SUMMER DIET AND STATUS OF RIVER OTTERS ON REDWOOD CREEK

by

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ABSTRACT

The summer diet and status of river otters, Lutra canadensis pacifica, were studied on Redwood Creek in northwestern California in 1980, 1981 and 1982. Two juvenile male river otters were captured and implanted with radio transmitters; one in 1981 and the other in 1982. Both were captured at the same trap site, occupied the same home range, and used the same activity center. Both animals died within months after capture.

The estimated population of river otters for the study area was 8 animals in 1980, 14 in 1981 and 13 in 1982. The mean density was one otter/3.7 km of waterway. Litter size ranged from 1-4 with an average of 2.5 pups/breeding female, and the population appeared to be increasing.

Thirteen den and resting sites were found during the study. Otters used dens excavated by other animals, logjams and in rocks at the end of the levee at the mouth of the creek.

Fish were the principle prey in the summer diet of otters, occurring in 86-97 percent of the 302 scats analyzed. Invertebrates, amphibians and birds were next in importance in that order. Based on chi-square analysis the relative take of all prey species except caddis fly larvae

and freshwater snails, Juga sp., was independent of years. River otters probably did not seriously impact salmonid populations on Redwood Creek. Fish were also the primary prey in freshwater and estuarine summer diets of otters occurring in 86 percent of 51 freshwater scats and 81 percent of 36 estuarine scats collected in 1982. Significant changes occurred between areas for Humboldt sucker (Catostomus occidentalis humboldtianus), threespine stickleback (Gasterosteus aculeatus), unidentified fish, caddis fly larva, crustacea and birds. Although species composition and percentage changed between years and habitats the basic river otter diet of fish, invertebrates, amphibians and birds did not. Findings in this study were similar to most otter food habits research in North America, Europe and southern Africa.

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INTRODUCTION

Three subspecies of river otter, the pacific river otter, Lutra canadensis pacifica, L. c. brevipilosus, and the Sonora river otter L. c. sonora were considered to occur in California (Grinnell 1914, Grinnell et al. 1937, Harris 1968). Hall (1981) has since combined L. c. brevipilosus with L. c. Pacifica. The Pacific river otter formerly occurred throughout most of the state (Merriam 1899, Stephens 1906, Grinnell 1914, Grinnell et al. 1937, Orr 1949, Ingles 1954 and Yocom et al. 1956) while the Sonora river otter was found exclusively in the Colorado River Basin (Grinnell 1914, Grinnell et al. 1937) (Figure 1). The range of the Pacific otter has been substantially reduced and the Sonoran otter is extirpated in California (Kirk 1975, Schempf and White 1977) (Figure 1). Currently otters are locally abundant in the Sacramento Delta Region (Grenfell 1974, Kirk 1975) and along the northwest coast of California (Schempf and White 1974, Manning 1983, Reeves unpublished data).

Historically, otter pelts were used by Native Americans along the northwest coast as a sign of wealth, to pay debts, to buy one's wife, as arrow quivers and bow decorations (Mason 1893, Nelson 1978, Lake 1982). The first written accounts of river otters in the state come

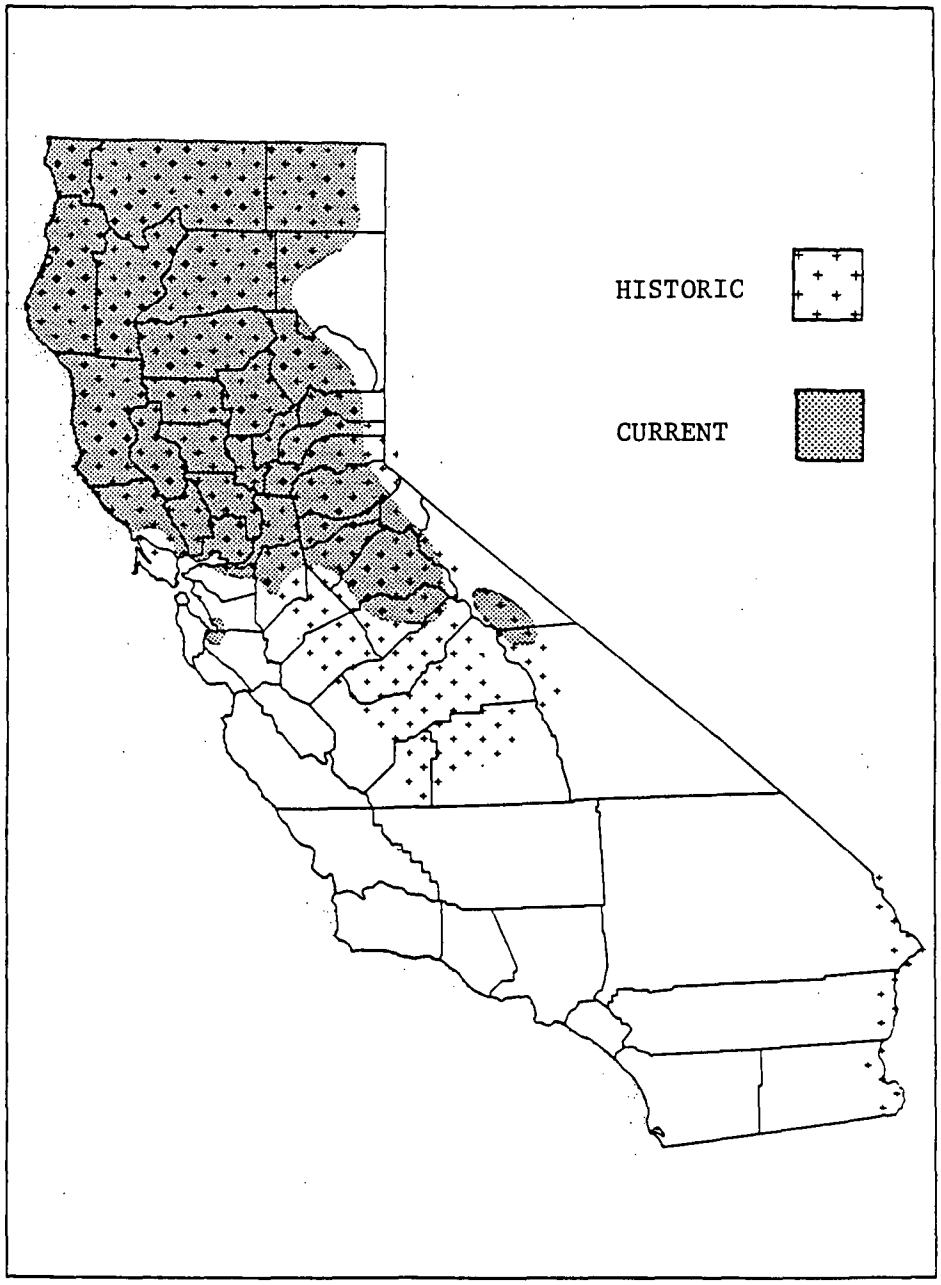

Figure 1. Historic and Current Distribution of River Otters in California.

