had the highest peak daily means of 17.6 birds resting on Eagle Island followed by gulls at 14.1 foraging downstream of the spillway (Table 6). Although gulls appeared in larger numbers during the month of May and tapered off through the rest of the season. American white pelicans appeared in May and increased in numbers throughout July. Double crested cormorants were present in consistent numbers during the entire juvenile fish outmigration.

The spillway tailrace zone (SWT2) was the most active zone for foraging and flybys close to the dam while Eagle Island (EAIS) was the predominate place for birds to rest (Figure 23). Gulls were the most numerous piscivorous predators found in the near dam zones. They foraged mainly in the spillway tailrace zone (SWT2) and in smaller numbers in the powerhouse tailrace zone (PHT2) both of which are not covered by avian deterrent lines. Although Eagle Island had the largest seasonal average daily bird count, very little foraging occurs in this zone. American white pelicans were mainly counted in the EAIS zone however they were also seen in several of the zones closer to the dam. Double crested cormorants were the third most prominent bird counted in several of the tailrace zones as well as the forebay.

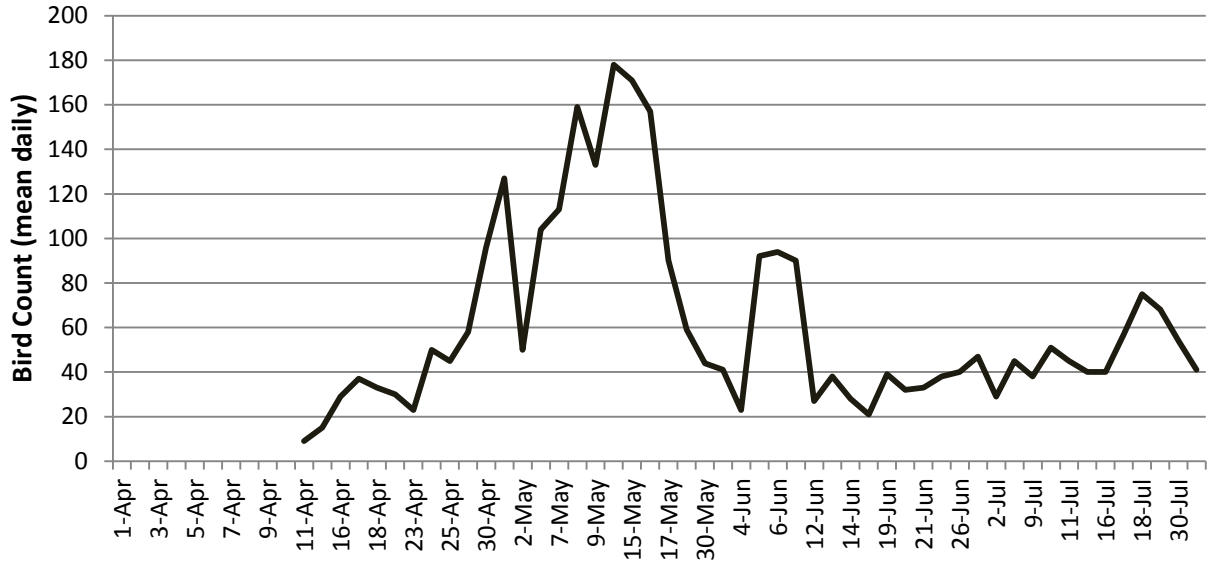

Figure 21. Mean daily bird counts at Ice Harbor Dam during primary smolt outmigration, April 11 through July 31, 2012.

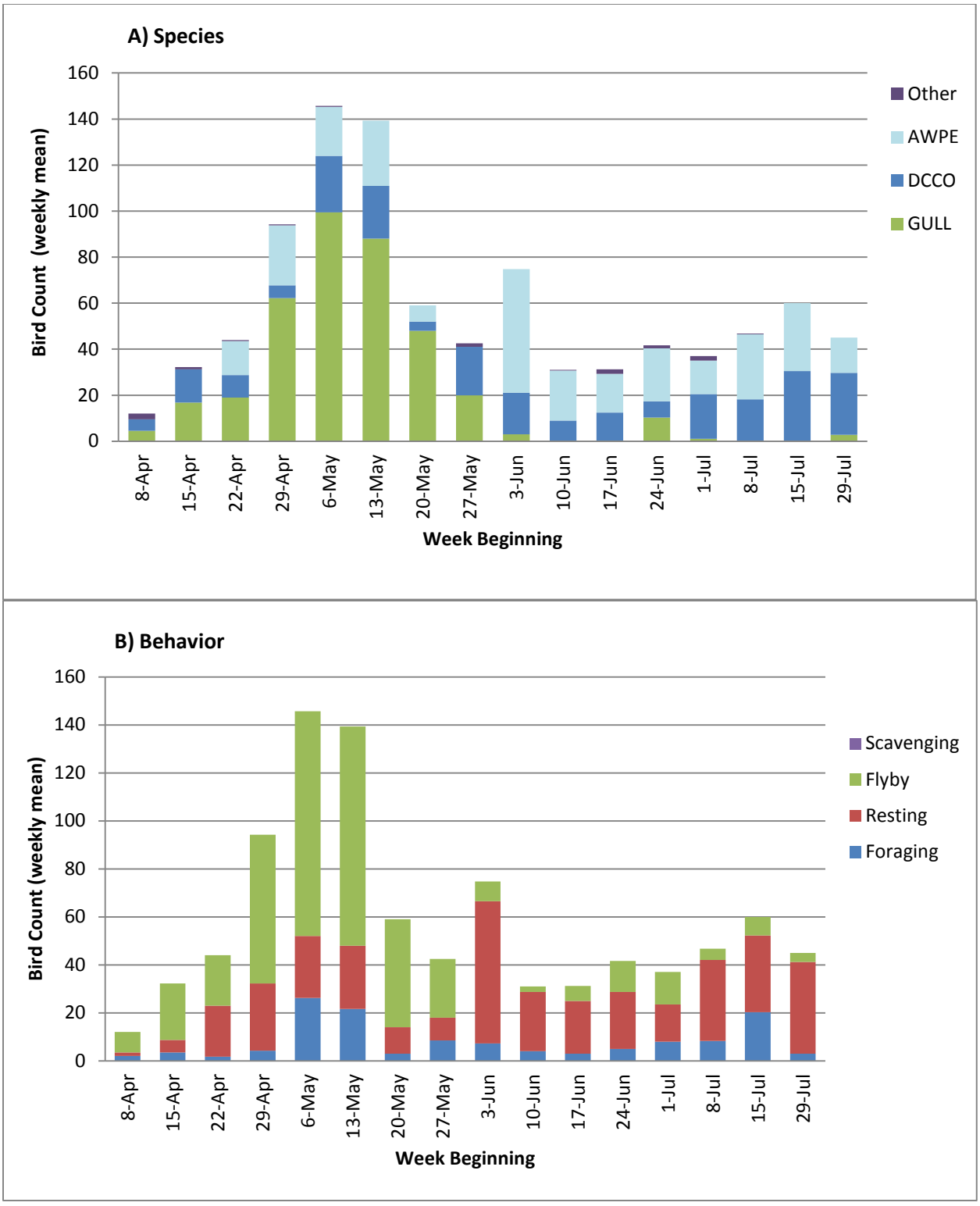

Figure 22. Timing, abundance, diversity, and behavior of nine fish eating birds at Ice Harbor Dam April 11 through July 31, 2012. A) The most numerous species; GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, Other = remaining six monitored species. B) Behavior of the birds in graph A.

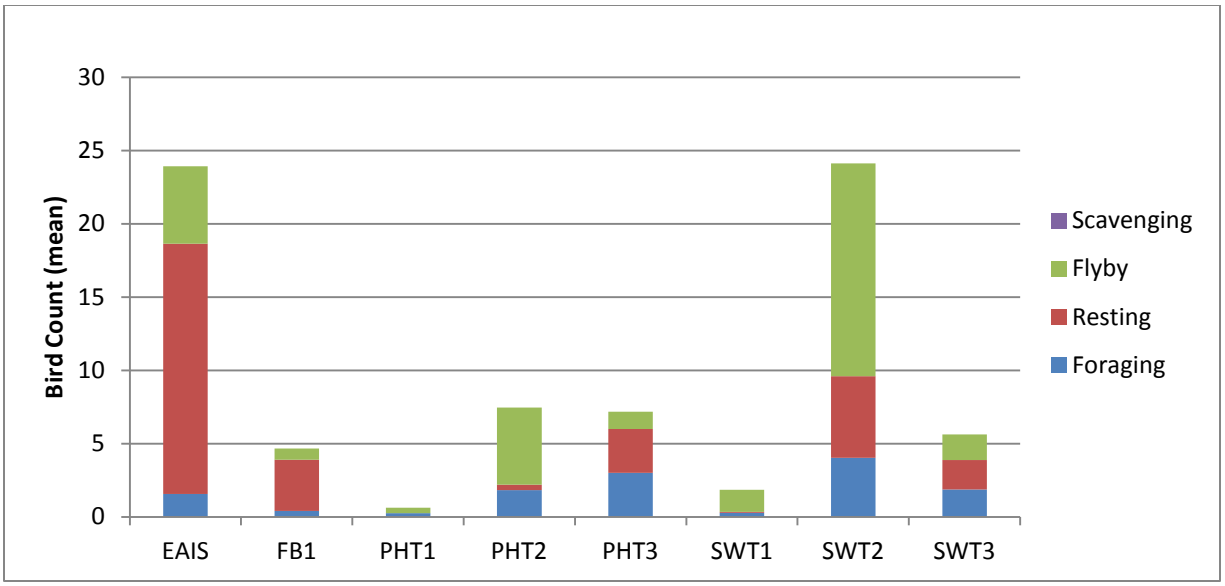

Figure 23. Spatial distribution of birds by zone and behavior at Ice Harbor Dam, seasonal daily mean for April 11 through July 31, 2012. EAIS = Eagle Island downstream of the dam, FB1 = forebay, PHT 1-3 = powerhouse tailrace zones, SWT 1-3 = spillway tailrace zones.

Table 6. Seasonal daily mean bird counts by zone and species at Ice Harbor Dam (all behaviors), April 11 through July 31, 2012.

Species	EAIS	FB1	PHT1	PHT2	PHT3	SWT1	SWT2	SWT3
American White Pelican	**17.6**	0	0	**0.5**	**5.3**	0	**3.9**	**3.6**
Bald Eagle	0	0	0	0	0	0	0	0
Caspian Tern	0	**0.3**	0	0	0	0	**0.3**	0
Common Merganser	0	0	0	0	0	0	0	0
Double Crested Cormorant	**1.9**	**4.1**	**0.4**	**2.7**	**1.8**	**0.3**	**6.1**	**2.0**
Great Blue Heron	0	**0.1**	0	0	0	0	0	0
Grebe	0	0	0	0	0	0	0	0
Gull	**4.4**	**0.2**	**0.2**	**4.2**	0	**1.6**	**14.1**	0
Osprey	0	0	0	0	0	0	0	0

LOWER MONUMENTAL

Lower Monumental Dam is located at Snake River rkm 67 (river mile 41.6). The monitored area was divided into five count zones covering 0.46 sq kilometers (0.18 sq mi) (Figure 24). The powerhouse is equipped with screens that divert juvenile fish away from turbine units to the juvenile bypass system located on the north shore with an outfall 0.95 km downstream of the dam. The dam is surrounded by farmlands and fairly isolated from populated areas.

