SEASONAL PREY OF THE NORTH AMERICAN RIVER OTTER,

*LONTRA CANADENSIS*, AT DELTA SITES

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By
Decie Boone

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Approved:

[Signatures]

Date:

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Abstract

Previous studies have suggested that the diets of river otter (*Lontra canadensis*) vary in response to seasonal shifts in prey availability. To test this hypothesis for river otter located within the Sacramento-San Joaquin Delta, this study observed the seasonal behaviors of river otter at two locations and collected and analyzed their spraint samples. The results from the two locations were compared.

The results did not show a statistically significant difference in the type of prey consumed at each location (p = 0.1). Results also showed no significant difference in the number of prey consumed at one site over the other. Fish and crayfish (*Procambus clarkia*), the preferred prey among the otter, were determined to be present at both locations throughout the year. This continual presence of the preferred prey of the otter was reflected in their diet. Study results showed a statistically significant shift in the seasonal prey preference.
Acknowledgements

I would like to acknowledge and thank Mr. Conrad Diethelm of the DOW Wetlands and Ph.D. Dick Bogaert of the Mt. View Sanitary District for their assistance. These individuals were beneficial in providing access to study sites, which consisted of two separate locations within the Sacramento-San Joaquin Delta that have river otter populations. Both experts provided me with in-depth knowledge of their respective sites, as well as unlimited site access during the research phase.

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1. Introduction

The following study was completed to test for the presence of seasonal prey shifts in populations of *Lontra canadensis* (otter) at two locations within the Sacramento-San Joaquin Delta (Delta). In this study, otter populations at the two study sites were observed for approximately two years. This study consisted mainly of otter spirant analysis, but also included recording otter eating habits and behaviors when possible.

1.1 Description

Otter have long cylindrical-shaped bodies measuring approximately 0.9 to 1.5 meters (3 to 5 feet) long, with tails approximately 50 centimeters (20 inches) long. Their weights range from 5-14 kilograms (11 to 30 pounds). Their fur is mainly dark brown in color with a lighter-colored underbelly and muzzle, which is more pronounced in mature males and females (Photograph 1). Their heads are small and rounded and similar in appearance to that of a small, domesticated cat. Their noses are small and protrusive and their eyes are set on either side of their face in binocular fashion. The ears are small and are adapted to close when under water.

Otter necks are thick and muscular to aid in oscillations through the water. There is no narrowing between the head and the thorax. Their legs are short and their feet are webbed, with the hind feet having significantly more webbing than the front. Additionally, both hind feet contain four pads, each containing glands. The pads aid in traction on slippery surfaces, and the glands work as chemical transmitters, possibly for identification purposes (Braun 2005).
1.2 Distribution and Decline

Nine species of otter are known throughout the world (Preston et al. 2004). Otter are classified within the family *Mustelidae*, which also includes weasels, badgers, and skunks. According to a taxonomic study, the North American river otter belongs to a new category of otter, which is a genus of freshwater otter from the American Continent (Van Zyll de Jong 1972). This genus is composed of four species of river otter including: northern, southern, neotropical, and marine. The new genus of otter originated in Eurasia then spread southward from the Bering Land Bridge across North America and down the Panamanian Land Bridge.

In an early review, Van Zyll de Jong (1972), described the distribution of Nearctic otter (*Lontra canadensis*). At the time of European settlement, the Nearctic otter lived throughout much of the North American continent except in areas with extensive permafrost and deserts without permanent streams. Until the 19th century, the otter was found in and along all major waterways of the United States and Canada. Prior to the influx of Europeans, who trapped otter for their pelts greatly reducing the population, the otter’s range once encompassed the largest geographic area of any North American mammal, approximately 20 million square kilometers (~7.7 million square miles). Northwest companies indicate that otter harvest peaked in about 1800 when some 65,000 otters were taken in North America. Otter take gradually declined to a low of about 4,500 in 1904 (NGPC 2013).

