NORTHWESTERN NATURALIST 90:233–237 WINTER 2009

SEASONAL VARIATION IN RIVER OTTER DIET IN COASTAL NORTHERN CALIFORNIA

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Key words: coastal, diet, latrine, *Lontra canadensis*, Nearctic River Otter, northern California, scat

An animal's ability to acquire and assimilate energy is key to its fitness and survival. Dietary assessment of an organism is prerequisite to understanding its ability to achieve daily energetic needs, ultimately affecting population status and viability (Brafield and Llewellyn 1982). This is particularly relevant for the Nearctic River Otter (*Lontra canadensis*), a carnivore at the top of the aquatic food web which has adapted to a wide variety of aquatic ecosystems. The River Otter's high metabolic rate necessitates the capture of large quantities of prey daily (*sensu* Kruuk 2006). In this study, we located otter latrine sites during a 12-mo annual cycle in coastal northern California (2005–2006), reporting the frequency of prey remains found in otter scat (spraint) collected at these sites and comparing values to those reported in other regional studies.

We collected River Otter scat from 13 latrines at 5 sites around the perimeter of Humboldt Bay, and from a 6th site 19 km north along the Pacific coast in Humboldt County, northern California. Humboldt Bay (UTM: Zone 10, E 407634, N 4523226, NAD 27) is the 2nd largest estuarine bay in California with a surface area of 62.4 km^2 at high tide (Proctor and others 1980). Extensive tidal mudflats, drainage channels and adjacent sloughs are exposed at low tides, giving way to saltmarsh habitat at higher elevations where most of the latrines were located. Humboldt Bay saltmarshes are dominated by Pickleweed (*Salicornia virginica*), Humboldt Cordgrass (*Spartina densiflora*), and Saltgrass (*Distichlis spicata*) (Barnhart and others 1992). The northernmost site, Little River, is a riparian estuary adjacent to agricultural pastures and dune habitat. The 6 study sites (Table 1) comprised 1 estuary running into the ocean through a sand-spit habitat, 1 dead-end slough at the north end of the bay, 1 water treatment marsh complex adjacent to the bay, 1 deep channel of the bay, and 2 watercourses running into the bay. The sites were influenced by semi-diurnal tides. Based on temporal and spatial information from multiple re-sightings, we hypothesized that the latrine sites were visited by separate resident female-family groups and transient males (Black 2009; also see Shannon 1989).

Humboldt Bay is inhabited by a diverse number of fish species including estuarine and marine taxa; 110 species have been recorded (Barnhart and others 1992). Salmonid migrations through the bay occur from spring to early winter depending on species (Groot and Margolis 1991; Barnhart and others 1992). Juvenile fish migrate seaward through spring into summer (Groot and Margolis 1991; CDFG 2004; NRS 2005). Several types of crustaceans (mostly *Cancer* spp.) are prominent in Humboldt Bay and adjacent nearshore waters (Barnhart and others 1992). Dungeness Crab (*Cancer magister*) is known to be seasonally abundant in estuaries, with peak populations occurring in summer (McMillan and others 1995). The bay and adjacent habitats also are key wintering and migratory staging areas for thousands of waterbirds, peaking during the winter months (Colwell 1994; Harris 2005).

All scat discernable as individual deposits were collected at least once per month from each site from 19 July 2005 through 27 July 2006. River Otter scat has a unique smell and is thought to function as part of their scent communication (Rostain and others 2004; Oldham and Black 2009). When no scat was located, the site was visited again within 2 wk. Each scat was washed in a mechanical washing machine in a nylon stocking and then air dried in a paper cup (Golightly and others 1994).

TABLE 1. River Otter latrine site characteristics within study area in Humboldt County, California, and months of use from July 2005 through July 2006. Asterisk denotes 1 to 3 pups were also observed at the site.