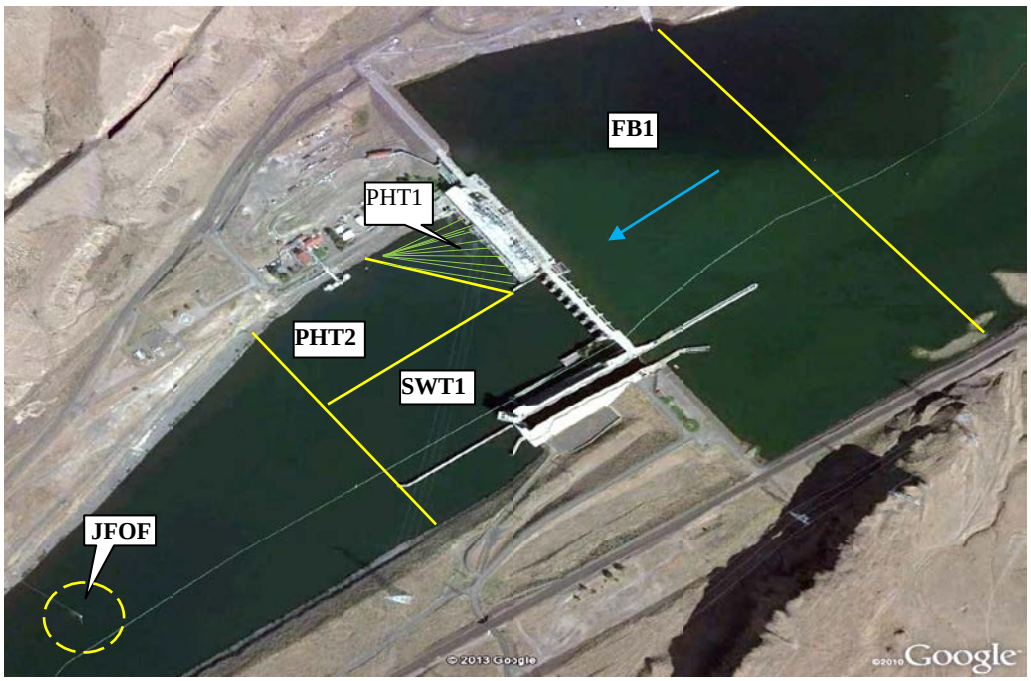

Figure 24. Zone map used at Lower Monumental Dam in 2012. Yellow lines demarcate zones, green lines represent the avian deterrent lines (not exact number), and the blue arrow indicates flow direction.

Project biologists monitored bird numbers and behavior from April 24 to July 31, 2012. Bird counts were taken once a day for 98 of the 122 day season. Lower Monumental Dam ranked the fifth highest in overall seasonal mean daily bird counts and fourth highest in seasonal mean daily foraging birds (Figure 3). Bird counts peaked with a maximum daily count of 148 on May 2 (Figure 25).

All four behaviors (foraging, resting, fly by, and scavenging) were observed at Lower Monumental. Foraging was cataloged 46.8% of the time, resting 49.8%, flyby 3.3%, and scavenging 0.1% (Figure 26). Foraging peaked in early May dropping off quickly by mid May. A sizeable number of resting birds were observed here throughout the season.

Bird activity at the dam was focused in two of the five count zones (Figure 27). Foraging and resting occurred mostly in the spillway zone (SWT1) with very little activity below the powerhouse or juvenile fish outfall. Double crested cormorants, gulls, and Caspian terns respectively, foraged in the SWT1 zone (Table 7). Resting birds accounted for the majority of forebay zone (FB1) counts although some foraging did occur. Gulls comprised the majority of birds found in the forebay zone followed by double crested cormorants, and American white pelicans.

The Lower Monumental Project staff counted six of the nine piscivorous bird species (Table 1). The most abundant of these birds were gulls, double crested cormorants, American white pelicans, and Caspian terns (Table 7). Gulls had a seasonal mean of 12.8, and double crested cormorants had a seasonal mean of 10.9. Grebes and osprey were also observed on a few occasions throughout the season.

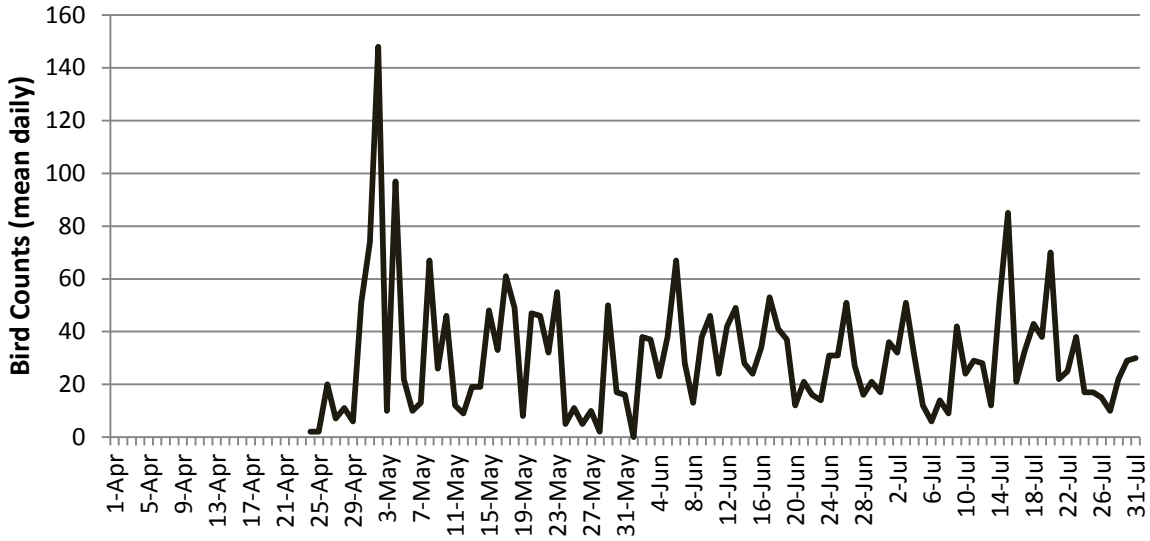

Figure 25. Mean daily bird counts for Lower Monumental Dam during peak smolt outmigration, April 24 through July 31, 2012. No counts were recorded April 1- 22.

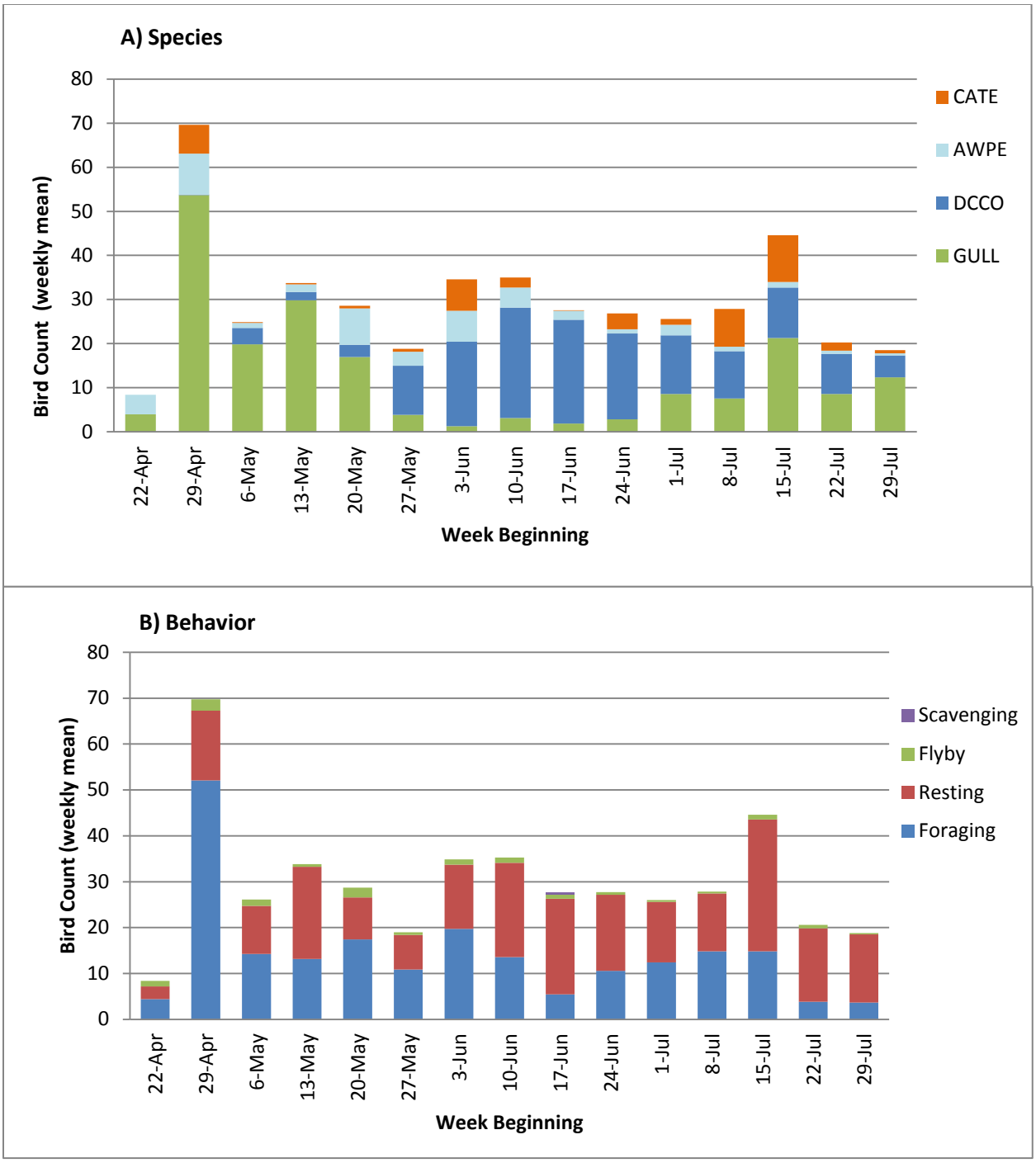

Figure 26. Timing, abundance, diversity, and behavior of nine fish eating birds at Lower Monumental Dam April 24 through July 31, 2012. A) The most numerous species; GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, CATE = Caspian tern. B) Behavior of the birds in graph A.

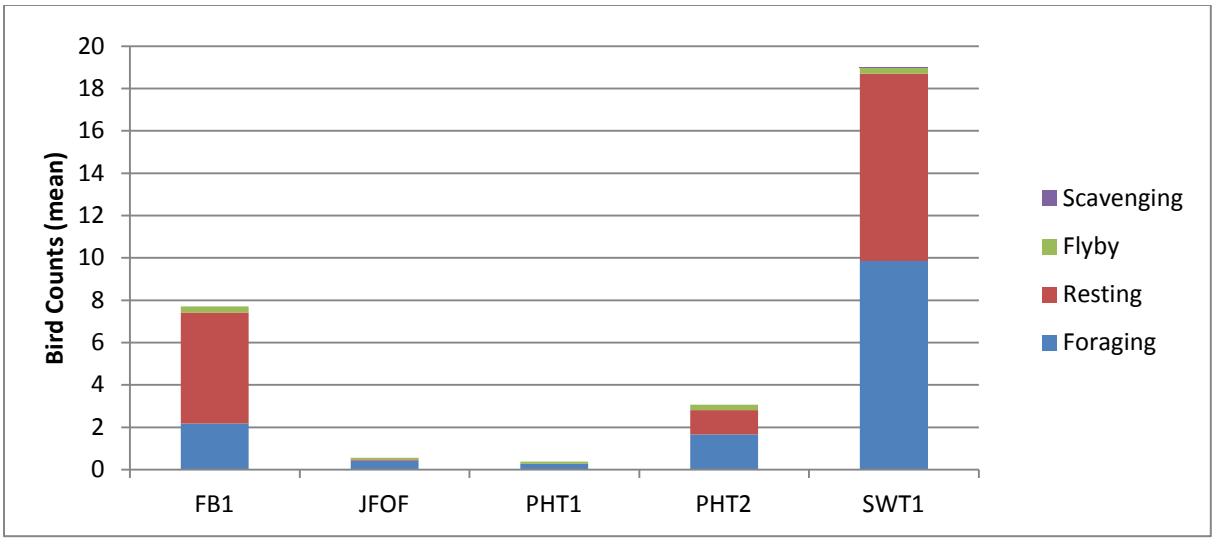

Figure 27. Spatial distribution of birds by zone and behavior at Lower Monumental Dam, seasonal daily mean for April 24 through July 31, 2012. FB1 = forebay, JFOF = juvenile fish outfall, PHT1 - 2 = powerhouse tailrace, SWT1 = spillway tailrace.