from Jedediah Smith's expedition along the Trinity and Klamath Rivers in the late 1820's (Grinnell et al. 1937, Dale 1941). From 1830 to 1833 otter pelts sold for $2.00 each (Grinnell et al. 1937). By 1842 the price had risen to $2.50 a pelt when 30 "land otters" sold for this price in the Sacramento Valley (Grinnell et al. 1937). In 1852 an otter was killed in Lake Tulare and the hide used for a gun case (Grinnell 1914). This is the southern-most record of river otter in the San Joaquin Valley. Otters from throughout the state commonly were taken for scientific collections by personnel from the University of California, Berkeley, Museum of Vertebrate Zoology (Grinnell 1914) and the Smithsonian's National Museum of Natural History (NMNH) in Washington, D.C. in the late 1800's and early 1900's (Reeves unpublished field notes, based on a visit to the NMNH in 1980).

In 1921 a season was established for trapping river otters in California. However, during the following forty years the reported annual take never exceeded 163 otters (Gould 1977). In 1961 the California Fish and Game Commission gave them Protected Furbearer status (Gould 1977). Most early biological information about California river otters consisted of harvest records, distribution records, some natural history (Grinnell 1914, Grinnell et al. 1937, Yocom et al. 1956, Morejohn 1969, Schempf and White 1974, Kirk 1975) and food habits (Morejohn 1969, Grenfell 1974, Modafferi and Yocom 1980).

In 1977 concern regarding the status of river otters in North America prompted increased research on their population ecology, distribution and status (Melquist and Hornocker 1983, Jenkins 1983). From June 1980 to November 1982 Redwood National Park, Humboldt State University and the California Department of Fish and Game cooperated in a study agreement on river otters in northwestern California to determine (1) their status on Redwood Creek and (2) their feeding ecology with regard to the sport fishery.

STUDY AREA

The study area extended 26 kilometers upstream from the mouth along the main stem of Redwood Creek, Humboldt County, California (Figure 2). The Redwood Creek drainage basin is 720 square kilometers and ranges in altitude from mean sea level to 1600 meters. The creek flows 108 kilometers in a north-northwesterly direction. Width of the basin varies from 2.8 to 4.4 kilometers. Climate in the Redwood Creek watershed is characterized by rainy winters with an average of 200 centimeters of rain, most of which falls between October and March (Janda 1977) and short, warm, dry summers with especially frequent fog near the coast. Mean maximum temperature is 16.2^{o} C and the mean minimum temperature is 6^{o} C. Coghlan (1984) describes in detail the climatology and flood history of the Redwood Creek Basin.

Vegetation within the basin is dominated by coastal redwoods (Sequoia sempervirens), 81 percent of the old growth having been cut by 1978 (Best 1984). The dominant species in riparian areas is red alder (Alnus oregana). Other common trees are big leaf maple (Acer macrophyllum), California bay (Umbellularia californica), willow (Salix spp.), and dogwood (Cornus nuttali). Occasional redwoods are found within the riparian zone. Vegetative disturbance

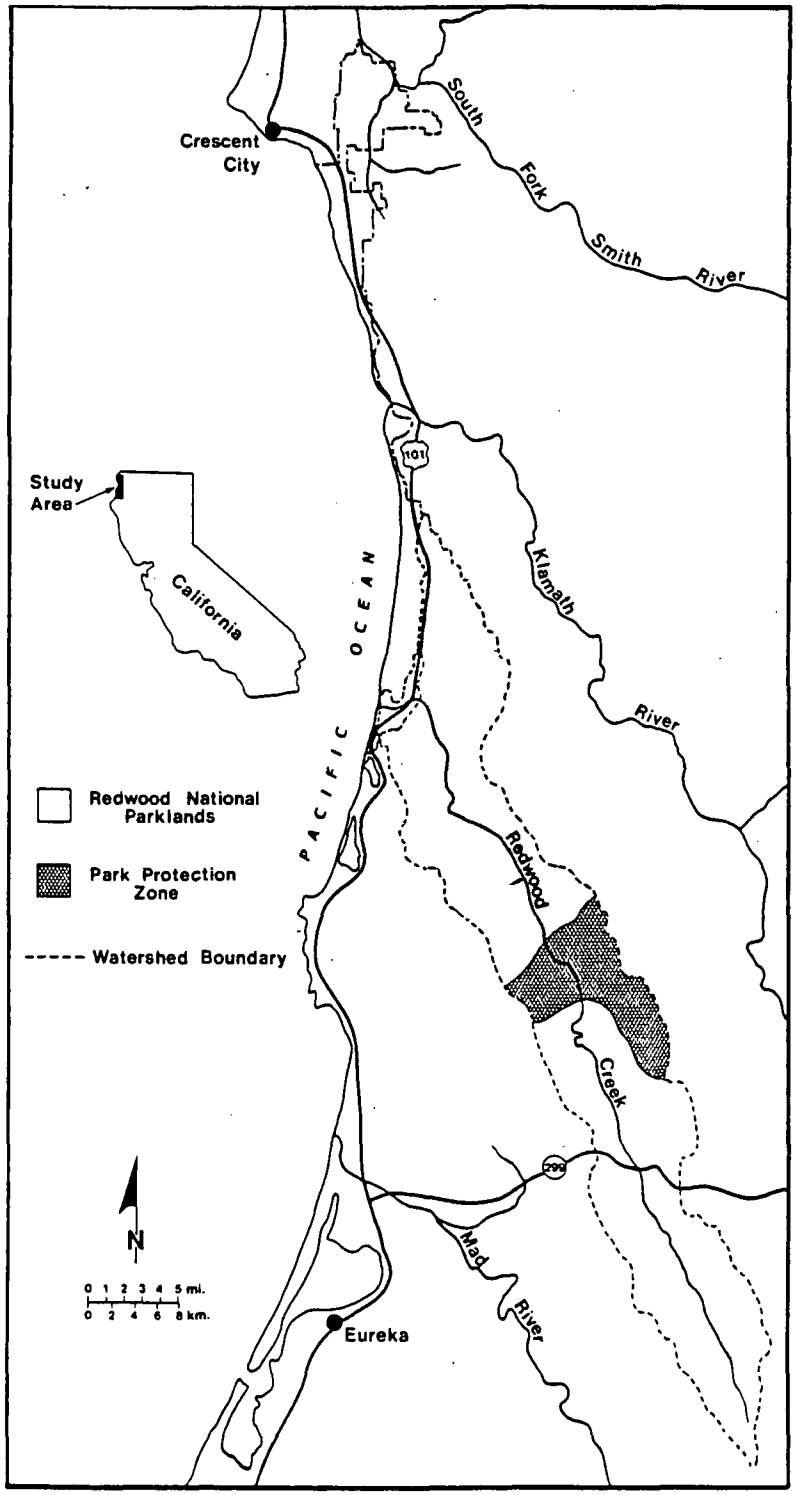

Figure 2. Redwood Creek Study Area.

on upper slopes due to logging and associated roads has resulted in high sediment deposits in Redwood Creek and adjacent tributaries through erosion (Madej 1984). Levee construction completed in 1968, has eliminated the riparian habitat that formerly occurred along both banks in the lower reach of the creek.