Otter have been hunted and marketed for the commercial value of their incredibly soft and warm pelts for centuries. Commercial hunting of the Nearctic otter intensified
following the arrival of European settlers into North America between the 1500's and 1600's. In the 1700s, Russian settlers, attracted by the richness of both marine and freshwater mammals in and around the Pacific and Alaskan Islands, continued to harvest and further stress the freshwater otter populations. The freshwater and marine otter continued to endure the ravishes of hunting well into the 20th century. According to hunting records dating to 1941, one expedition that year came home with one million dollars worth of otter pelts. Around this time the typical price of an otter pelt was one quarter (Larsen 1984).

The vast abundance of both the marine and freshwater otter made them easy targets for hunters, which fueled an influx of fur hunters and traders throughout the west. Additionally, otter were, and continue to be, considered a large nuisance to fishermen who claim that the animals eat the available fish, resulting in lost profits.

Within the past two decades, wetland conservation programs and reintroduction programs have helped otter to re-inhabit approximately 75 percent of their original historic range. The present distribution of the otter in North America extends from Florida to northern Alaska and from Eastern Newfoundland to the Aleutian Islands (Larsen 1984).

1.3 Prey

The otter is well adapted to water and their diet consists primarily of aquatic animals such as fish and crustaceans. Otter are also known to eat reptiles, amphibians, birds, insects, mollusks, and small mammals. Fish are the most significant prey of the
otter, appearing in the animal’s diet throughout the year. Crustaceans (e.g., crayfish) are the second most prevalent staple of the otter diet; in some geographic areas, they are even more important than fish (Larsen 1984). One 1974 study conducted in the Suisun Marsh found that at certain times of the year, crayfish accounted for nearly 100 percent of the otter diet (Grenfell 1974). Penland and Black (2009) in their study of scats in Humboldt Bay determined that fish was the dominant prey type, followed by crustaceans.

1.4 Spraint Sites

Spraint sites are locations that otter specifically designate for excrement, herein referred to as spraint. In this study, spraint sites were used continuously by multiple otter and often contained more spraints at locations nearer to food sources. The number of spraints was generally a good indicator of otter activity at a particular location. As a generalization, more spraints equates to more otter.

Otter are known to repeatedly visit spraint sites throughout their home ranges (Ben-David et al. 1998). Spraint sites are also associated with social interaction and there is also evidence that marking at spraint sites increases during the mating season (Ben-David et al. 1998).

Researchers interested in studying the diet of freshwater otter populations have two common methods. Serfass et al. (1996) examined spraint contents collected in the field, while Toweill (1974) examined gut contents from otter caught by fur trappers. The food contents are generally identified and separated by family and species, where possible, in order to determine the prey selection and amount.
1.5 Home Range

The home range of the male otter can be up to 160 linear kilometers (~100 miles). Females can range up to 80 linear kilometers (50 miles) without pups and up to 48 kilometers (30 miles) with pups (OLROIFP 2010). The otter's home range varies according to age and sex and can be determined by the resources present including: the distribution of available habitat, food, and water.

Weather and topography can also influence how far an individual travels. For example, an otter may travel further during wet winter months, with increased watershed connectivity. Watershed connectivity can further travel thus increasing the availability of food. During the dry summer months, watershed connectivity is at a minimum, thus decreasing the ability for travel and food (OLROIFP 2010).

2. Study Locations, Observation and Spraint Collection Methods

The study areas consisted of the DOW Wetlands Preserve in Antioch California (DOW); Figure 1 shows a vicinity map of DOW and Figure 2 shows an aerial map. The second study area was the Mountain View Sanitary District in Martinez, California (Mt.View). Figure 3 shows the Mt. View vicinity map and Figure 4 shows the Mt. View aerial map. Both sites are located within the Sacramento-San Joaquin Delta. The Delta is located inland from San Francisco Bay. Here the fresh to brackish water from major waterways converge and mix with in-coming saltwater from the Pacific Ocean. The Delta then flows west to the Pacific Ocean. The Delta supplies more than 25 million Californians with their drinking water. In addition, it provides much needed water to
agricultural, industrial, and manufacturing businesses located in more than 5,000 square miles from Sacramento to the north and Palo Alto to the south.

