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IMPORTANCE OF MIGRATING SALMON SMOLT IN RING-BILLED (*LARUS DELAWARENSIS*) AND CALIFORNIA GULL (*L. CALIFORNICUS*) DIETS NEAR PRIEST RAPIDS DAM, WASHINGTON

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and Christi A. Yoder¹

ABSTRACT.—Ring-billed (*Larus delawarensis*) and California Gulls (*L. californicus*) have been implicated in depredations on migrating salmon smolt in the Columbia River. As part of a gull management program conducted in 1995 and 1996, we collected *L. delawarensis* ($n = 120$) and *L. californicus* ($n = 45$) near Priest Rapids Dam, Washington, and analyzed stomach contents to determine food habits and thus the importance of fish in gull diets. Percent volume measurements and index of relative importance rankings suggested a greater reliance on fish by *L. californicus* than by *L. delawarensis*. Peak percent consumption of fish by both species occurred in May, coinciding with peak salmon out-migration through Priest Rapids Dam; and for both species number of fish consumed by gulls was higher below Priest Rapids Dam. Gulls collected prior to, and after, peak smolt migration indicated low importance rankings for fish in both *L. delawarensis* and *L. californicus* diets. However, the importance ranking of fish in gull diets changed over time and was higher for both species as the smolt migration peaked in May.

Key words: *California Gull*, *Columbia River*, *dams*, *diet*, *Larus delawarensis*, *Larus californicus*, *Ring-billed Gull*, *salmon migration*, *salmon smolt*.

The Columbia River was once known for having some of the world's largest runs of anadromous salmon. Fish runs that historically numbered 10–16 million have been severely reduced (Groen 1992). These decreases in salmon have been attributed to a number of factors including overfishing at sea and on the river, development, dams, fish disease, and predation by fish and birds; but the impact of each of these factors, especially losses to birds such as gulls, is not well documented (Ruggerone 1986).

Salmon smolt migration begins around early April from upper portions of the Columbia River, and numbers peak at Priest Rapids Dam from late April through May. The timing of this migration corresponds with the initiation of Ring-billed (*Larus delawarensis*) and California Gull (*L. californicus*) nesting on Columbia River islands. Cabin Island, located 1.5 km upstream of Priest Rapids Dam, had an estimated breeding population of 7000 *L. delawarensis* and 200 *L. californicus*. In addition, an aerial survey conducted June 1995 along the Columbia River from Chief Joseph Dam south to the Dalles Dam (9 dams and 310 km of river) found that gulls occupied 17

Columbia River islands. Gull populations on 5 of the 17 islands were estimated at 35,000 breeding adults (C. Yoder 1995 unpublished data).

Ruggerone (1986) reported juvenile salmonids being vulnerable to avian predation immediately below Columbia River dams because of the disorienting and stunning effect of passing through a turbine and currents carrying fish close to the surface. His data indicated *L. delawarensis* consumed approximately 120,000 migrating juvenile salmonids during a 25-d smolt-migration period at Wanapum Dam (approximately 24 km upstream of Priest Rapids Dam), representing 2% of the total hatchery-reared and wild salmon spring out-migration. It has been estimated that 17% of migrants are killed by dam turbines independent of gull predation (McKenzie et al. 1984, Ruggerone 1986).

We collected *L. delawarensis* and *L. californicus* during the peak of salmon smolt migration at Priest Rapids Dam, Desert Aire, Washington, and at the nesting colony on Cabin Island. Cabin Island is 30 ha with approximately 4 ha used by *L. delawarensis* and *L. californicus* as a loafing/nesting area. Collections

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were made to quantify the relative importance of salmon smolt in the diet of these 2 gull species during salmon smolt migration.

METHODS

We collected gulls on 19 April, 5 May, and 13 June 1995 from the breeding colony on Cabin Island and on 7 and 21 May 1996 below Priest Rapids Dam. We categorized sample dates according to nesting stage: 19 April, prenesting; 5–25 May, nesting; and 13 June, postnesting. Gulls were frozen within 4 h of collection. In the laboratory each carcass was weighed to the nearest 0.1 kg and aged as adult or juvenile according to plumage characteristics. We removed the stomach-esophageal contents from each gull and placed them in isopropyl alcohol.

Stomach-esophageal contents were flushed onto a 40-gauge wire screen. Contents were washed with water to remove mucus and to separate food items, and then drained. Total

volume of each food category per sample was measured to the nearest 0.5 mL by water displacement in a 100-mL graduated cylinder. For each sample we recorded total number of individuals, volume of each category (i.e., fish, grain, insect, mammal, earthworm, herbaceous plant matter, and miscellaneous debris), collection site, and collection date (Jarvis and Southern 1976). We used the index of relative importance (IRI) to create tables indicating relative importance of various food items (Pinkas et al. 1971), which reduced biases introduced by numerous small or a few very large items occurring in only 1 or a few stomachs (Duffy and Jackson 1986).