Several mammals in the study area overlap in feeding habits and/or habitat requirements with river otters. Mink (Mustela vison), raccoon (Procyon lotor), and beaver (Castor canadensis), were observed to utilize the creek and riparian area. Black bear (Ursus americanus), mountain lion (Felis concolor), bobcat (Felis rufus), coyote (Canis latrans), and porcupine (Erithizon dorsatum), were common along Redwood Creek. Dasmann (1964b), Lauck (1964) and Yocom and Dasmann (1965) describe the wildlife of the coastal Redwood region in detail.

Fish-eating birds such as common mergansers (Mergus merganser), great blue herons (Ardea herodias), black-crowned night herons (Nycticorax nycticorax), bald eagles (Haliaetus leucocephalus), ospreys (Pandion haliaetus), and belted kingfishers (Cerlye alcyon) were observed inland along the creek. Western grebes (Aechmophorus occidentalis), double crested cormorants (Phalacrocorax auritus), brown pelicans (Pelecanus occidentalis), and various species of gulls (Larus sp.) were commonly observed in the two sloughs and embayment at the mouth of the creek.

Genelly (1964), Yocom and Dasmann (1965) and Yocom and Harris (1975) describe the avifauna of the coast redwoods.

Based on personal communication with RNP biologists, Terry Hofstra, Jim Harrington, Dave Anderson and Randy Brown along with personal observation, fish of the Redwood Creek Basin are chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch), steelhead and rainbow trout (Salmo gairdneri), cutthroat trout (S. clarki), sculpin (Cottus spp.), threespine stickleback (Gasterosteus aculeatus), Humboldt sucker (Catostomus occidentalis humboldtianus, and Pacific lamprey (Lampetra tridentada). Starry flounder (Platichthys stellatus) and staghorn sculpin (Leptocottus armatus) are found in the embayment and the north and south sloughs near the mouth.

Principal land use of the basin outside of Redwood National Park is logging (Best 1984). Cattle ranching and dairy farming are also prominent. Recreational use such as hiking, fishing and horseback riding occur primarily within Redwood National Park.

METHODS

Trapping

Live-trapping techniques using Hancock traps were developed for river otters by Northcott and Slade (1976). This technique proved successful in Idaho (Melquist and Hornocker 1979a) and British Columbia (Dr. Garry Stenson University of British Columbia personal communication). Hancock traps were used unsuccessfully on Redwood Creek in 1980 and 1981. Victor number two coil-spring and number three leaf-spring leghold traps were used in 1981 and 1982.

Trap jaws were padded with canvas and the traps, boiled with fir and redwood needles, then attached by chain to 1.1 meter pieces of 1.3 cm diameter iron reinforcement bars. This was to prevent traps from being pulled out of sand and gravel bars along the creek. The traps were handled with gloves. Sets were made in areas of relatively high otter use, and were baited with fish and with scent composed of otter urine and scent glands.

A ketch-all pole was used to physically restrain captured animals. Otters were chemically immobilized using ketamine hydrochloride and acepromazine in doses recommended by Melquist and Hornocker (1979a).

Implants

Implantations of radio-telemetry transmitters into two otters were done by James Lane, DVM of Fortuna, California, following procedures outlined by Melquist and Hornocker (1979a). After implantation one otter was confined for three weeks and the other for two days. Each was released at its original capture site.

Radio-Telemetry

Animals with implanted transmitters were relocated using a hand held receiver and antenna. All telemetry equipment was purchased from Telonics Inc., Mesa, Arizona. Relocation procedures described by Melquist and Hornocker (1979b) were used. In addition, all relocation points were confirmed with visual observation of the animal and/or the resting or den site it occupied. Triangulation was not used. Locations of otters were transcribed on aerial photographs of the study area. Dens and resting areas were located with radio-telemetry and by tracking. Activity centers were areas where otters spent 10 percent or more of recorded time.

Density, Sex and Age

Density estimates of river otters along the main stem of Redwood Creek were based on observation of otters and their sign, radio-telemetry and trapping. Large single

otters accompanied by juveniles were considered to be adult females. Relatively large solitary otters were classed as adult males. Position of the genital openings was used on two occasions to confirm the sex of uncaptured otters observed in the study area. Classification as either adult or juvenile was based on size.

Food Habits

River otter scats were collected during the dry season, June through October, in 1980, 1981 and 1982. Scats from the Redwood Creek estuary were collected only in 1982. Logs, rocks, logjams, sandbars, and other objects protruding along waterways were checked frequently in the study area; all scats with deposition dates known to within plus or minus one week were collected. Date and location were recorded for each scat. Each sample was placed in an individual plastic bag and frozen until analysis.

The scats were thawed, soaked and washed in tap water in a container with one millimeter mesh at the bottom prior to analysis. Prey remains were identified by comparison with a reference collection of species taken from Redwood Creek. Fish were identified to genus and occasionally to species (Wise 1980). Many scats contained fragments of invertebrates, sand and small quantities of vegetation. These were probably ingested incidentally as food items in the stomachs of their prey or while the

otters searched for food. Such items considered to be ingested incidentally were not included in the analysis.

Frequency of occurrence and relative frequency of prey items were recorded. Frequency of occurrence is the number of scats in which a food species occurred divided by total scats analyzed. Relative frequency of a prey item is obtained by totalling all occurrences of identified food and expressing each prey item as a percent of the total occurrences of all identified food items. Frequency of occurrence facilitated comparison with other North American otter feeding studies. Relative frequency was used because it gives a reasonably true picture of the importance of the different food categories and possibly a picture of preference by otters (Erlinge 1968, Rowe-Rowe 1977a). Erlinge (1968) and Rowe-Rowe (1977a) fed known amounts of different food categories to European otters, Lutra lutra, and South African otters, then analyzed the scats. In both studies the comparison of the known amounts of food fed to the otters and the relative frequency of those items in the scats were not significantly different.

Prey items in scats from Redwood Creek were tested for significant difference between years and between freshwater and estuarine habitats using Chi-square tests at the 0.05 significance level. Foraging behavior of river otters was based on direct observation of one tame, two instrumented and 14 wild otters.