Table 7. Seasonal daily mean bird counts by zone and species at Lower Monumental Dam (all behaviors), April 24 through July 31, 2012.

Species	FB1	JFOF	PHT1	PHT2	SWT1
American White Pelican	**1.1**	**0.1**	0	**0.7**	**1.3**
Bald Eagle	0	0	0	0	0
Caspian Tern	**0.3**	**0.1**	0	**0.1**	**2.6**
Common Merganser	0	0	0	0	0
Double Crested Cormorant	**1.3**	**0.1**	**0.1**	**0.5**	**9.1**
Great Blue Heron	0	0	0	0	0
Grebe	**0.2**	0	0	0	0
Gull	**4.7**	**0.3**	**0.2**	**1.7**	**6.0**
Osprey	0	0	0	0	0

LITTLE GOOSE

Little Goose Dam is located at Snake River rkm 113 (river mile 70.3). The powerhouse is equipped with screens to divert juvenile fish away from turbine units and down to a juvenile bypass facility on the south shore with an outfall 0.42 km downstream of the dam. The monitored area was divided into five zones that cover 0.52 sq km (0.21 sq mi) (Figure 28).

Figure 28. Zone map used at Little Goose Dam in 2012. Yellow lines demarcate zones, green lines represent the deterrent lines downstream of the powerhouse (not exact number), and the blue arrow indicates flow direction.

Project biologists monitored bird numbers and behavior from April 24 to July 31. Counts were taken from two to four times a day everyday of the 122 day season. Results presented here are based on these 353 unique sessions. Little Goose ranked seventh (or second lowest) in overall seasonal mean daily bird counts and seventh (or second lowest) in seasonal mean daily foraging birds (Figure 3). Bird counts peaked in early May with a smaller peak occurring in mid July (Figure 29). Mean daily bird counts reached a high of 105 on May 5.

All four behaviors (foraging, resting, fly by, and scavenging) were observed at Little Goose with foraging cataloged 82.2% of the time, resting 13.9%, flyby 3.0%, and scavenging 0.3%. Foraging peaked in early May dropping off quickly by mid May (Figure 30). A sizeable number of resting birds were observed throughout the season.

Foraging birds were distributed throughout the five counts zones but the majority focused efforts in the forebay (Figure 31). The forebay is also where the majority of resting birds were counted.

Although all of the nine monitored species made an appearance at Little Goose Dam the most abundant birds were gulls, double crested cormorants, and American white pelican. Seasonal mean gull count was 10.6 (Table 1). Double crested cormorants were found exclusively in the forebay while gulls and American white pelicans were observed in all five zones (Table 8). The other six species were observed less frequently with some, such as the bald eagle, only counted once during the season.

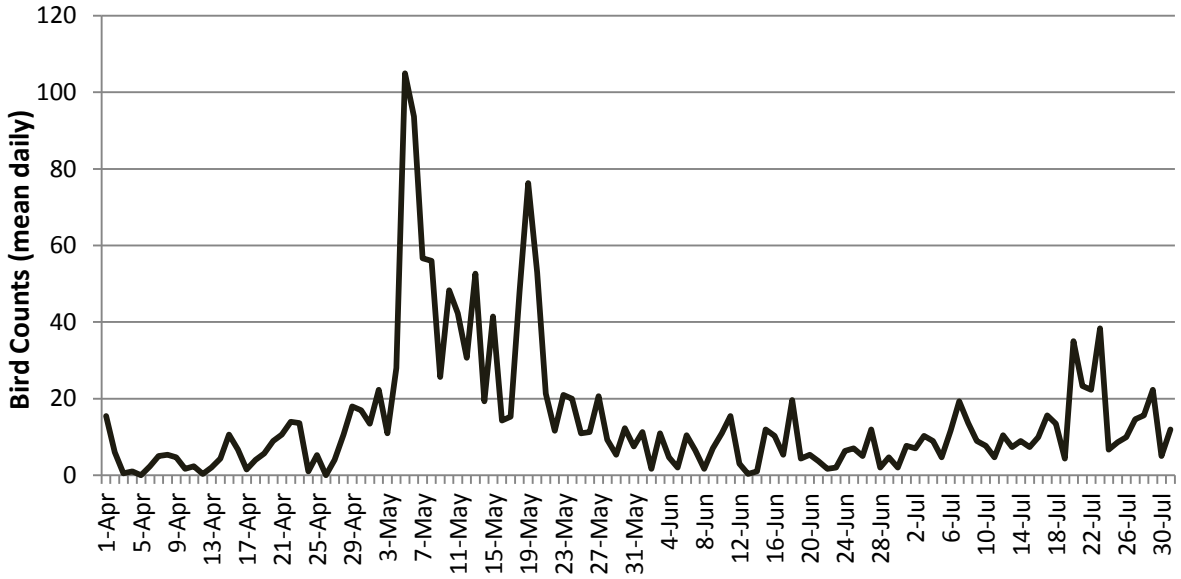

Figure 29. Mean daily bird counts for Little Goose Dam during primary smolt outmigration, April 1 through July 31, 2012.

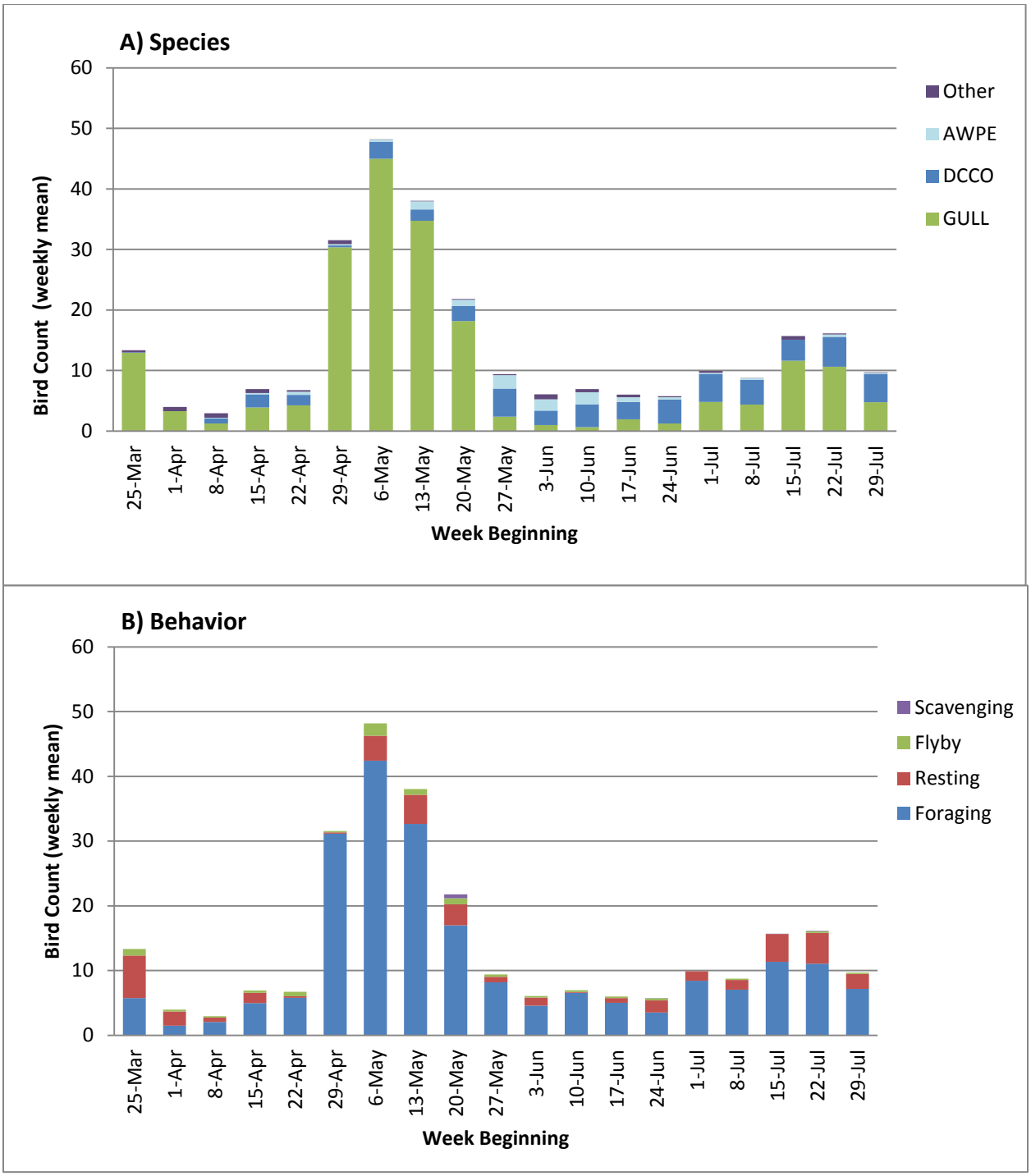

Figure 30. Timing, abundance, diversity, and behavior of nine fish eating birds at Little Goose Dam April 1 through July 31 2012. A) The most numerous species; GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, Other = remaining six monitored species. B) Behavior of the birds in graph A.

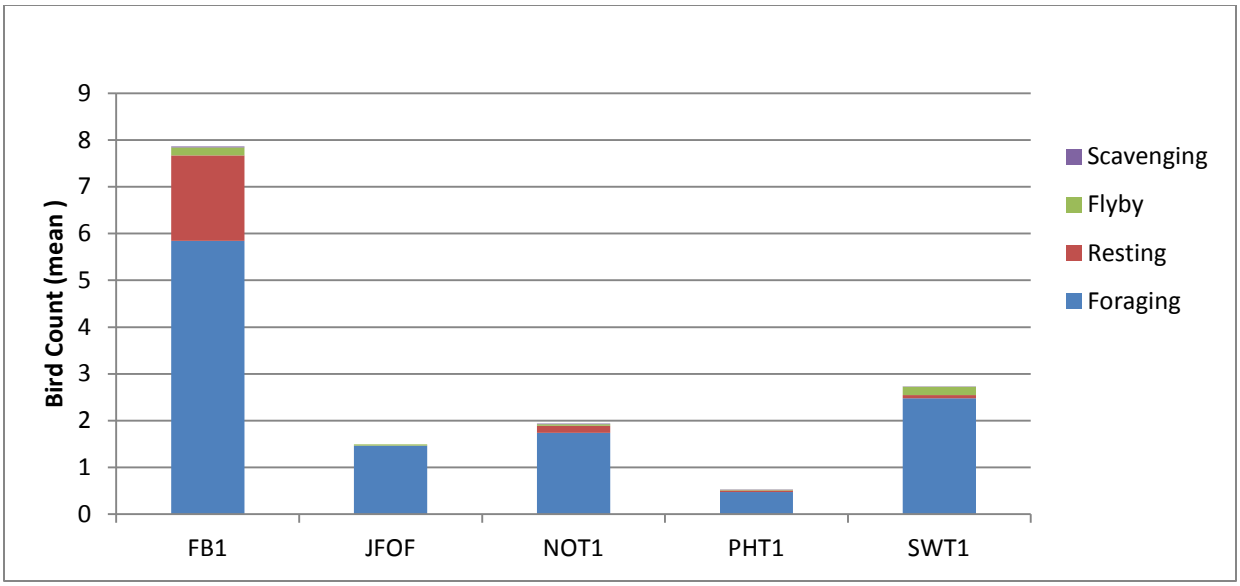

Figure 31. Spatial distribution of birds by zone and behavior at Little Goose Dam, seasonal daily mean for April 1 through July 31, 2012. FB1 = forebay, JFOF = juvenile fish outfall, NOT1 = North tailrace of earthen dam, PHT1 = powerhouse tailrace, SWT1 = spillway tailrace.