2.1 DOW Wetlands Location

DOW is located south of the DOW chemical plant at 901 Loveridge Road, Pittsburg, California (Figures 1 and 2). DOW is a 471-acre former US Steel dumping ground purchased by the DOW Chemical Company in 1989. It is lush with vegetation and has a continuous supply of both fish and crayfish throughout the year (Photograph 2). My site contact was Conrad Delthiem, a former DOW employee who has volunteered at DOW since 1998. Mr. Delthiem indicated that the site is comprised of a series of tidal ponds located along the Delta. It is located approximately one mile north of Highway 4, which is heavily traveled.

2.1.1 Site Description

According to Mr. Delthiem (pers. com.), following the 1989 purchase of DOW, the site flooded when one of the nearby Delta levees was breached; the area remained flooded until 1997. With help from the Wildlife Habitat Council (WHC), DOW restored the wetlands to their current condition. The WHC was established in 1988 by organizations such as Anheuser-Busch Companies, Inc., DuPont Company, ExxonMobil, General Electric Company, Tenneco Oil Company, United States Steel Corporation, and environmental groups. Its mission is to combine cooperative efforts between the environmental community and industry (DCC 2010). Additionally, since 2002 the DOW chemical company and the Environmental Protection Agency have been working together to create a government/industry restoration bond to restore the wetlands (DCC 2010).
DOW is supplied with water from both the Delta and the DOW chemical plant. DOW is partially surrounded by undeveloped land containing wildlife with the remainder of the surrounding area containing heavy industry including: a power plant, a sewage treatment facility, and a railroad that runs directly through the site (DCC 2010). The site contains diverse habitat types, including estuarine tidal marsh, emergent marsh, seasonal wet meadows, savannah, scrub shrub, and forested fringe, and serves as a nature preserve and environmental buffer zone, with 220 acres actively managed for wildlife (DCC 2010).

DOW consists of a scenic stretch of land on the San Joaquin River. Its wetland preserve is home to the salt marsh harvest mouse (*Reithrodontomys raviventris*), a federally and state listed endangered species. Other larger species present at DOW include beaver (*Castor canadensis*), western pond turtle (*Actinemys marmorata*), and red-eared sliders (*Trachemys scripta elegans*) (DCC 2010). DOW is also home to more than 130 bird species and is a major stopping point along the Pacific Flyway, a migratory bird route that originates in the Arctic and ends in Patagonia, Chile, and Argentina where it joins other flyways. Birds viewed during observations included coots (*Fulica americana*), snowy egret (*Egretta thula*), great egret (*Ardea alba*), various gulls (*Sternidae sp.*), Canada geese (*Branta canadensis*), bufflehead (*Bucephala albeola*), blue heron (*Ardea herodias*), ring-necked duck (*Aytha collaris*), least tern (*Sternula antillarum*), double breasted cormorant (*Phalacrocorax auritus*), and mallard (*Anas platyrhynchos*). (DCC 2010)
2.2 Mt. View Sanitary District Location

Mt. View is located adjacent to the Benicia Bridge (Figures 3 and 4). My site contact at this location, Dick Bogaert, Ph.D., is a Wetlands Biologist/Analyst. Since 1923, Mt. View has provided sewage collection and treatment services for a portion of the City of Martinez and unincorporated areas of Contra Costa County. It is also the first wastewater treatment facility in the San Francisco Bay Area to be certified as a Green Business. To attain this status, the facility had to comply with regulations to conserve resources, recycle, and reduce waste (MVSD 2011).

2.2.1 Site Description

Mt. View operates and maintains approximately 100 miles of sewage systems. It is responsible for collecting and treating an average of two million gallons of wastewater per day for 25,000 residents including small businesses. Following treatment, the water from Mt. View flows into a series of marshes as opposed to having a deep-water outfall, as do most wastewater treatment plants; see photograph 3 (MVSD 2011).