RESULTS

Trapping

Three otters were captured and two of these were subsequently recaptured. A yearling female caught on 10 June 1981 was killed in the trap by a mountain lion. A 2.8 kg juvenile male was captured 5 August 1981, implanted with a transmitter and released 24 August 1981. One recapture and 34 relocations were made on this animal before it was killed by an unidentified predator in November 1981.

A second juvenile male weighing 2.0 kg was captured on 1 August 1982, implanted and released 4 August 1982. One recapture and 10 relocations were made on this animal before it died between 14 and 16 August 1982. This animal had reopened the wound where the implant was made.

Both juvenile males were captured at the same trap site, occupied approximately the same home range, used the same dens and one activity center (Figure 3).

Density, Sex, Age and Litter Size

In the summers of 1980, 1981 and 1982 there were estimated to be 8, 14 and 13 river otters, respectively, in the study area. These estimates include otters of unknown age and sex, 2 to 3 adult females, 1 to 2 adult males and 2 to 7 unsexed juveniles (Table 1). Six litters containing

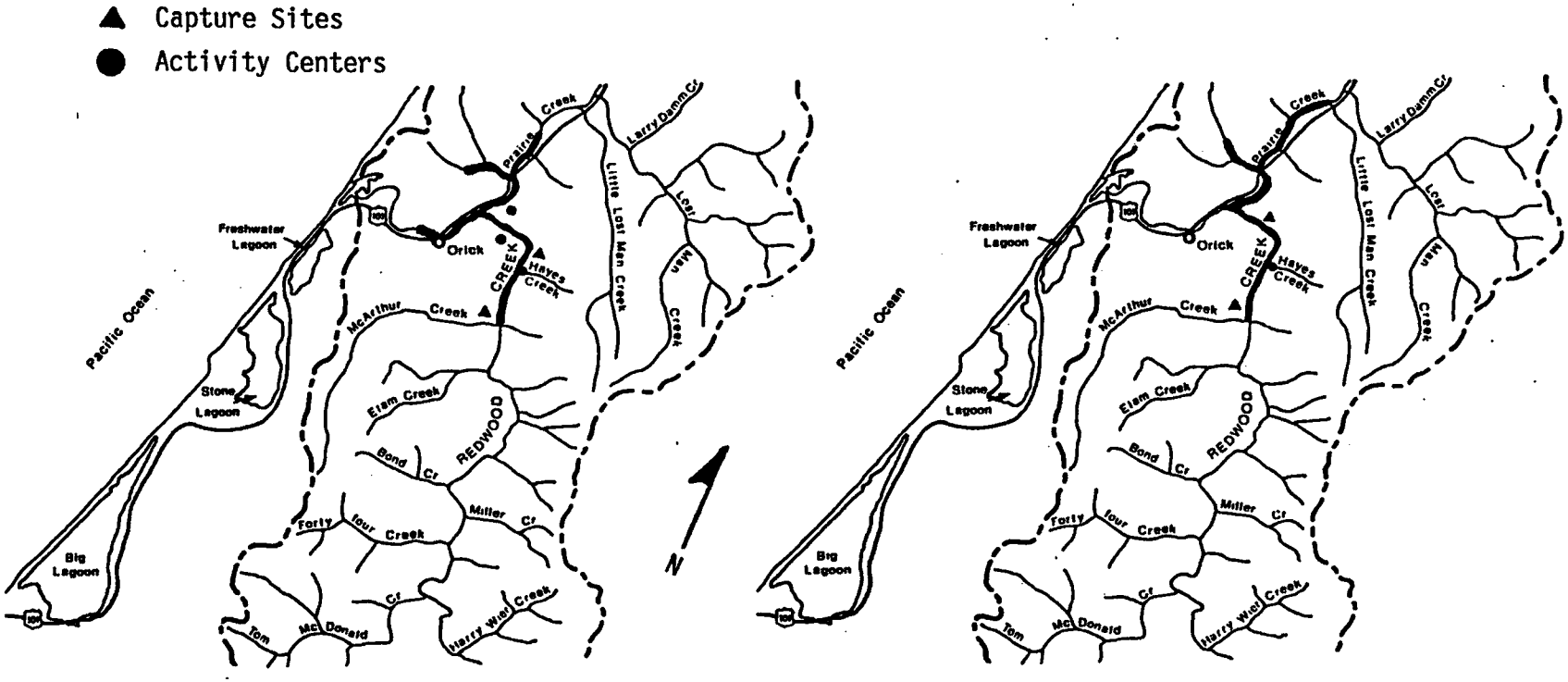

Figure 3. Home Range and Activity Centers of Two Juvenile Male River Otters on Redwood Creek.

Table 1. River Otter Densities Based on Observation, Sign and Radio-Telemetry for the Main Stem of Redwood Creek, Humboldt County, California, 1980-1982.

Category	Mean no. of otters	Waterway/otter (km)
All otters[a]	11.3	3.7
Males	1.7	15.3
Females	2.7	9.6
Juveniles	5.0	5.2

[a]Includes otters of unknown age and sex.

15 pups were observed during the study. Litter size ranged from 1 to 4 with an average of 2.5 pups per litter.

Den and Resting Sites

Eleven den and two resting sites were found during the study. Four dens were burrows in the bank, four were in logjams, two burrows were under trees within 20-30 meters away from the creek and one was in rocks at the end of the levee at the mouth of the creek. One resting site was in dense riparian vegetation and the other was in vegetative debris on the levee.

Summer Food Habits

The analysis of summer food habits of river otters was based on 302 scats (Table 2). In 1980 fish species from four families occurred in 97 percent of the scats. In 1981 five families of fish occurred in 88 percent of the scats and in 1982 four families were found in 86 percent of the samples. Sculpin (Cottidae), sucker (Catostomidae) and stickleback (Gasterosteidae) commonly occurred in the scats. Chinook salmon and steelhead (Salmonidae) were less common. One occurrence of lamprey (Petromyzonidae) was found in 1981.

Invertebrates occurred in 32 percent of the scats in 1980, 55 percent in 1981 and 61 percent in 1982 (Table 2). Caddis fly larva (Trichoptera) comprised a major portion of river otter diet both in frequency of occurrence

Table 2. Summer Food Habits of River Otters Based on 302 Scats Collected from Redwood Creek, Humboldt County, California, 1980-1982.