RESULTS

Cabin Island Samples

Larus delawarensis ($n = 77$) and *L. californicus* ($n = 22$) stomach contents indicated diet varied as the breeding season progressed, with herbaceous plant matter consistently ranking

TABLE 1. Percent frequency^a (F) and volume in mL (V) of most common food items in Ring-billed (*Larus delawarensis*) and California Gull (*L. californicus*) stomachs collected on Cabin Island, Washington, 1995.

Sample dates No. individuals	19 April 1995 $n^{RB} = 16, n^{CG} = 4$		5 May 1995 $n^{RB} = 18, n^{CG} = 5$		25 May 1995 $n^{RB} = 22, n^{CG} = 13$		13 June 1995 ^b $n^{RB} = 21$	
	F	V	F	V	F	V	F	V
Fish								
RB	0	0	22	4	5	t ^c	0	0
CG	25	t	2	13	31	54		
Grain								
RB	6	t	6	t	14	13	29	4
CG	25	0.5	0	0	0	0		
Insect								
RB	25	t	28	0.6	73	15	29	47
CG	0	0	0	0	8	t		
Mammal								
RB	6	0.5	6	49	9	45	5	0.5
CG	0	0	0	0	0	0		
Earthworm								
RB	0	0	11	6	0	0	5	0.5
CG	0	0	0	0	0	0		
Herbaceous plant matter								
RB	93	87	78	35	86	25	86	35
CG	50	82	80	41	77	44		
Miscellaneous debris ^d								
RB	81	12	72	5	23	2	57	13
CG	75	17	80	46	77	2		

^aNumber of gulls with food item divided by total sample size

^bNo California gulls collected on this date

^cTrace volumes and numbers less than 0.5 mL

^dUnidentifiable or nonfood items

^{RB}Ring-billed Gull

^{CG}California Gull

among the more important food items. Collections made on 19 April 1995 found no fish in *L. delawarensis* samples and only a trace volume in *L. californicus* (IRI = 4; Table 3). On 5 May, *L. delawarensis* samples contained small amounts of fish (4% volume, IRI = 5) as did *L. californicus* samples (13% volume, IRI = 3; Table 3). On 25 May, *L. delawarensis* samples contained only a trace volume of fish (IRI = 10), but we found a much larger amount in *L. californicus* samples (54% volume, IRI = 3; Tables 1, 3). On 13 June, *L. delawarensis* samples contained no fish (Table 1), and no *L. californicus* were present in the collection area during this time.

Priest Rapids Dam Samples

We found an increase in fish consumption from *L. delawarensis* ($n = 43$) and *L. californicus* ($n = 23$) collected below Priest Rapids Dam compared to those from Cabin Island. On 7 May 1996, *L. delawarensis* and *L. californicus* samples contained fish (26% volume,

IRI = 4 and 65% volume, IRI = 1, respectively; Tables 2, 4). On 21 May, *L. delawarensis* samples contained 41% volume of fish (IRI = 2), and *L. californicus* samples contained an even larger amount of fish (85% volume, IRI = 1; Tables 2, 4).

DISCUSSION

Percent-volume measurements and index of relative importance rankings suggest a greater reliance on the fish resource by *L. californicus* than by *L. delawarensis* for both sampling locations and all sampling dates. Peak percent consumption of fish by both species occurred in May, coinciding with peak salmon out-migration through Priest Rapids Dam. The number of fish consumed by gulls was higher below Priest Rapids Dam for both species. This result would be expected because gulls below the dam are almost exclusively feeding on fish, whereas gulls collected at Cabin Island could have recently returned

TABLE 2. Percent frequency^a (F) and volume in mL (V) of most common food items in Ring-billed (*Larus delawarensis*) and California Gull (*L. californicus*) stomachs collected below Priest Rapids Dam, Washington, 1996.

Sample dates No. individuals	7 May 1996 (nesting) $n^{RB} = 21, n^{CG} = 17$		21 May 1996 (nesting) $n^{RB} = 22, n^{CG} = 6$	
	F	V	F	V
Fish				
RB	43	26	50	41
CG	65	65	83	85
Grain				
RB	29	26	9	t ^b
CG	6	0	0	0
Insect				
RB	67	15	36	2
CG	41	2	33	t
Mammal				
RB	5	t	0	0
CG	6	0.5	0	0
Earthworm				
RB	0	0	0	0
CG	12	1	0	0
Herbaceous plant matter				
RB	81	31	59	55
CG	88	21	83	15
Miscellaneous debris ^c				
RB	33	3	23	2
CG	65	10	5	t

^aNumber of gulls with food item divided by total sample size
^bTrace volumes and numbers less than 0.5 mL.
^cUnidentifiable or nonfood items
RBRing-billed Gull
CGCalifornia Gull

TABLE 3. Index of relative importance ($IRI_i = (N + V) \times F$) on Cabin Island, Washington, 1995, of individual prey items of Ring-billed (*Larus delawarensis*) and California Gulls (*L. californicus*). Shown are importance rankings of 7 food categories and (IRI values).