Site	Habitat Type	Social Group Size	Latrines	Months in use
Little River	Estuary/Ocean	5	3: rocks, dunes	9 of 12[b]
Mad River Slough	Slough/Bay	3*	2: salt marsh	8 of 12[c]
Arcata Marsh	Marsh/Bay	5*	3: pond shore	12 of 12
Woodley Island	Bay Channel	4*	1: boat raft/dock	12 of 12
Elk River	Estuary/Bay	4	3: salt marsh	12 of 12
Hookton Slough[a]	Estuary/Bay	6*	1: boat raft/dock	9 of 12[d]

[a] fed by Salmon Creek
[b] no scats December - March
[c] no scats November - February
[d] no scats December - January, June

Based upon indigestible hard parts, prey remains were categorized as fish, bird, shellfish, aquatic insect, or other. The prey remains, however, were not identified to species. Diet was described as relative frequency of occurrence (number of occurrences of prey type × 100/number of scat samples; Fedriani and others 1998). This method provides an index of the presence-absence of prey in the diet. Frequency of occurrence of items in scat found at latrines, however, does not necessarily equate to frequency of occurrence within the total diet of otters (Carss and Parkinson 1996) as seen with the Eurasian Otter (*Lutra lutra*).

Contingency tables (χ^2) were used to compare frequency of food types among sites and seasons; tables included number of scats with and without food categories. Categories with empty cells were not included in analysis and no more than 20% of expected cells contained values <5. Seasons in coastal northern California are not clearly defined by severe climate variables, so data were organized into periods of high, intermediate, and low rainfall, and were based on water flow levels in local streams (DWR 2007); high = November through April (with 1,000,000 acre-feet/mo); intermediate = May through July (75,000 to 500,000 acre feet/mo); low = August through October (<20,000 acre-feet/mo). During the study period, no months had between 20,000 and 75,000 acre-feet or between 500,000 and 1,000,000 acre-feet of water flow.

We collected 440 River Otter scats during more than 100 trips to study sites (Table 2). Study latrines adjacent Humboldt Bay were used by otters in all 12 mo, whereas scats were present at the estuarine site adjacent the ocean (Little River) only from April through December. For scats collected at Humboldt Bay sites, fish was the dominant prey type, followed by crustaceans (mostly crab), birds, and aquatic insects. The coastal estuary site differed from this ranking in that crustaceans were the most common prey item, followed by fish, aquatic insects, and birds.

Differences in prey frequencies among sites were confirmed by comparing frequencies of each prey type (Table 3). Scat from Elk River and Woodley Island contained more remains of fish than expected, while scat from Little River and the Arcata Marsh had fewer fish remains than expected. Little River scat contained more crustacean remains than expected, with Woodley Island and Arcata Marsh sites having fewer crustacean remains than expected. Arcata Marsh had more bird remains than expected, with Elk River, Little River, and Woodley Island sites having fewer bird remains than expected. Aquatic insects were not compared because of small sample sizes, but they were consumed at a low frequency at all sites except for Arcata Marsh where they occurred in 21.5% of scats (Table 2).

Considering this coastal area as a whole and lumping all sites together, crustaceans were consumed more than expected in the intermediate season but less than expected in months with high rainfall (Table 4), and birds were consumed more than expected in high rainfall months but less than expected in other seasons (Table 4).

Fish as the major food of River Otters in our study area is consistent with the majority of reports from Alabama to Alaska, as documented by Melquist and others (2003) who reviewed 49 analyses of scat, digestive tract, or stomach contents. River Otters living in coastal northern California have several opportunities to capture a variety of fishes during different migratory events to and from the ocean, the bay, and adjacent tributaries (Groot and Margolis 1991;

TABLE 2. Frequency of occurrence of prey remains found in River Otter scats for each study site in coastal Humboldt County, California, July 2005 through July 2006. Total for each category was divided by total sample size at each study area to determine frequency of occurrence within the study area.

	Little River $n = 104$		Elk River $n = 80$		Arcata Marsh $n = 80$		Hookton Slough $n = 44$		Woodley Island $n = 79$		Mad River Slough $n = 53$		Total $n = 440$	
Taxa	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Fish	50	48.1	54	66.7	38	48.1	26	54.2	65	82.3	32	60.4	265	60.2
Shellfish	52	50.0	30	37.0	18	22.8	20	41.7	17	21.5	16	30.2	153	34.8
Bird	1	1.0	1	1.2	17	21.5	6	12.5	2	2.5	9	17.0	36	8.2
Insect	4	3.8	1	1.2	17	21.5	1	2.1	1	1.3	1	1.9	25	5.7
Other invertebrate	9	8.7	0	0.0	3	3.8	1	2.1	0	0.0	0	0.0	13	3.0
Unknown vertebrate	2	1.9	1	1.2	6	7.6	2	4.2	1	1.3	1	1.9	13	3.0

TABLE 3. Chi-square contingency table values comparing River Otter prey remains in scats from latrines in 6 study sites in coastal Humboldt County, California (July 2005 through July 2006), when seasons were pooled. $df = 5$.