Since 1974, Mt. View has reclaimed its effluent through use of its 21 acre wetland Moorhen Marsh. Moorhen Marsh flows into a 130 acre natural wetland, McNabney Marsh, which Mt. View assists in managing. Since 1988, Mt. View has jointly assisted in managing McNabney Marsh with the East Bay Regional Parks District, the Contra Costa County Mosquito and Vector Control District and the California Department of Fish and Wildlife (MVSD 2011).
The wastewater from Mt. View provides organic and inorganic nutrients that Dr. Bogaert believes help support the basic food chain of the marsh (pers. com.). The marshes support a variety of aquatic invertebrates, waterfowl, and other wildlife. Thus far biologists have identified 123 species of birds, 69 species of plants, 26 species of mammals and 34 species of aquatic invertebrates in the marsh (MVSD 2011).

During winter bird migrations, the marsh entices European wigeon (*Anas penelope*), green-winged teal (*Anas crecca*), sandpiper (*Calidris sp.*), North American shoveler (*Anas clypeata*), and northern pintail (*Anas acuta*) to feed and rest. Unusual birds show up in the fall through early spring. In seasons past, red-shouldered hawk (*Buteo lineatus*), and stilt (*Himantopus sp.*), have visited the marsh (MVSD 2011). Birds viewed during observations included: coot, snowy egret, great egret, black heron (*Egretta ardesiaca*), various gulls, Canada geese, blue heron, double breasted cormorant, mallard, long-billed dowitcher (*Limnodromus scolopaceus*), black-necked stilt (*Himantopus mexicanus*), killdeer (*Charadrius vociferous*), and belted kingfisher (*Megaceryle alcyon*). Other species present include red-eared sliders, and beaver (MVSD 2011).

2.3 Methods

2.3.1 Spraint Collection and Analysis Methods

Spraint analysis was used to determine the frequency of occurrence of specific types of prey in the diet during a given season, thus in turn, determining if there were any shifts in food consumed from season to season.
Spraints were collected and analyzed for their contents from August 2005 through February 2007. Spraints were collected from regularly used spraint sites at DOW and Mt. View. Generally only fresh spraints were collected, however, on some occasions, older spraints were collected if fresh spraints were not found. Spraints were collected with a small plastic scoop, placed into labeled Ziploc® bags, and refrigerated until they were later analyzed for their content. Prior to sample collection, the spraints were photographed. The images were later downloaded and sorted by observation date and location.

Length and width measurements were recorded prior to removing spraint samples from Ziploc® bags to prevent sample disturbance. Next, one tablet of Efferdent® denture cleaner was placed into a small, labeled, glass finger bowl. The finger bowl was then filled with tap water to dissolve the Efferdent® tablet completely. The spraint sample was then placed into the finger bowl and was left to soak overnight in the mixture of tap water and Efferdent® (Photograph 4).

Next, the spraint samples were placed into a mesh fishnet and rinsed under running water for approximately 30 seconds until the water ran clear. The finger bowl was then rinsed and dried and the spraint sample was replaced into the dry, labeled finger bowl. The sample was then placed into a Precision Thelco Model 18 drying oven at 25ºC for approximately one hour, and then allowed to air dry to prevent shrinkage.

Once dry, the sample was placed under a 10X microscope. Sample contents were identified and sorted into the following categories: fish, crayfish, insect parts, hair,
blackberries, and unidentified. The percentages of items identified at each location appear in Figures 5 through 8. The occurrences of prey in spraints were tabulated using a numerical scale (1-5), which corresponded to the approximate percentage of prey in the sample, i.e., 0 = 0%; 1 = 1%-20%; 2 = 21%-40%; 3 = 41%-60%, etc.

Statistical analyses comparing DOW and Mt. View were completed using the recorded contents from the spraints. The analyses were done to determine if there were statistical differences for the following:

1. The percentage of a given prey item in a collected spraint.
2. Whether the two sites drew from the same food sources.
3. Whether the otter diets remained the same from season to season.