Table 8. Seasonal daily mean bird counts by zone and species at Little Goose Dam (all behaviors), April 1 through July 31, 2012.

Species	FB1	JFOF	NOT1	PHT1	SWT1
American White Pelican	**0.1**	**0.1**	**0.3**	**0.1**	**0.2**
Bald Eagle	0	0	0	0	0
Caspian Tern	**0.1**	0	0	0	0
Common Merganser	**0.1**	0	0	0	0
Double Crested Cormorant	**2.7**	0	0	0	0
Great Blue Heron	0	0	0	0	0
Grebe	0	0	0	0	0
Gull	**4.7**	**1.4**	**1.6**	**0.4**	**2.5**
Osprey	**0.1**	0	0	0	0

LOWER GRANITE

Lower Granite Dam is located at Snake River rkm 173 (river mile 107.5). The powerhouse at Lower Granite is equipped with screens that divert juvenile fish away from the turbines and through a juvenile bypass system on the south shore tailrace. The area observed at Lower Granite was divided into six count zones covering 0.31 sq km (0.12 sq miles) (Figure 32).

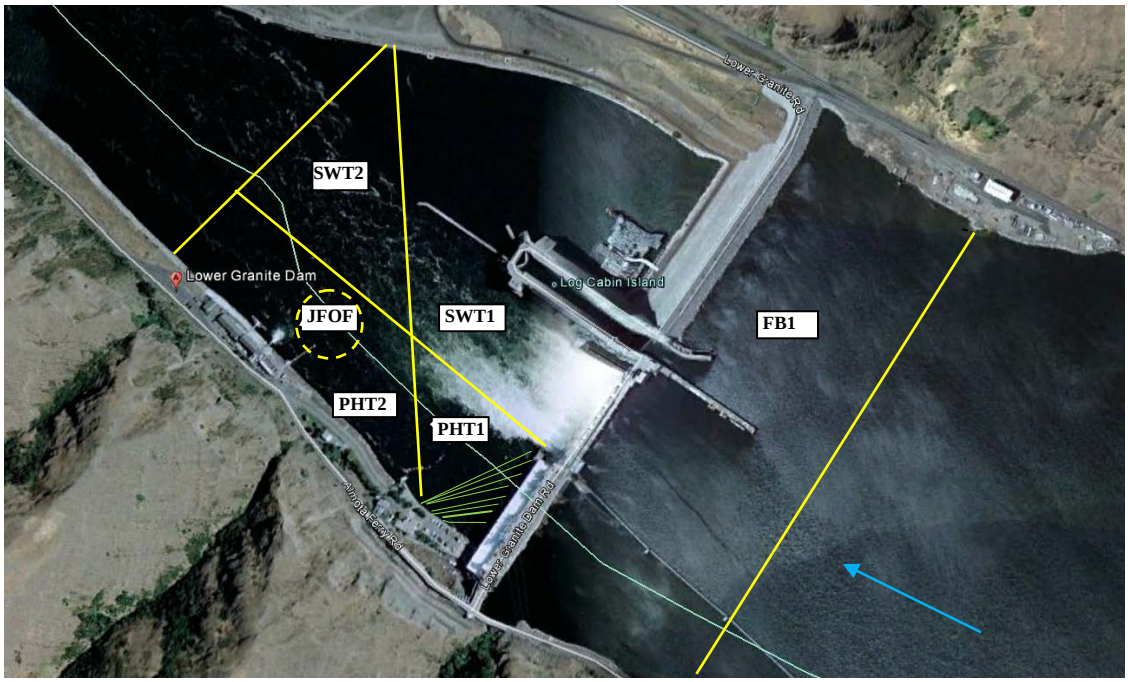

Figure 32. Zone map of Lower Granite Dam used in the 2012 season. Yellow lines delineate the zones, green lines represent avian deterrent lines (not exact number), and the blue arrow indicates flow direction.

Bird counts were collected from one to three times a day, on 77 of the 122 day season. Lower Granite ranked eighth in seasonal mean bird count, at 11.3, and had the lowest foraging count of the eight projects (Table 1). Mean daily bird counts increased in mid May peaking at 63 on June 19 (Figure 33). Counts steadily decreased through June and remained low through July.

Three of the four behaviors were observed at Lower Granite with foraging being the most prominent behavior. Foraging represented 93.3% of the behaviors displayed at Lower Granite, resting was cataloged 0.4% of the time, and flyby 6.3%. Foraging gull numbers increased through May and peaked in June before dropping off sharply by July while foraging American white pelicans appeared in June and remained through July (Figure 34). No scavenging was observed.

Bird activity over the season was minimal in all zones in comparison to other Projects; birds were typically the most active over the spillway (SWT2). It should be noted that the forebay zone FB1 was not counted regularly and is included in only 32% (25 of 77) of the daily counts. This may explain why a sparse amount of resting behavior was recorded as resting behavior is

often the observed behavior when birds are seen in forebays. When piscivorous birds were within the monitored area, they were foraging mostly in the spillway tailrace zone 2, and only occasionally resting (Figure 35).

Eight of the nine monitored birds were sighted at Lower Granite dam, bald eagles being the exception. American white pelicans and then gulls were the most prominent. Four other birds, Caspian terns, common mergansers, grebes, and osprey had maximum counts of only one individual (Table 9). Maximum count of American white pelicans was 88, highest daily mean was 44.5. For gulls these values were 25 and 24.5 respectively.

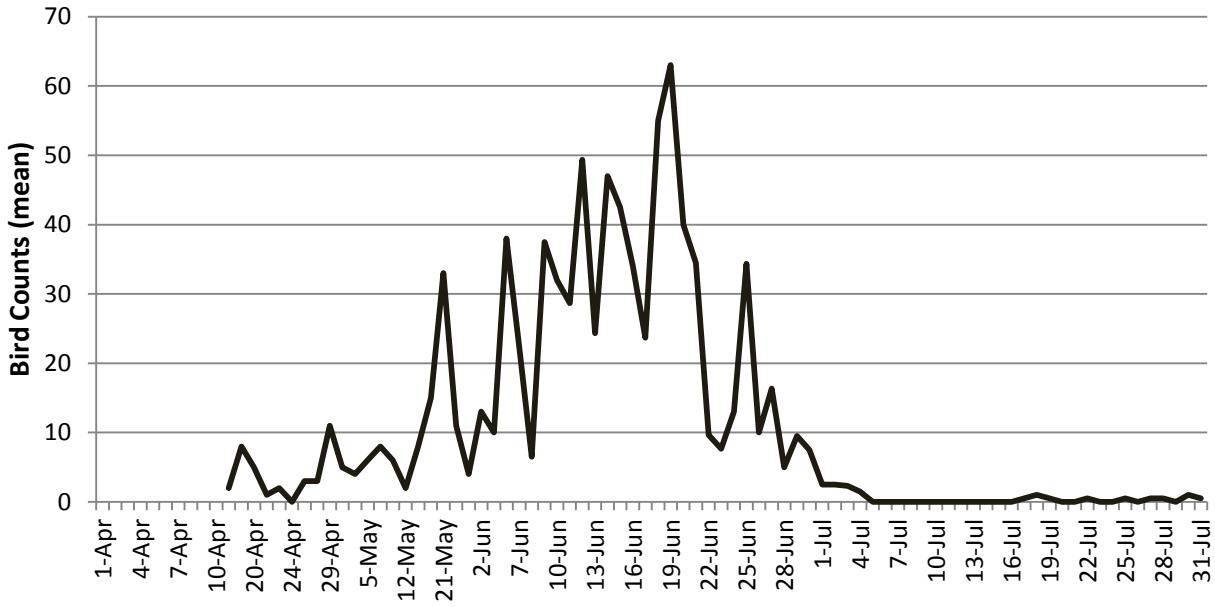

Figure 33. Mean daily bird counts at Lower Granite Dam during primary smolt outmigration, April 11 through July 31, 2012.

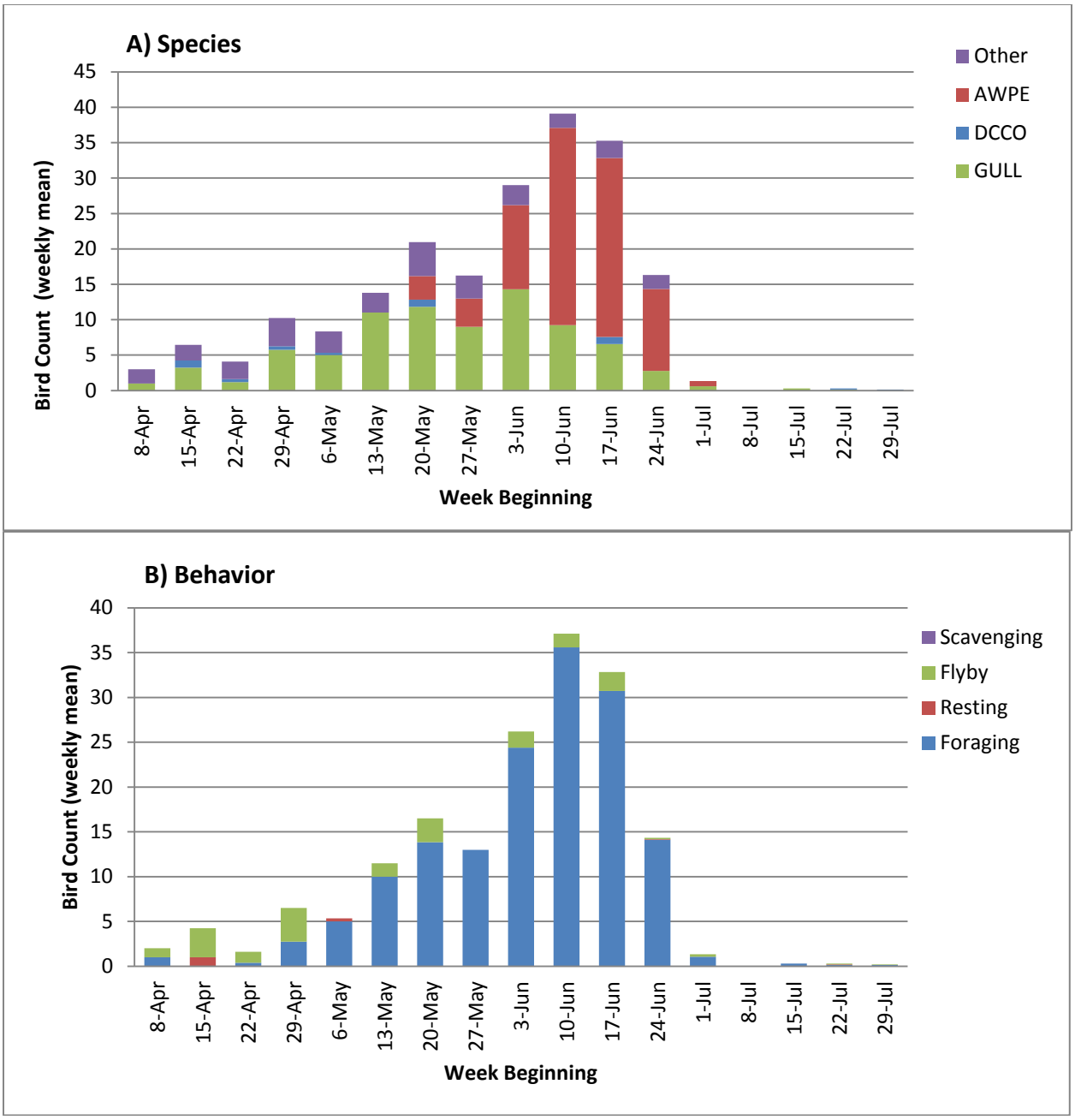

Figure 34. Timing, abundance, diversity, and behavior of nine fish eating birds at Lower Granite Dam April 11 through July 31, 2012. A) The most numerous species; GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, CATE = Caspian tern. B) Behavior of the birds in graph A.