	Fish				Shellfish				Bird			
	Observed		Expected		Observed		Expected		Observed		Expected	
Sites	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without
Elk River	54	27	48.8	32.2	30	51	28.2	52.8	1	80	7.0	74.0
Hookton Slough	26	18	26.5	17.5	20	24	15.3	28.7	9	35	3.8	40.2
Mad River Slough	32	21	31.9	21.1	16	37	18.4	34.6	9	44	4.6	48.4
Arcata Marsh	38	41	47.6	31.4	18	61	27.5	51.5	16	63	6.8	72.2
Little River	50	54	62.6	41.4	52	52	36.2	67.8	1	103	9.0	95.0
Woodley Island	65	14	47.6	31.4	17	62	27.5	51.5	2	77	6.8	72.2
X^2	28.7				24.6				43.1			
P	<0.001				<0.001				<0.001			

TABLE 4. Chi-square contingency table values comparing River Otter prey remains from scats in 3 seasons based on stream flow rates in coastal Humboldt County, California, July 2005 through July 2006. $df = 2$.

	High flows				Intermediate				Low flow					
	Observed		Expected		Observed		Expected		Observed		Expected			
	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without	X^2	$P \leq$
Fish	127	82	130	79	60	35	59	36	89	51	87	53	0.33	0.84
Shellfish	74	135	72	137	42	53	33	62	37	103	48	92	8.08	0.018
Bird	13	196	18	191	1	94	8	87	25	115	12	128	23.2	<0.001
Insect	10	199	11	198	7	88	5	90	7	133	8	132	0.91	0.63

CDFG 2004; NRS 2005). In the review by Melquist and others (2003), 7 of 49 studies reported that crustaceans were taken as often as or more often than fish. Crustacean remains predominated in 1 of 6 sites in our study, an estuarine habitat (Little River) that received twice-daily tidal movements into the river from the ocean. Though numbers were not quantified, we observed Dungeness Crab in the river adjacent latrines after high tidal events at this site.

Relative importance of prey types varied considerably among sites, even those that were adjacent to different parts of Humboldt Bay. This was particularly striking at the Arcata Marsh, where a larger proportion of scats contained birds and insect remains (21.5% each). This site has one of the bay's largest concentrations of shorebirds roosting during high tides, as well as a constant number of waterfowl (Higley 1986; Conklin and Colwell 2007). The peak of bird remains in scat during months with high rainfall corresponds to the peak influx of migratory birds in winter and early spring (Colwell 1994; Harris 2005). Similarly, more crustacean parts were identified in scats from periods of intermediate rains (May to July), which corresponds to reported summertime peaks of crabs in estuarine habitats (McMillan and others 1995). Modafferi and Yocum (1980) reported a similar order of importance of prey types from analysis of 100 scats collected at Lake Earl and Talawa, Del Norte County, California (150 km north of our study area); fish were also the dominant food type, then crustaceans, followed to a lesser extent by birds and insects.

The general patterns described in this study support the notion that River Otters take prey in relation to their availability or ease of capture (reviewed in Melquist and other 2003; Kruuk 2006). River Otters in this region also appear to be 'opportunistic' foragers, by taking fish at all sites because fish are pervasive and moving through this coastal system, and by taking more crustaceans and birds when they are available. River Otters in this study used latrines in all months of the year at 3 sites that were on or adjacent to Humboldt Bay, whereas 2 sites located on sloughs at either end of the bay and the estuarine site exposed to the ocean were not used in mid-winter months. Opportunistic observations by those participating in the citizen science Otter Records Network (Black 2009) suggest that River Otters at the estuarine habitat (Little River) moved inland

to smaller tributaries in forested habitats at higher elevations during winter (JMB, unpub. data).

Acknowledgments.—We thank A Oldham and R Golightly for their contribution and support.

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* Unpublished