Food item	No. of occurrences			Frequency (%)			Relative frequency (%)		
	1980	1981	1982	1980	1981	1982	1980	1981	1982
Fish	73	155	44	97	88	86	83	66	65
Cottidae									
Sculpin (*Cottus* sp.)	63	128	36	84	73	71	36	29	26
Catostomidae									
Humboldt Sucker (*Catostomus occidentalis humboldtianus*)	36	64	21	48	37	41	20	14	15
Gasterosteidae									
Threespine stickleback (*Gasterosteus aculeatus*)	21	45	21	28	26	41	12	10	15
Salmonidae									
Chinook (*Oncorhynchus tshawytscha*)	25	30	8	33	17	16	14	7	6
Steelhead (*Salmo gairdneri*)	1	26	4	1	15	8	<1	6	3
Unidentified Salmonidae		1	1		<1	2		<1	<1
Petromyzontidae									
Pacific lamprey (*Lampetra tridentata*)		1			<1			<1	
Unidentified fish			1			2			<1
Invertebrates	24	96	31	30	55	61	15	28	24
Caddis fly larva (*Trichoptera*)	4	88	30	5	50	59	2	20	21
Freshwater snail (*Juga* sp.)	21	23	4	28	13	16	12	5	4
Unidentified invertebrates	2	11		3	6		1	3	
Amphibians	2	19	12	3	11	24	1	4	10
Pacific giant salamander (*Dicamptodon ensatus*)	2	19	7	3	11	14	1	4	5
Unidentified amphibian			7			14			5
Birds	2	9	1	3	5	2	1	2	<1
Anatidae									
Common merganser (*Mergus merganser*)	2	9	1	3	5	2	1	2	<1

Table 2. Summer Food Habits of River Otters Based on 302 Scats Collected from Redwood Creek, Humboldt County, California, 1980-1982. (continued)

Food item	No. of occurrences			Frequency (%)			Relative frequency (%)		
	1980	1981	1982	1980	1981	1982	1980	1981	1982
Total sample size	75	176	51						
Total occurrences of items in scats	177	444	141						

and bulk. Whole scats were composed of Trichopteran casings and the exoskeletons of larvae. Some scats were composed entirely of freshwater snail shells too.

Amphibians were found in 3 percent of the 1980 scats and in 11 percent and 24 percent of the scats for 1981 and 1982, respectively. The Pacific giant salamander (Dicamptodon ensatus) was the only amphibian identified. Birds were present in 3 percent of the 1980 scats, 5 percent of the 1981 scats and 2 percent of the 1982 scats.

In 1980 fish composed 83 percent of the prey items (Figure 4), in contrast to 66 percent in 1981 and 65 percent in 1982. Invertebrates composed 15 percent of the prey items in 1980, 28 percent in 1981 and 24 percent in 1982. Amphibians accounted for 1 percent of the prey items in 1980, 4 percent in 1981, and 10 percent in 1982. Birds were 1 percent of the prey items in 1980, 2 percent in 1981 and less than 1 percent in 1982. Based on chi-square analysis of prey items, all species in the diet of river otters, except caddis fly larvae and freshwater snails, were independent of years ($p>0.05$, chi-square=27.55). Caddis fly larvae increased in the diet from 1980-1982 while freshwater snails decreased over the same period.

Freshwater and Estuarine Food Habits

The summer food habits of freshwater and estuarine river otters were based on the analysis of 51 scats collected from the main stem and 36 scats collected from

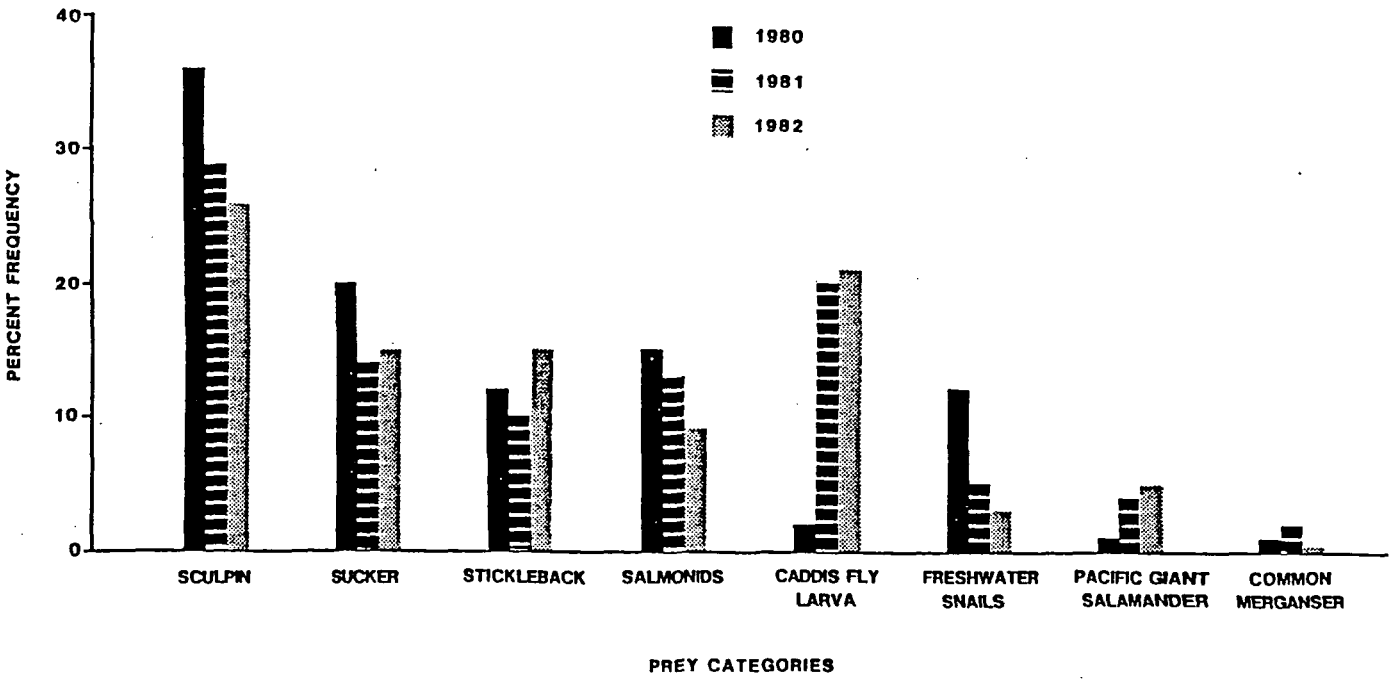

Figure 4. Relative Percent Frequency of Prey Items in the Summer Diet of River Otters on Redwood Creek, Humboldt County, California, 1980-1982.

the estuary of Redwood Creek in 1982 (Table 3). Fish were the most abundant prey item in scats from each area. The significant differences between areas occurred for sucker ($p<0.05$, chi-square=16.326), stickleback ($p<0.05$, chi-square=4.0009), unidentified fish ($p<0.05$, chi-square=8.816), caddis fly larva ($p<0.05$, chi-square=18.664), crustacea ($p<0.05$, chi-square=16.65) and birds ($p<0.05$, chi-square=10.195) (Figure 5).