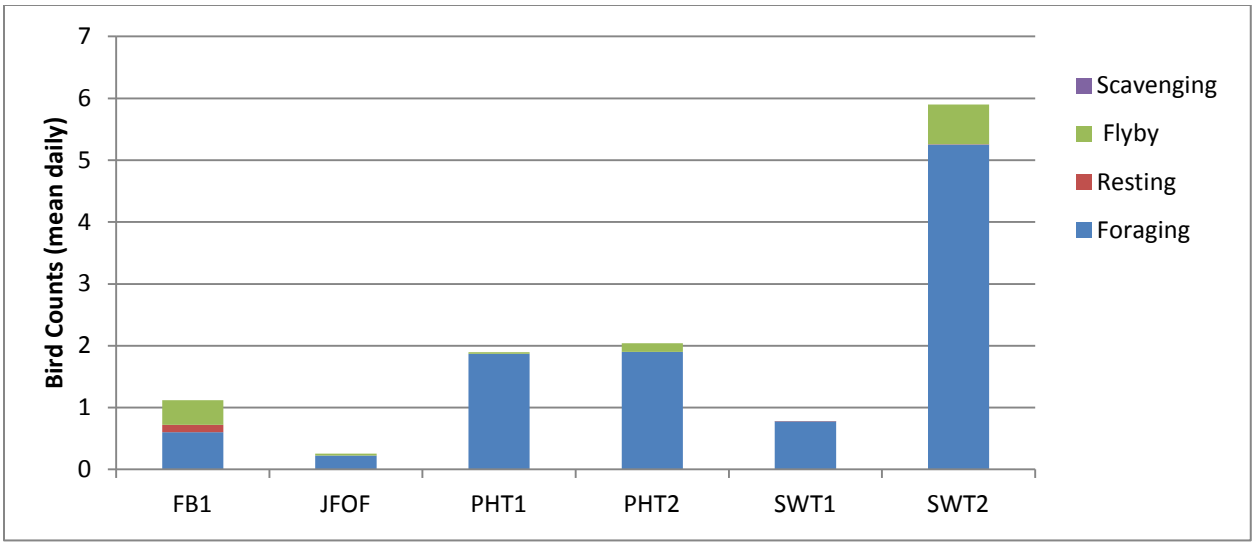

Figure 35. Spatial distribution of birds by zone and behavior at Lower Granite Dam, seasonal daily mean for April 11 through July 31, 2012. FB1 = forebay, JFOF = juvenile fish outfall, PHT1 & 2 = powerhouse tailrace zones, SWT1 & 2 = spillway tailrace zones.

Table 9. Seasonal daily mean bird counts by zone and species at Lower Granite Dam (all behaviors), April 11 through July 31, 2012.

Species	FB1	JFOF	PHT1	PHT2	SWT1	SWT2
American White Pelican	0.2	<0.1	**1.4**	**1.5**	0.2	**3.7**
Bald Eagle	0	0	0	0	0	0
Caspian Tern	0	0	0	<0.1	0	0
Common Merganser	0	0	0	0	0	0
Double Crested Cormorant	0.4	0	0	<0.1	0	<0.1
Great Blue Heron	0	0	<0.1	0	0	<0.1
Grebe	0	0	0	0	0	0
Gull	0.5	0.2	0.5	0.5	0.6	**2.2**
Osprey	<0.1	0	0	0	0	0

DISCUSSION

During the spring salmonid outmigration period, McNary and The Dalles dams consistently had the greatest number of foraging birds. However, unexpectedly many of the highest observed point counts were from birds resting at dams during the winter. Consideration should be given to increasing both passive and active hazing at McNary and The Dalles dams. Monitoring of piscivorous birds at each dam must be maintained to continue ongoing evaluation of trends including identification of any potential predation hotspots.

When comparing all projects, McNary and The Dalles dams consistently had the highest number of foraging birds (primarily gulls). While no gull tracking studies have been done to date within this area, this is likely explained by the close proximity of these dams to gull colonies at Miller Island Rocks and the Blalock Islands complex. The Miller Island Rocks colony has been identified through recovered PIT tags as a colony historically focused on salmonids more so than other gull colonies (Roby-BRNW 2011). Previous monitoring showed that prior to boat hazing and installation of a large avian deterrent line array in early 2010, John Day Dam had as many or more foraging birds (Zorich et al. 2012). The lack of foraging birds at Bonneville dam could be explained by the less than complete monitoring effort there, its location, or the configuration of the tailrace. There are currently no known nesting colonies of water birds in the Bonneville pool. Looking downstream, colonies are not encountered until the estuary (Roby & Collis et al. 2011). The closest upstream colony is at Miller Island Rocks above The Dalles Dam. The configuration of Bonneville's tailrace is such that islands divide the spillway from each powerhouse tailrace. This may increase the effectiveness of shore base hazers working here to dissuade birds using starter pistols and screamer or cracker shells. The hazers are simply closer to the foraging areas, especially when compared to The Dalles and McNary Dams or the boat based hazers working in the tailrace of John Day Dam. Similar to Bonneville Dam, Lower Monumental, Little Goose and Lower Granite dams are relatively distant from any large nesting colonies of piscivorous birds. However, many of the bird species of concern utilize areas within the lower Snake River as resting areas.

Dams may provide important winter refuge for some fish eating bird species. During the winter, outside the smolt outmigration window, abundance of gulls, double crested cormorants and common mergansers occasionally increased dramatically. For example, maximum single counts for the 2012 calendar year were: gulls = 1,355 on November 8, 2012 at John Day Dam, double crested cormorants = 389 on December 12, 2012 on Eagle Island near Ice Harbor Dam, and common mergansers = 126 on November 16, 2012 at The Dalles Dam. The gulls at John Day Dam were identified from pictures to be ring-billed gulls (*Larus delawarensis*) which nest nearby on Miller Island Rocks in the summer but were not seen foraging at the dam. During recent gut content studies gulls at John Day Dam, of the 428 gulls collected during the summer using shotguns, 426 were identified as California gulls, one was likely a Western Gull or Western Glaucus-winged hybrid, and the other was a ring-billed gull flushed from a nearby island (Zorich et al. 2010 and 2011). These birds were mostly resting and, when foraging, may

have been targeting juvenile shad in the river at that time. For example, Oregon State University conducted a diet analysis study of overwintering double crested cormorants at Little Goose and Lower Granite dams which indicated that shad was an abundant food source for these birds and juvenile salmonids comprised a very small portion of their diet (Roby-BRNW 2011).

This program of standardizing piscivorous bird monitoring at eight USACE dams has great value to the region, although more work still needs to be accomplished. Consideration should be given to increasing deterrent efforts at The Dalles and McNary dams. These actions could include hazing from a boat downstream of the spillway during the two-month peak of fish outmigration, or adding avian lines covering the spillway tailrace, to help protect fish there. Also, seeking out alternative deterrent methods is essential in the planning of appropriate management actions. Bird deterrents have been used for several years in a variety of occupational fields from crop protection, protecting human health and welfare, and at airports to avoid planes striking birds. For example, Technology International Inc., of Louisiana has begun trials using infrasound, low frequency sound below human hearing, to deter birds from airports. These and similar technologies could greatly reduce our costly long-term dependence on hazing using pyrotechnics. However, they would require evaluation to ensure they do not adversely impact salmonids.

Finally, continuing the standardized avian monitoring program is necessary to determine if increasing deterrent efforts at one dam help to reduce piscivorous bird abundance at the dam, and/or whether it simply moves the problem from one place to another. With continued project participation and effort over time this program will have the ability to detect long term trends in bird abundance, and it has already proven useful for in-season detection of hot spots.

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APPENDICES

APPENDIX A. AVIAN OBSERVER PROTOCOL

Bird counts were collected in accordance with the following protocol:

1. Perform counts at least once a day and in every zone if possible. Record counts by behavior category: foraging, resting, flyby, or scavenging. Every zone should have a data point so in the **Species** field record "No Birds" if no fish eating birds are in that zone. Once the survey is complete enter the data into the database that day.

2. For each survey be sure to enter the following header information:
   Project: Name without Dam suffix.
   Observer: first and last name (for example "Nathan Zorich")
   Date: the date of the scan.
   Hazer: record "Y" if present on project or "N" if not. We might refine this later, such as "Hazer in Zone? Y/N". Depends on how important people feel that is. If a hazer is on project they are likely impacting all zones. Boat or shore hazing can be reported in the Notes.
   Spill: record "Y" if spilling or "N" if not
   Surface Passage: If your project has an RSW, TSW, corner collector, ice/trash sluice way etc. that pulls water from the surface (compared to deeper tainter gate releases), "Y" if it is open, "N" if it is closed, "NA" if this is Not Applicable to your project.
   Juvenile System: (On/Off) Is your juvenile bypass system or other juvenile collection system *diverting fish from the river*?
   Juveniles to outfall? (Y/N) Are smolt going back to the river near the project? This may act to attract birds. Includes both SbC operations and primary/secondary return to river operations.
   Juveniles to transport? (Y/N) Are smolt collected by the JBS routed to a raceway, barge, or truck? These smolt not available for birds.

3. For each zone be sure to enter the following information:
   Time: time the count was made in that zone.
   Zone: the zone code (see code list on project maps)

4. We are monitoring specifically for nine fish eating birds (see species codes below or datasheet). If they are not present then, "No Birds" should be recorded as species along with zeros under behavior counts– zeros are data too! It is just as important to know when there are no birds at our projects as it is to know when there are.

   Species: species of bird observed, focusing on the nine most common fish eaters (see species list at end). If not on the list you can use "Other" and then give the species or common name in the **Notes** field. "No Birds" also accepted here when no piscivorous birds are seen and counts should be zero.

5. **Behaviors** fall into four general categories: Foraging, Resting, Scavenging, or just Flying by. Animals display an amazing variety of behavior. Below are some general guidelines to help you decide.

BEHAVIORS COMMON TO ALL BIRD SPECIES:

Flyby: number in transit through the project area. Not stopping to forage. The bird is flying from point 'A' to point 'Z' not searching for food. Typically but not exclusively, these birds are flying at a higher elevation than foraging birds.

Scavenging: opportunistic feeding (e.g. carcasses, sea lion or fisherman scraps).
Will be the same for all species, the key is that the bird is feeding on something that is dead. We've seen this below fishing platforms.

SPECIES SPECIFIC BEHAVIOR:

American White Pelican **(AWPE)**
Foraging: They feed using a subtle dip of their large bill. So if they are floating on water, it is assumed they are foraging.
Resting: Sitting on an island, land, or structure.

Bald Eagle **(BAEA)**
Foraging: Flying in circular searching pattern and/or striking water surface with talons for fish.
Resting: Perched on tree, transmission tower, or shore.

Caspian Tern **(CATE)**
Foraging: Flying in circular searching pattern and/or diving head first for fish.
Resting: Floating or perched on shore or structure.