For the above-mentioned statistical analyses, the statistical tests used were the Mann-Whitney U Test (MWU) and the Kruskal-Wallis Test (KW). The MWU test was used to determine whether there was a statistically significant difference between DOW and Mt. View regarding the quantities of types of prey collected throughout the study based on the percentage found in spraints. The KW test was used to determine whether there was a statistically significant difference between DOW and Mt. View regarding spraint contents from season to season.

2.3.2 Behavioral Observation Methods

During behavioral observations, signs of otter including prints and spraints were documented. When otter were spotted, the observer documented the number of
individuals viewed, their behavior, and the length of the observation. Observations took place in three to four-hour time periods. Observation areas were chosen for their large viewing areas with minimal obstructions. Otter were identified using binoculars along with the unaided eye. At both sites, the researcher walked around the perimeter of an area composed of a series of ponds. Whenever an otter was observed, the researcher stopped to record its behavior. Each otter was observed until it was out of viewing range. Once the otter was out of viewing range, the walk around the perimeter of the ponds continued.

3. Results

3.1 Spraint Collection and Analysis Results

As evidenced through spraint contents at the two sites, overall diets differed between the two sites with only a marginal preference for crayfish MWU (U = 425, P = 0.1) at the Mt. View site. Here U is the statistic whose distribution is known, and P is a probability with the value ranging from zero to one. This P value shows a slight but not quite statistically significant increase in the numbers of crayfish captured and eaten at the Mt. View site as compared to DOW. When compared to each other, there was also no statistical difference in the consumption of other foods, which included fish, blackberries, and insects.

Overall, spraint contents differed among the four seasons for insects (KW: \( H \) (corrected for ties) = 7.6, df = 3, P tied = 0.055), for hair (KW: \( H \) (corrected for ties) = 15.8, df = 3, P tied = 0.0012), and for berries (KW: \( H \) (corrected for ties) = 7.6, df = 3, P tied = 0.055).
The distribution of otter sightings was tested to determine whether the two sites drew from the same population. The MWU gave a result of $Z = -0.289$, $P = 0.7728$, not close to statistical difference. Therefore, statistically the two sites draw from the same population of otter, however field observations were contrary to this determination (See Discussion Section 4.0).

The MWU test was done to determine whether the two sites drew from the same food sources. Because the sample size for the number of spraints in which fish were found at both sites was larger than 8, a $Z$-value was used to approximate the significance level for the test. For fish, the MWU gave a result of $Z = -0.873$, $P = 0.3827$ (not reaching statistical significance). Therefore, according to the results of the MWU, otter groups did not differ significantly for percent consumption of fish overall.

For crayfish, the MWU gave a result of $Z = -0.655$, $P = 0.5127$, not a significant difference. Therefore, according to the results of the MWU, the two otter groups drew from the same sources of crayfish, although observations showed otherwise.

Examination of spraints showed that the otter diet included stickleback (*Gasterosteus aculeatus*), crappie (*Pomoxis sp.*), non-native crayfish (*Procambarus clarkii*), blackberries, small rodents, and insects. Photographs and analysis of otter spraints showed a majority of crayfish remains throughout the 2005/2006-observation period which were determined to be from the non-native crayfish species.

A comparison of the seasonal averages of fish found in spraints at Mt. View to the seasonal averages of fish found in spraints at DOW was completed (Figures 5 through 8).
Results showed that on average, DOW spraints contained a composition of fish at least 20 percent higher than at Mt. View for spring and fall (Figures 6 and 8). In addition, both sites show a steady decline in the average percentage of fish found in spraints from Fall 2005 through Fall 2006, with the exception of DOW during winter and summer 2006 (Figures 5 and 7), which show sharp increases with the winter proportion of fish being twice as high as the previous season.

A seasonal comparison of the percent of crayfish found in spraints at Mt. View and the percent of crayfish found in spraints at DOW was performed (Figures 5 through 8). In contrast to the results for fish, results for crayfish showed that, in general, Mt. View spraints contained a higher percentage of crayfish than DOW for all seasons sampled. This result is in agreement with the MWU test referred to earlier in the results section. Both sites show a steady increase in the average percentage of crayfish in spraints from Fall 2005 through Fall 2006, with the exception of winter 2006 at both sites, which showed a sharp decline.