Suckers composed 15 percent of the prey items among freshwater scats, and did not occur in the scats found in the estuarine habitat. Frequency of stickleback changed from 15 percent in scats from freshwater habitat to 25 percent in scats from the estuary. More unidentified fish were found in the estuarine scats of otters (8.1 percent) than the freshwater scats (<1 percent). Caddis fly larvae in the scats varied from 21 percent in scats taken from the freshwater main stem to 2 percent in the estuary. Crustaceans accounted for 9.1 percent of prey items in the estuarine scats of river otters as compared to none in freshwater scats.

Observations of Foraging

Otters were observed on 66 occasions from June to October, 1980-1982. Observations ranged from 5 seconds to 13 hours. Most observations were made of swimming or resting otters near den sites.

Table 3. Summer Freshwater and Estuarine Food Habits of River Otters Based on 51 Scats from Freshwater and 36 Scats from Estuarine Habitats Collected on Redwood Creek, Humboldt County, California in 1982.

Food item	No. of occurrences		Frequency (%)		Relative frequency (%)	
	Freshwater	Estuary	Freshwater	Estuary	Freshwater	Estuary
Fish	44	29	86	81	65	70
Cottidae						
Sculpin (Cottus sp.)	36	26	71	72	26	26
Catostomidae						
Humboldt Sucker (Catostomus occidentalis humboldtianus)	21		41		15	
Gasterosteidae						
Threespine stickleback (Gasterosteus aculeatus)	21	25	41	69	15	25
Salmonidae						
Chinook (Oncorhynchus tshawytscha)	8	4	16	11	6	4
Steelhead (Salmo gairdneri)	4	5	8	14	3	5
Unidentified Salmonidae	1	1	2	3	<1	1
Unidentified fish	1	8	2	22	<1	8
Invertebrates	31	14	61	39	24	14
Caddis fly larva (Trichoptera)	30	2	59	6	21	2
Mollusca						
Freshwater snail (Juga sp.)	4	1	16	3	3	1
Crustacea		9		31		9
Unidentified invertebrates		2		6		2
Amphibians	12	5	24	14	10	5
Pacific giant salamander (Dicamptodon ensatus)	7	2	14	6	5	2
Unidentified amphibians	7	3	14	8	5	3

Table 3. Summer Freshwater and Estuarine Food Habits of River Otters Based on 51 Scats from Freshwater and 36 Scats from Estuarine Habitats Collected on Redwood Creek, Humboldt County, California in 1982. (continued)

Food item	No. of occurrences		Frequency (%)		Relative frequency (%)	
	Freshwater	Estuary	Freshwater	Estuary	Freshwater	Estuary
Birds	1	11	2	31	<1	2
Anatidae						
Common merganser (Mergus merganser)	1	2	2	6	<1	2
Laridae		2		6		2
Unidentified birds		7		19		7
Total sample size	51	36				
Total occurrences of items in scats	141	99				

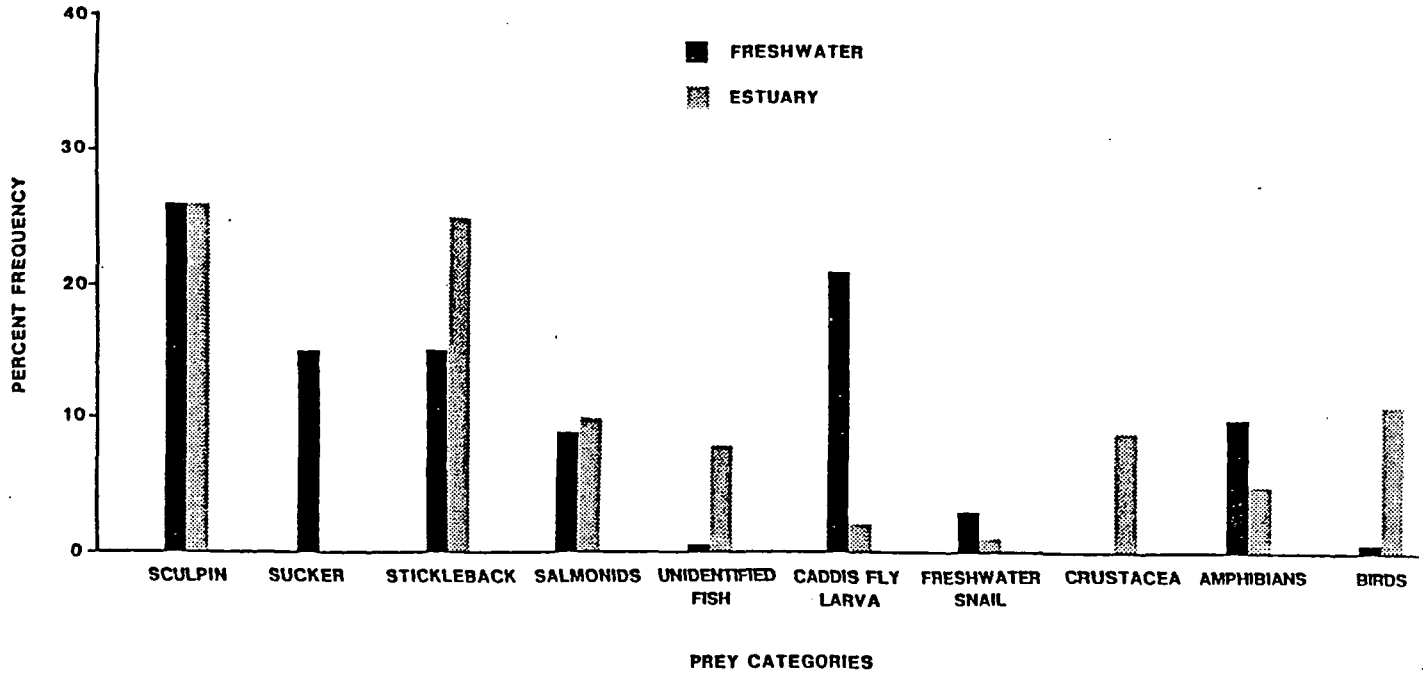

Figure 5. Relative Percent Frequency of Prey Items in Summer Freshwater and Estuarine Diets of River Otters on Redwood Creek, Humboldt County, California in 1982.

Based on 14 observations of feeding behavior, otters foraged in pools adjacent to dens, in riffles, along banks and in shallows among rocks along the edge of the creek. On the main stem of the creek juveniles were observed feeding on caddis fly larva, suckers and unidentified fish. On two separate occasions an adult female otter and a juvenile otter were observed to swim through large concentrations of suckers without pursuing them. The fish parted and appeared to make a path for the otters.