Common Merganser **(COME)**
Foraging: Diving underwater from surface.
Resting: Floating, head on back, not diving.

Double Crested Cormorant **(DCCO)**
Foraging: Diving underwater from surface.
Resting: Perched on shore or structure.

Great Blue Heron **(GBHE)**
Foraging: Standing within striking distance of water.
Resting: Standing on shore or structure away from water.

Grebe – Western or Clark's **(GREBE)**
Foraging: Diving underwater from surface.
Resting: Floating, especially floating with head on back. Not diving.

Gull – all species **(GULL)**
Foraging: Flying in circular searching pattern often close to water surface and/or diving head first for fish.
Resting: Floating or perched on shore or structure.

Osprey **(OSPR)**
Foraging: Flying in circular searching pattern and/or striking water surface with talons for fish. Carrying a fish in talons
Resting: Perched on tree, transmission tower, or nest box.

Notes: Use as needed. Specific info on location (i.e. log boom, tower) or to describe "OTHER" species such as "Common Loon", "Red-breasted Merganser". These abbreviations are from Institute for Bird Populations: http://www.birdpop.org/alphacodes.htm

APPENDIX B. AVIAN OBSERVER DATA SHEET

FCRPS Piscivorous Bird Count Data Sheet - USACE

Project:_____ **Observer :** _____ **Date:**_____

(First & Last name) **Sheet** __ **of** ___

Circle One

Spill:	ON	OFF	Juvenile System:		ON	OFF
Surface Passage:	ON	OFF				
Hazer on Project:	YES	NO	If on:	To Outfall	Transport	

Zone	Time (24hr)	Species	Counts by Behavior				Notes
			Foraging	Resting	Fly By	Scavenging	

Zones: See Zone map for each project's codes or print on backside of this sheet

In general PH = Powerhouse, SW=Spillway, T = tailrace, FB = forebay

Abbreviations from birdpop.org/alphacodes.htm

No fish eating birds	NB	Caspian Tern	CATE	Great Blue Heron	GBHE
Any Gulls	GULL	Double Crested Cormorant	DCCO	Bald Eagle	BAEA
Western and/or		Common Merganser	COME	Osprey	OSPR
Clark's Grebes	GREBE	Am. White Pelican	AWPE	Other	OTHER

APPENDIX C. YEARLY BIRD COUNTS

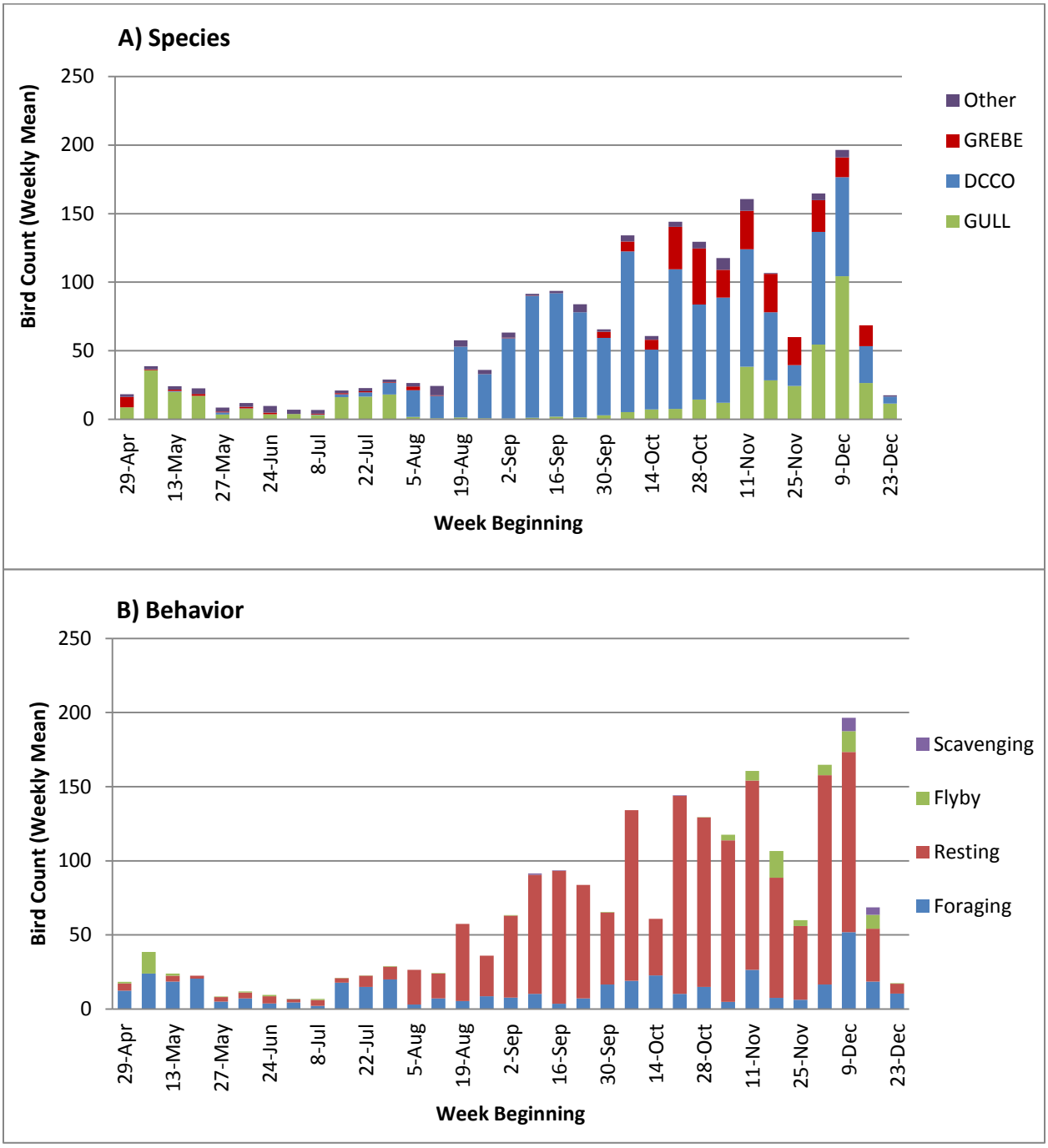

Figure C-1. Timing, abundance, diversity, and behavior of nine fish eating birds at Bonneville Dam in 2012. The three most numerous species. GULL = any gull species, DCCO = double crested cormorant, GREBE = western or Clark's grebes, Other = remaining six monitored species. B) Behavior of the birds in graph A.

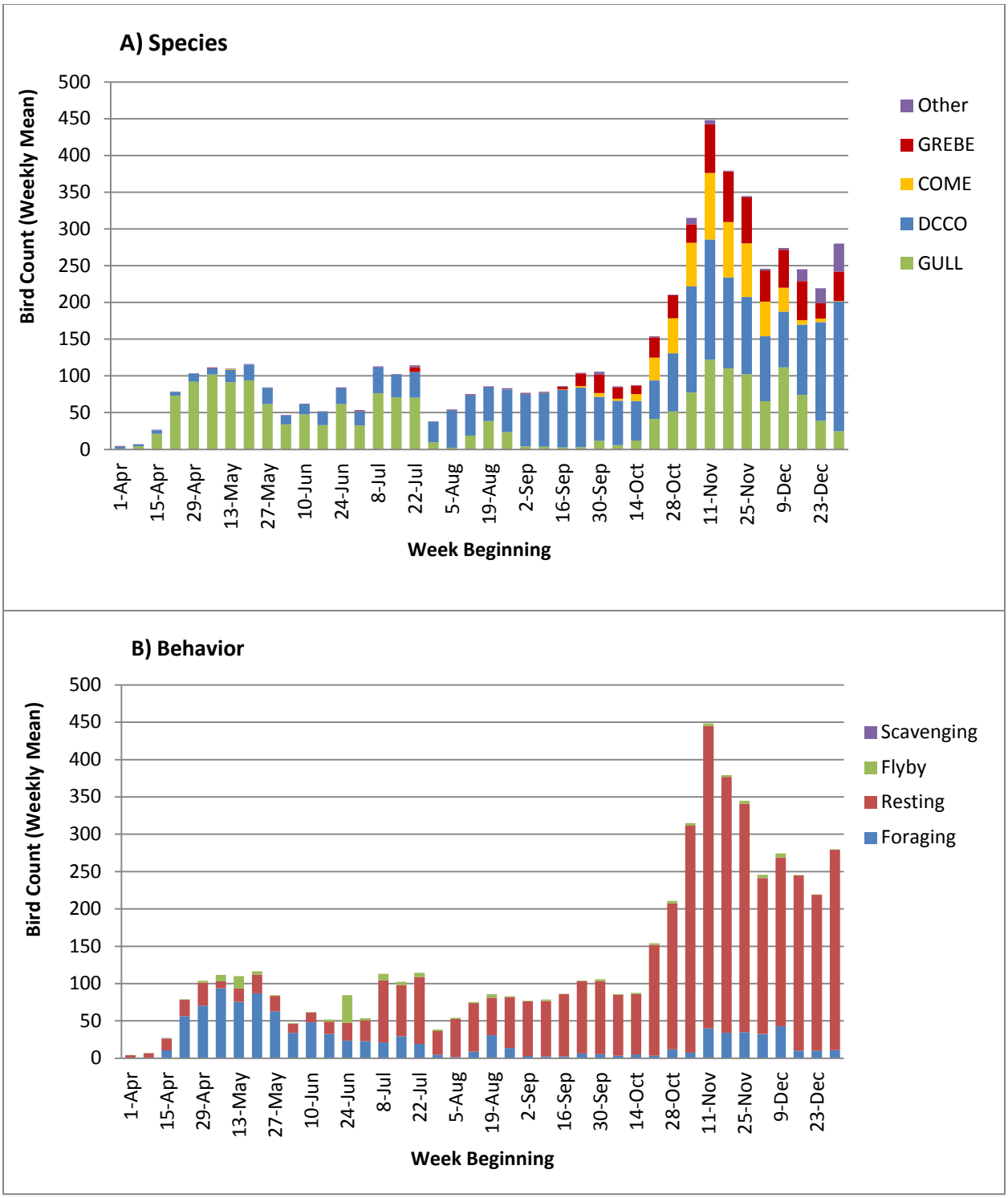

Figure C-2. Timing, abundance, diversity, and behavior of nine fish eating birds at The Dalles Dam in 2012. A) The four most numerous species. GULL = any gull species, DCCO = double crested cormorant, COME = common merganser, GREBE = western or Clark's grebes, Other = remaining five monitored species. B) Behavior of the birds in graph A.