Sample date	Fish	Grain	Insect	Mammal	Earthworm	Plant ^a	Miscellaneous ^b
19 Apr ^{RB}	(0)	5 (18)	3 (450)	4 (21)	(0)	1 (11346)	2 (4050)
19 Apr ^{CG}	4 (360)	3 (363)	(0)	(0)	(0)	1 (5550)	2 (4500)
5 May ^{RB}	5 (308)7	7 (18)	3 (381)	4 (312)	6 (121)	1 (6162)	2 (2736)
5 May ^{CG}	3 (48)	(0)	(0)	(0)	(0)	1 (6800)	2 (7200)
25 May ^{RB}	6 (10)	5 (280)	2 (3650)	3 (441)	(0)	1 (5676)	4 (299)
25 May ^{CG}	3 (2170)	(0)4	4 (32)	(0)	(0)1	1 (6468)2	2 (3234)
13 June ^{RB}	(522)3	4 (1769)	3 (13)	5.5 (13)	5.5 (6536)	1 (2280)	2

^aHerbaceous plant matter
^bUnidentifiable or nonfood items

CGRing-billed Gulls
 RBCalifornia Gulls

N = percentage by number of prey of type I
 V = percentage by volume of prey of type I
 F = frequency of occurrence of prey of type I

TABLE 4. Index of relative importance ($IRI_i = (N + V) \times F$) below Priest Rapids Dam, Washington, 1996, of individual prey items of Ring-billed (*Larus delawarensis*) and California Gulls (*L. californicus*). Shown are importance rankings of 7 food categories, and (IRI values).

Sample date	Fish	Grain	Insect	Mammal	Earthworm	Plant ^a	Miscellaneous ^b
7 May ^{RB}	4 (849)	3 (1073)	2 (2747)	(0)	(0)	1 (5103)	5 (594)
7 May ^{CG}	1 (5720)	6 (12)	4 (697)	7 (15)	5 (60)	2 (4576)	3 (2145)
21 May ^{RB}	2 (3450)	5 (45)	3 (828)	(0)	(0)	1 (5192)	4 (345)
21 May ^{CG}	1 (9794)	(0)	3 (429)	(0)	(0)	2 (3984)	4 (100)

^aHerbaceous plant matter
^bUnidentifiable or nonfood items

CGRing-billed Gulls
 RBCalifornia Gulls

N = percentage by number of prey of type I
 V = percentage by volume of prey of type I
 F = frequency of occurrence of prey of type I

from terrestrial foraging forays. Gulls collected prior to, and after, peak smolt migration indicated low overall importance of fish in *L. delawarensis* and *L. californicus* diets. However, the importance ranking of fish in gull diets changed over time and was higher for both species as the smolt migration peaked in May. The reason for greater use of fish by *L. californicus* versus *L. delawarensis* is presently unknown and should be the focus of future research. However, the 35:1 ratio of breeding *L. delawarensis* to *L. californicus* on Cabin Island suggests the former consumed the majority of salmon smolts even though their diets were more diverse than *L. californicus*

diets. A study comparing *L. californicus* and *L. delawarensis* food habits in Alberta, Canada, reported fish also occurring more frequently in *L. californicus* samples (Vermeer 1970). The *L. californicus* diet was characterized by a heavy reliance on plant matter and fish, but the *L. delawarensis* diet was more varied and contained large volumes of several food items. In addition to plant matter, grain, insects, and mammals consistently occurred more frequently and in greater volumes in *L. delawarensis* samples, indicating a preference for terrestrial foraging habitat. Reliance on plant foods by both species early in the season, followed by a switch to animal foods as the

breeding season progressed, was also documented in Alberta and the Great Lakes and was presumed to indicate opportunistic feeding habits (Vermeer 1970, Jarvis and Southern 1976).

Although only a small percentage (2%) of total migrating salmon smolt were eaten by gulls, and of this amount a certain number (17%) were recently killed by dam turbines, the cumulative impact of gull predation on salmon populations at each of the 9 Columbia River dams and 4 Snake River dams is substantial, especially in combination with other negative impacts on Columbia River salmon (e.g., passage through turbines, nitrogen supersaturation, migration delays, and disease [Ruggerone 1986]). Management actions at Cabin Island to disperse gull nesting greater distances from hatchery release points, as well as active gull hazing below Priest Rapids Dam, should continue so as to provide disoriented smolts an opportunity to recuperate and continue their migration. In addition, monitoring population changes in *L. delawarensis* and *L. californicus* at Cabin Island could provide further information on foraging competition between these two species.

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