DISCUSSION

Trapping

Otters were difficult to trap on Redwood Creek. The first otter to be trapped and implanted was kept in captivity three weeks to assure healing of the surgical wound. However, discussions with Wayne Melquist who used implants, and released animals within hours of surgery led to release of the second otter after only three days. Examination of the carcass of this second animal revealed that the animal had reopened the surgical wound. This may have contributed to the death of the animal.

Density, Sex, Age and Litter Size

Differences in the annual density estimates on Redwood Creek probably resulted from a less intensive search in the study area in 1980 compared to 1981 and 1982, rather than real changes in otter numbers. In Idaho the estimated population density for otters was one otter per 3.9 km of waterway (Melquist and Hornocker 1983), compared to one otter per 3.7 km of waterway on Redwood Creek. In contrast to my study on Redwood Creek, Melquist and Hornocker (1983) included secondary streams and tributaries. However, these authors provide the caution that ". . .it is probably of little value to compare

density estimates until regulatory mechanisms for each population are identified."

Juveniles were more abundant than adult otters on Redwood Creek. Melquist and Hornocker (1983) also found a predominance of young animals in their study area and concluded that the population they studied was increasing. They based their conclusion on the assumption that increasing populations tend to have a predominance of juvenile animals (Dasmann 1964a, Krebs 1972). If these assumptions are correct then the otter population on Redwood Creek was increasing. However, Mossman (in press) cautions that high reproduction may be offset by high adult mortality and emigration and/or high losses of juveniles prior to reproductive maturity. What seems to be an increasing population of river otters on Redwood Creek may not be.

The mean litter size of otters seen on Redwood Creek (2.5) was similar to otter fetal counts of 2.29 in New York (Hamilton and Eadie 1964), 2.75 in Oregon (Tabor and Wight 1977), 2.73 in Maryland (Mowbray et al. 1979) and 2.75 in Virginia (Anderson and Scanlon 1981). Melquist and Hornocker (1983) reported 2.4 pups per breeding female based on direct field observation. Fetal counts tend to be a bit higher than counts of young after they have left the natal den. This suggests that litter sizes on Redwood Creek may be similar to those found in Oregon.

Den and Resting Sites

Logjams and beaver bank dens were the two most common den sites used by river otters in the study area. Resting areas were more exposed and used less than 10 percent of the time by telemetered animals. Melquist and Hornocker (1983) reported Idaho otters to use beaver bank dens and logjams more than other kinds of dens. They also state that selection of den and resting sites is apparently based on availability and convenience. All but two dens along Redwood Creek were located near pools containing concentrations of fish and/or invertebrates. Availability could therefore be defined as ease of access by otters to a den and convenience defined as location of the den relative to a feeding area. Use of dens may also vary seasonally relative to fluctuations in water and whether or not the den is used for pupping (Reeves 1977, Melquist and Hornocker 1983).

Summer Food Habits

Fish were the most abundant prey category in the summer diet of river otters on Redwood Creek (Table 2). Non-game species of fish were considered to range in size from 3-25 centimeters (Moyle 1976, Kisanuki 1980), and chinook and steelhead were considered to be juveniles ranging in size from 14-24 centimeters (Hofstra 1983). This is similar to the findings of most river otter food

habits research in North America (See Toweill and Tabor 1982 for a summary of these studies up to 1981). More recently Zackheim (1982), Melquist and Hornocker (1983), Stenson et al. (1984) and Larsen (1984) also obtained similar results. However, Grenfell (1974) found crayfish to be the main category of prey for otters in a central California marsh. For the European otter (Lutra lutra) (Erlinge 1967, 1969, Jenkins and Harper 1980), the clawless otter Aonyx capensis), and the spot-necked otter (Lutra maculicollis), (Rowe-Rowe 1977c) fish also were the main category of prey in the diet.

Cottids were the most abundantly represented family of fish in otter scats from Redwood Creek. Greer (1955) and Zackheim (1982) found sculpin to be the principle fish in summer scats of Montana otters. Melquist and Hornocker (1983) noted an increased representation of sculpin in scats during the summer months although salmonids were the primary fish in the summer diet of Idaho otters. Larsen (1984) noted that although cottids changed proportionally in the diet seasonally they were the most important group during all seasons in coastal southeastern Alaska. Toweill (1974) found cottids to be the major prey item in the winter diet of otters in Oregon. On the other hand Modafferi and Yocom (1980) found starry flounder to be the most prevalent fish in the summer diet of otters in California coastal lagoons, while Manning (1983) found sucker to be more common than other species of fish in

summer scats of river otters on the Eel River in northwestern California.

The proportion of sculpin remains in otter scats declined over the three years of the study on Redwood Creek; however, the decline was not statistically significant. Sculpin may be particularly susceptible prey for otters because they are bottom dwelling species and remain immobile until a potential predator is quite close (Toweill and Tabor 1982). Their seasonal occurrence in river otter diets may appear to fluctuate in proportionately to other prey items (Greer 1955, Zackheim 1982, Melquist and Hornocker 1983, Larsen 1984), but sculpin play an important role as a reliable and sustaining food for otters (Melquist and Hornocker 1983, Larsen 1984).

Humboldt suckers were next in occurrence in the diet of Redwood Creek otters. Suckers were second in importance for Montana otters as well (Zackheim 1982); however, Manning (1983) found suckers to be the principle fish in the summer diet of Eel River otters. In Idaho, largescale suckers (Catostomus macrocheilus) were important prey for otters in spring and summer when the suckers were spawning (Melquist and Hornocker 1983). As slow-swimming fish, suckers are easy for otters to catch (Toweill and Tabor 1982, Melquist and Hornocker 1983). When present, suckers appear to be an important year-round food source for otters (Melquist and Hornocker 1983).

Threespine stickleback were the third most common fish species occurring in the scats from this study. Kendall (1967) found stickleback in the diet of otters on Little River and Mill Creek in northern California. On Mill Creek they were the primary prey whereas on Little River they were secondary in the diet of otters. No other studies have reported stickleback in the diet of otters.

Salmonids were next in frequency of occurrence. All food habits studies of otters in waterways containing salmonids have reported them in otter diets (Erlinge 1967, 1969, Rowe-Rowe 1977c, Jenkins and Harper 1980, Toweill and Tabor 1982, Zackheim 1982, Melquist and Hornocker 1983, Manning 1983, Larsen 1984). In Montana (Greer 1955) and Idaho (Melquist et al. 1981, Melquist and Hornocker 1983) they were seasonally important in the diet. Toweill (1974) found a high occurrence of salmon in otter diets during spawning season in Oregon. In Idaho, otters concentrated near salmon spawning areas (Melquist et al. 1981, Melquist and Hornocker 1983). Otters have been reported to scavenge on dead salmon in California (Grinnell et al. 1937). However, based on vertebrae size all but two occurrences of salmonid remains in the scats from Redwood Creek were considered to be those of juvenile salmonids. Adult summer steelhead concentrate in pools along the main stem of Redwood Creek (Hofstra 1983), but were not found in the scats of river otters. Manning (1983) found salmonids in 20 percent of the scats in the summer diet of otters on the

Eel River, which also has summer steelhead runs, but failed to identify salmonid species. His findings of salmonids in the diet of otter corresponds to the findings of this study. Even in areas where salmonids were important prey, otters have not been shown to depress salmon or other fish populations (Toweill and Tabor 1982, Melquist and Hornocker 1983).