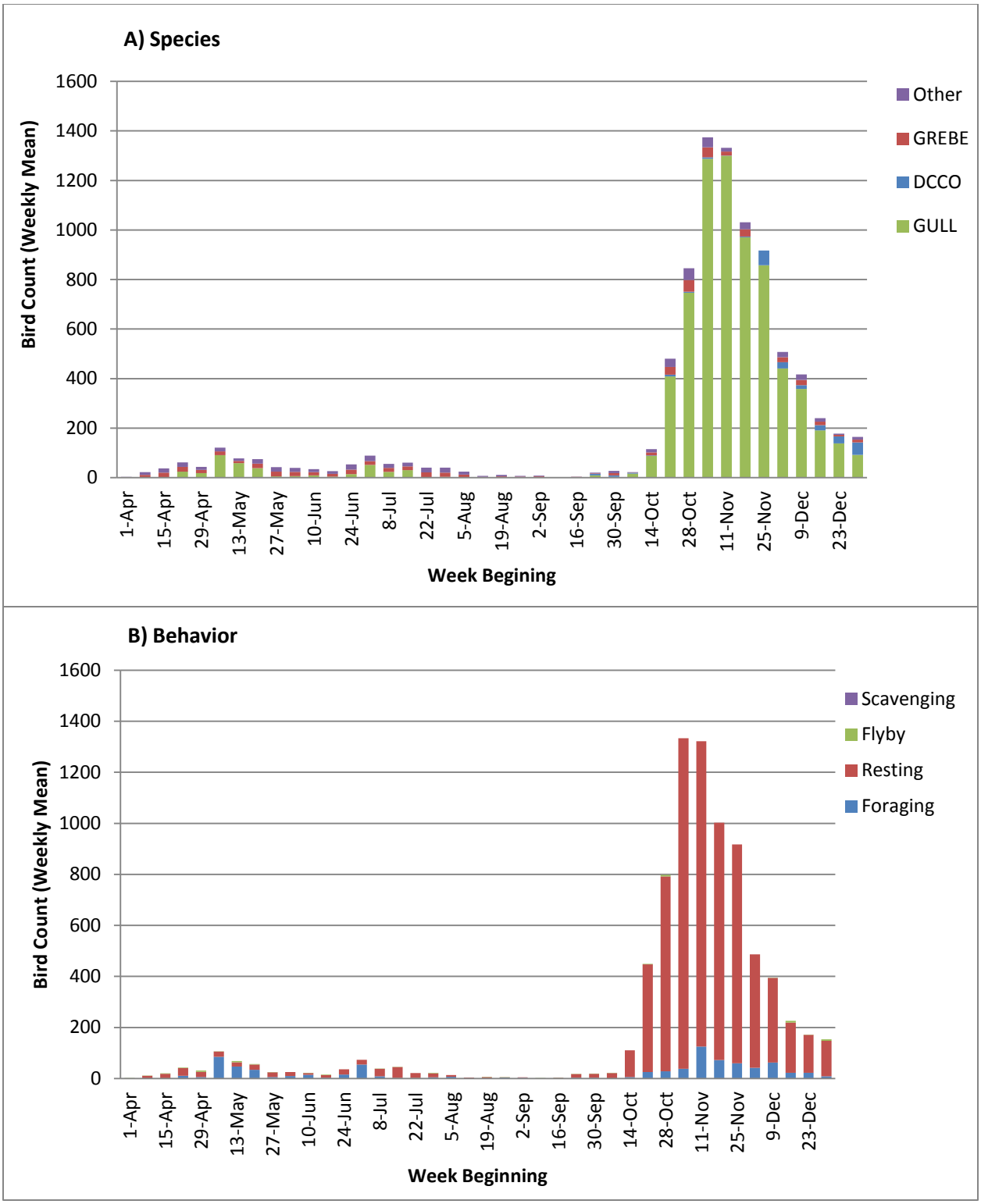

Figure C-3. Timing, abundance, diversity, and behavior of nine fish eating birds at John Day Dam in 2012. A) The four most numerous species. GULL = any gull species, DCCO = double crested cormorants, GREBE = western or Clark's grebes, Other = remaining six monitored species. B) Behavior of the birds in graph A.

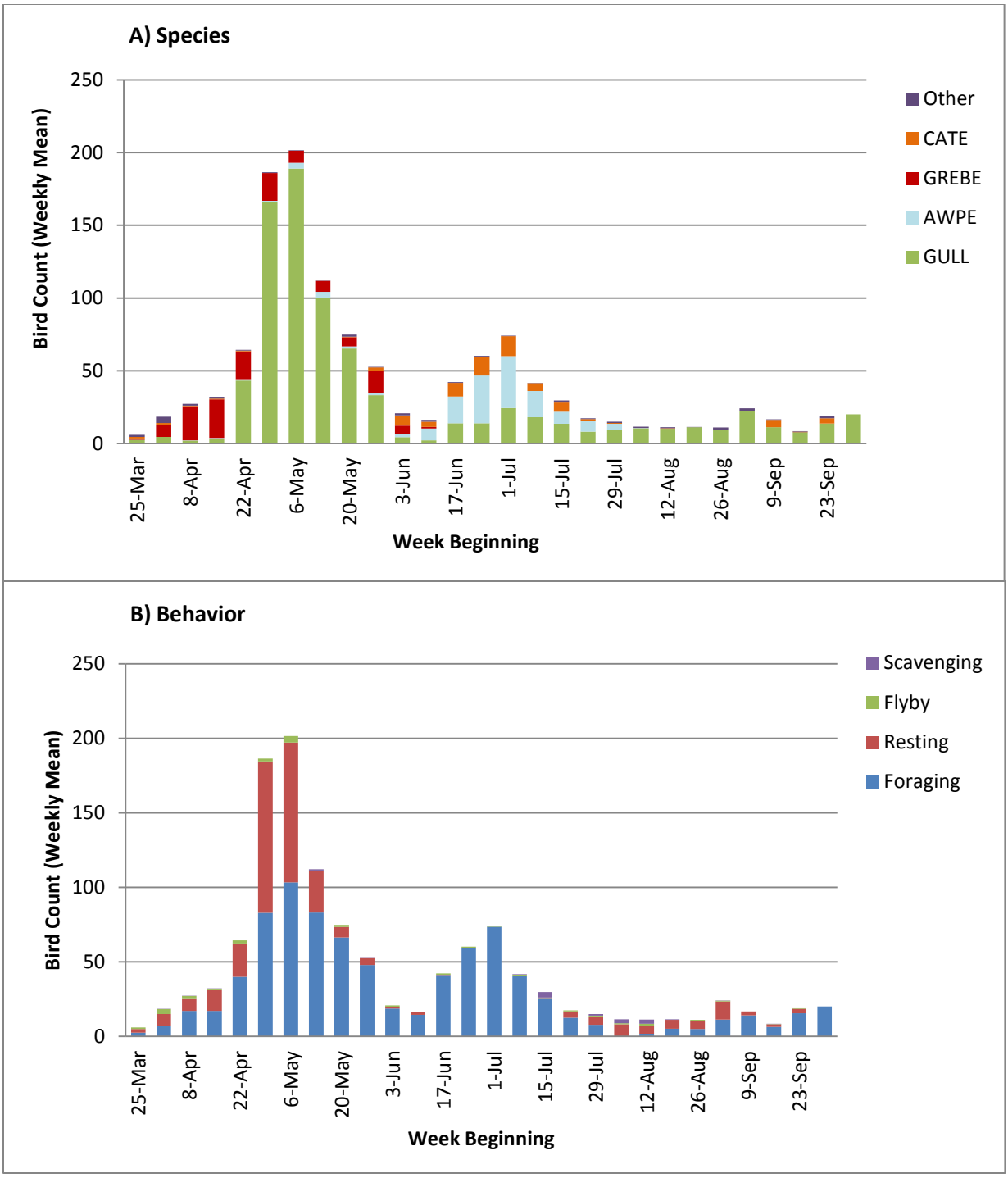

Figure C-4. Timing, abundance, diversity, and behavior of nine fish eating birds at McNary Dam in 2012. A) The four most numerous species. GULL = any gull species, AWPE = American white pelican, GREBE = western or Clark's grebes, CATE = Caspian terns, Other = remaining five monitored species. B) Behavior of the birds in graph A.

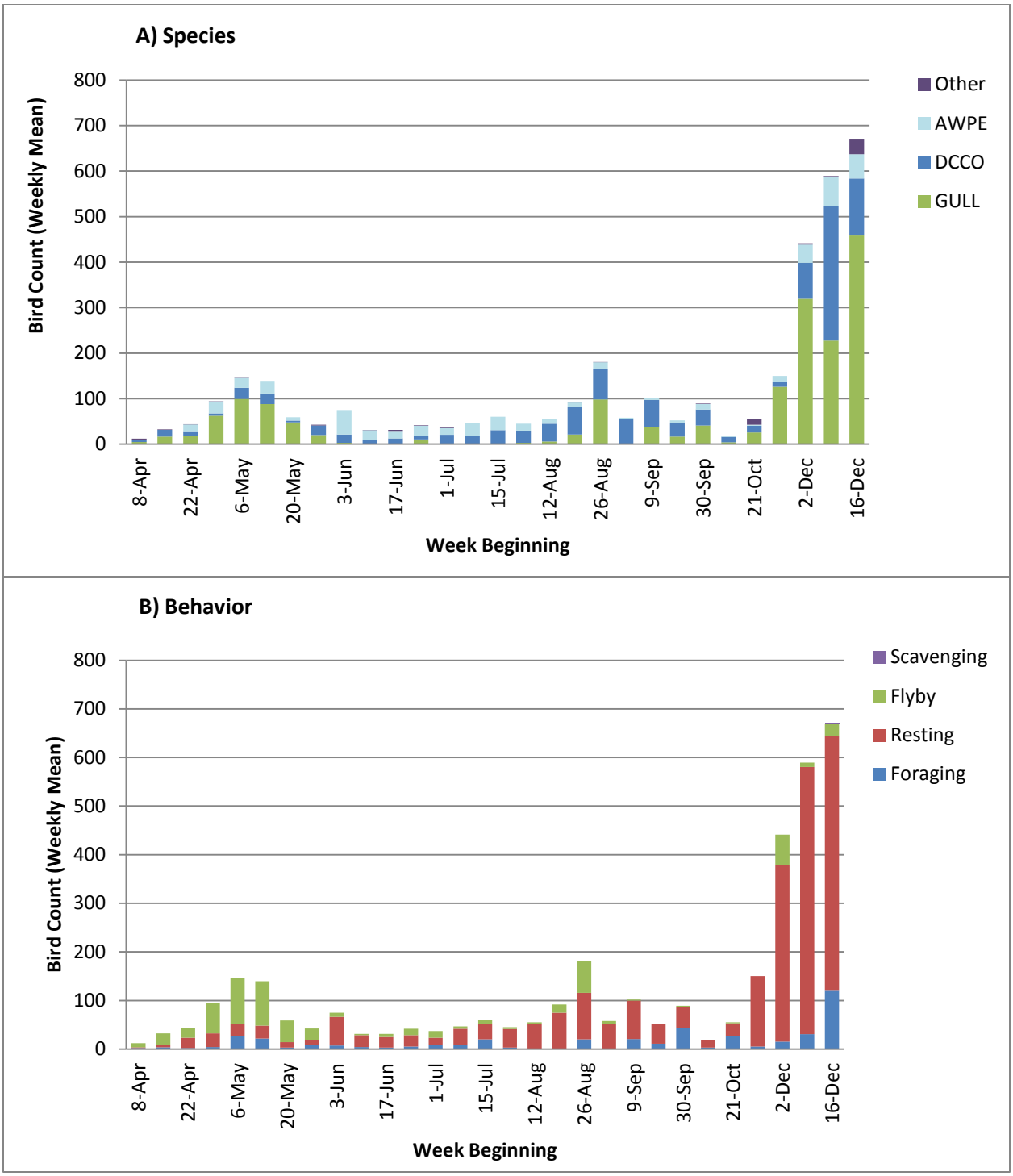

Figure C-5. Timing, abundance, diversity, and behavior of nine fish eating birds at Ice Harbor Dam in 2012. A) The three most numerous species. GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, Other = remaining six monitored species. B) Behavior of the birds in graph A.