Invertebrates were the second most abundant prey category for otters on Redwood Creek, after fish. This does not differ from the majority of studies conducted on river otter food habits (Modafferi and Yocom 1980, Toweill and Tabor 1982, Zackheim 1982, Melquist and Hornocker 1983, Larsen 1984). Again, only Grenfell (1974) found crayfish to be the principle prey category for otters.

A significant increase in frequency of caddis fly larvae cases in river otter scats from Redwood Creek occurred between 1980 and 1981. This may be due to bias in collecting of scats. Scats were not collected in June and July of 1980 and Trichopteran larva are common from late spring to early fall in the study area. However, based on U.S. Geological Service records, from monitoring stations along Redwood Creek and at the mouth, 1980 was also a year of low water flow with a mean discharge during the summer of 69 cubic feet per second (cfs). The mean summer discharge for 1981 and 1982 was 114 cfs and 89 cfs respectively. The occurrence of the freshwater snail Juga sp. in the diet of otters was inversely related to the

occurrence of trichopterans. Both groups varied significantly by year based on chi-square tests. Water current speed is a factor that controls the occurrence and abundance of invertebrates (Hynes 1970). Hynes further states that similar species may be affected by current quite differently. Thus current speed which affects relative numbers and/or researcher bias may account for the significant changes between years of invertebrates.

Amphibians were the third major category of food items based on scat analyses from Redwood Creek. Again this agrees with most freshwater feeding studies of otters in North America (Toweill and Tabor 1982). On the other hand Grenfell (1974), Kendall (1967), Larsen (1984) Melquist and Hornocker (1983), Modafferi and Yocom (1980), and Stenson et al. (1984), did not find amphibians in river otters diets.

Frogs are commonly eaten by otters in Oregon (Toweill and Tabor 1982), but Pacific giant salamanders were the primary amphibian eaten by otters on Redwood Creek. Toweill (1974) found one Pacific giant salamander in an Oregon otter stomach. Greer (1955), working in northwestern Montana, noted salamander remains in otter scats during all seasons except winter. Larval stages of the Pacific giant salamander occur in habitats similar to those used by rainbow trout (Antonelli et al. 1972) and also feed on Trichopteran larvae (Johnson and Schreck 1969, Antonelli et al. 1972). Larval stages of this salamander

were found while electroshocking for juvenile steelhead on Redwood Creek and its tributaries (David Anderson, RNP, personal communication). Otters may have encountered salamanders while actively hunting fish and while both species were foraging for trichopteran larvae.

Based on observation of otters foraging and finding trichopterans in scats, not containing salamanders I conclude that trichopterans were not secondarily ingested with salamanders.

Birds made up the last major category of food for otters on Redwood Creek. All were identified as common mergansers, Anatidae, which is the principle bird family found in the diet of otters (Toweill and Tabor 1982, Melquist and Hornocker 1983). Common mergansers with broods of up to nine juveniles were encountered frequently in the study area.

Freshwater and Estuarine Food Habits

The diet of Redwood Creek river otters in both freshwater and estuarine habitats reflect the findings of other food habit studies (Toweill and Tabor 1982). Fish, invertebrates, amphibians and birds made up the diet of river otters on Redwood Creek. Of these four categories only amphibians and birds changed in importance between freshwater and the estuary. Salinity and greater species richness of the estuary may have been responsible for this change. The number of species in most taxonomic groups

increases from the headwaters to the mouth of rivers and streams (Ricklefs 1979).

The importance of cottids did not change between areas. Stenson et al. (1984) found sculpins to be second in importance in the diet of coastal otters in British Columbia. Kendall (1967) and Modafferi and Yocom (1980) found starry flounder to be the primary prey of California coastal otters. Flounder may have been a component in the unidentified fish reported in scats from the estuary, but would still not be the principle prey of otters.

Differences in the frequency of invertebrates among scats of the two areas may be attributed to increased salinity in the estuary resulting with losses and gains of species. Trichopterans are not found in the estuary or north and south sloughs which are adjacent to the estuary. The small percentage of invertebrates in scats from the estuary may have been a result of otters foraging in freshwater. Crustaceans were found only in the estuary scats while none were found in scats from freshwater habitats. Crustaceans were found to be a secondarily important prey category in the diet of coastal otters (Modafferi and Yocom 1980, and Stenson et al. 1984). However, Kendall (1967) did not find crustaceans in scats collected from the lower reach of the Little River, but this coastal river had no estuary, and the mouth changes from year to year.

Birds and amphibians varied in importance between freshwater and estuarine river otter diets. Waterfowl, gulls and grebes are found in greater proportion in coastal otter diets than inland otter diets (Toweill 1974, Stenson et al. 1984). Bird feathers were common in uncollected scats near the estuary, and gull carcasses were found near the den in the estuary. Otters are known to feed on nesting gulls and storm-petrels (Footit and Butler 1977, Quinlan 1983), and on waterfowl when abundant (Grenfell 1974). Thus birds may be important as prey when vulnerable (nesting) and when concentrated in otter habitat during migrations. Amphibians were not found in fish samples collected in the estuary. Estuarine otters may have fed occasionally in freshwater, but appeared to stay near the mouth of Redwood Creek, based on diet.

CONCLUSIONS

Based on annual changes in the summer diet as well as variation between freshwater and estuarine habitats, otters on Redwood Creek appear to be opportunistic feeders. Toweill and Tabor (1982), Melquist and Hornocker (1983) and Stenson et al. (1984) also conclude that river otters are opportunistic in their feeding. As opportunistic feeders, otters select a diet of fish, invertebrates, amphibians and birds. Species composition may change between habitats and seasons, but the diet of the otter does not. The research on Redwood Creek and other river otter food habits studies confirm this. This "strategy" suggests otters are successful carnivores or as Ewer (1973) states ". . .the highly successful carnivore is the one that combines sufficient specialization to make it an effective predator on its chosen type of prey with flexibility enough to permit it to utilize a variety of foods in relation to changing seasons and varied habitats." Thus river otters on Redwood Creek are successful carnivores (Figure 6).

Figure 6. River Otter Feeding on a Sucker on Redwood Creek.

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