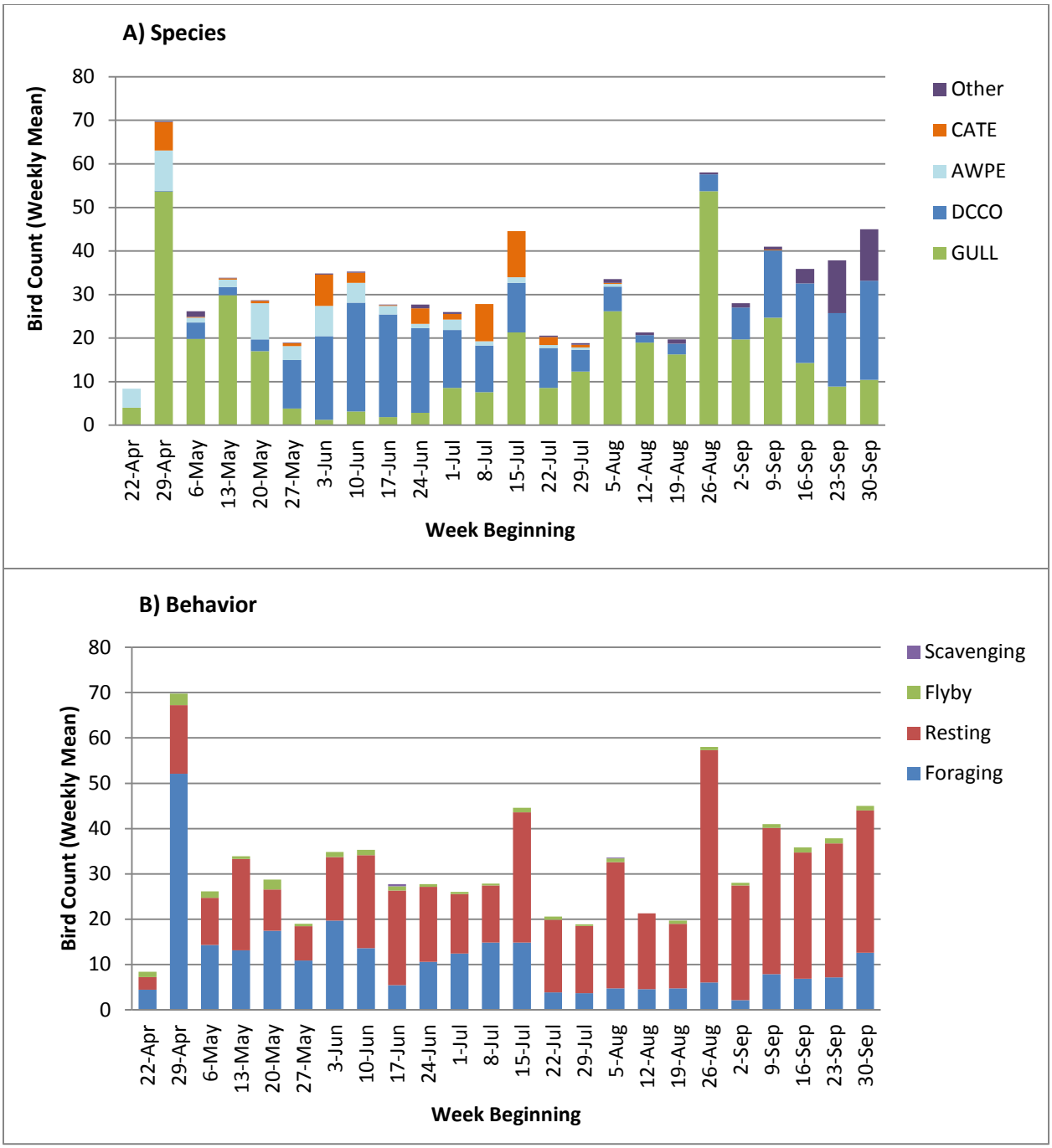

Figure C-6. Timing, abundance, diversity, and behavior of nine fish eating birds at Lower Monumental Dam in 2012. A) The four most numerous species. GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, CATE = Caspian tern, Other = remaining five monitored species. B) Behavior of the birds in graph A.

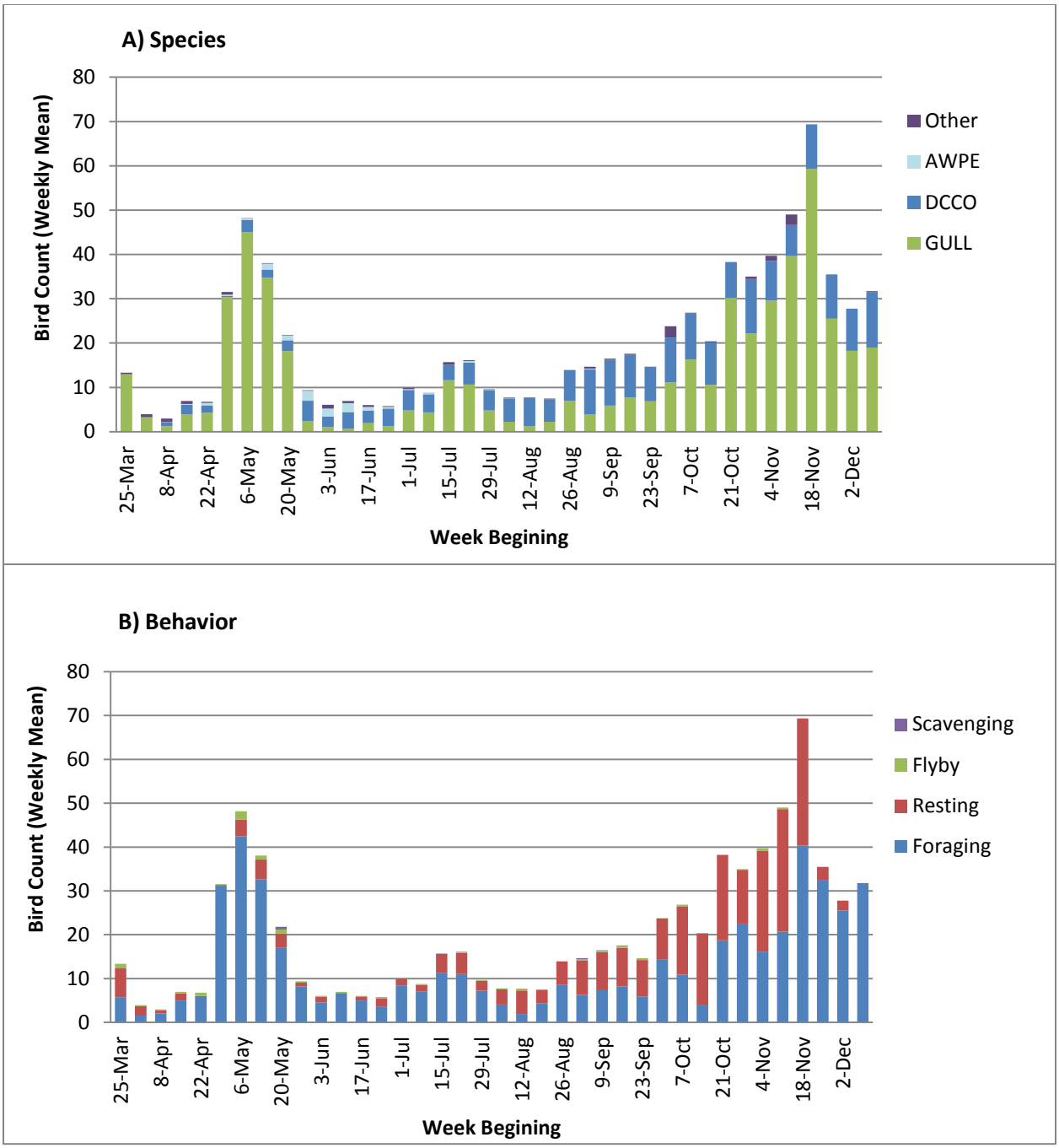

Figure C-7. Timing, abundance, diversity, and behavior of nine fish eating birds at Little Goose Dam in 2012. A) The three most numerous species. GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, Other = remaining six monitored species. B) Behavior of the birds in graph A.

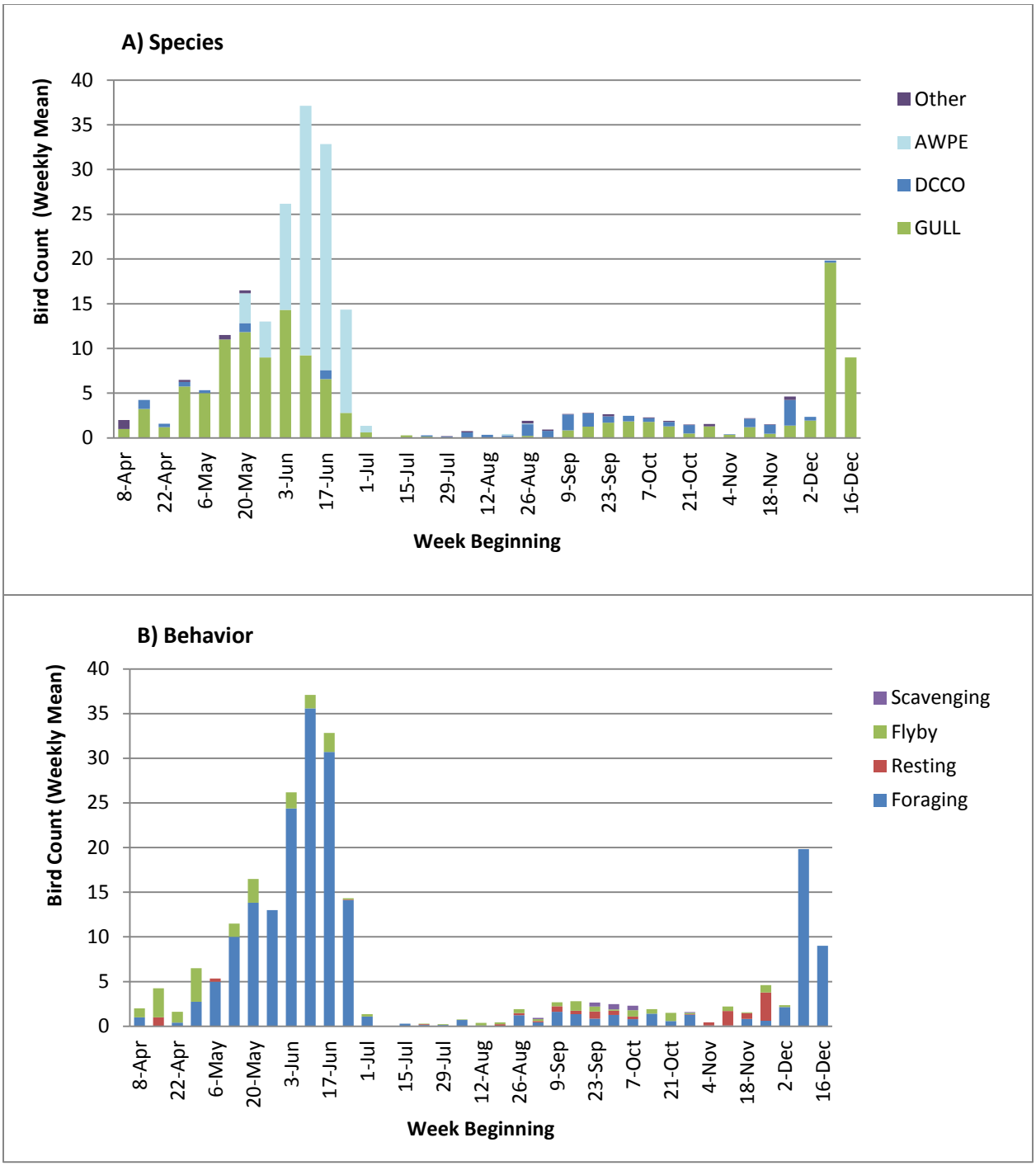

Figure C-8. Timing, abundance, diversity, and behavior of nine fish eating birds at Lower Granite Dam in 2012. A) The three most numerous species; GULL = any gull species, DCCO = double crested cormorant, AWPE = American white pelican, Other = remaining six monitored species. B) Behavior of the birds in graph A.