Two summer spraints included various insect parts, which appeared to be from dragonfly (of the family *Libellulidae*, genus unknown) (Figure 7). Both samples containing insect parts were taken from DOW. The quantity of insect parts in samples was too small to indicate a shift in diet during these seasons and may have been accidental.

The summer season showed the greatest difference in diet for the otter. During summer, spraints contained small amounts of animal hair, blackberries, and insect parts
(Figure 7). Whether the hair was from prey or from the otter itself could not be positively determined; the hair from the samples was approximately 6.35mm in length (0.25in) and coarse, while otter hair is also coarse, but ranges from 12mm to 30mm in length, (0.47in to 1.18in) (Van Zyll de Jong 1972). Considering hair was not found in the other samples, it is a fair assumption that the hair may have been from a small rodent. No bones, indicative of a rodent or otherwise, were found in the sample.

Figure 6 shows spraint samples from the spring season of 2006. As with the rest of the seasons, the main diet consisted of crayfish and fish. Two of the samples, both from DOW, contained only crayfish.

Table 1 shows the total number of spraints in which each prey item was identified. It also shows the percentage of spraints that each prey item was identified in. For example, throughout this study 298 spraints were collected and analyzed; blackberries were located in a total of 10 (3.36 percent) of these spraints.

Table 1: Total prey occurrences in spraints (DOW and Mt. View)

<table>
<thead>
<tr>
<th>Prey</th>
<th>Number of occurrences in spraints</th>
<th>Percentage of prey occurrence in total spraints (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>113</td>
<td>37.92</td>
</tr>
<tr>
<td>Crayfish</td>
<td>169</td>
<td>56.71</td>
</tr>
<tr>
<td>Blackberries</td>
<td>10</td>
<td>3.36</td>
</tr>
<tr>
<td>Insects</td>
<td>2</td>
<td>0.67</td>
</tr>
<tr>
<td>Hair</td>
<td>4</td>
<td>1.34</td>
</tr>
<tr>
<td>Total</td>
<td><strong>298</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 2 shows the breakdown of each prey item by season using a percentage scale from 0 to 100. For example, hair was identified only in spraints collected in the
summer; therefore 100 percent of the occurrences of hair were during the summer. As stated previously, the occurrences of prey in spraints were tabulated using a numerical scale (1-5), which corresponded to the approximate percentage of prey in the sample i.e. 0 = 0%; 1 = 1%-20%; 2 = 21%-40%; 3 = 41%-60% etc. The frequency of occurrence of fish, crayfish, blackberries, insects, and hair changed seasonally. Figures 5 through 8 graphically show the composition of spraints for each season.

Table 2: Percentage of prey occurrence in spraints by season (DOW and Mt. View)

<table>
<thead>
<tr>
<th>Prey</th>
<th>Winter (%)</th>
<th>Spring (%)</th>
<th>Summer (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>33.63</td>
<td>18.58</td>
<td>17.70</td>
</tr>
<tr>
<td>Crayfish</td>
<td>21.30</td>
<td>14.20</td>
<td>29.59</td>
</tr>
<tr>
<td>Blackberries</td>
<td>0.00</td>
<td>0.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Insect</td>
<td>0.00</td>
<td>0.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Hair</td>
<td>0.00</td>
<td>0.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

There was an inverse relationship between the occurrence of fish and crayfish in the diet of otter; as the occurrence of fish decreased, crayfish occurrence increased, and conversely, as fish increased, crayfish decreased.

Nematodes of the genus *Dioctophymatildae* were identified in three spraints collected on three separate dates from the same location of Mt. View during the winter seasons. The *Dioctophymatildae* were approximately three inches in length.

3.2 Behavioral Observation Results

Otter were observed hunting both individually and in groups of three or more working together to herd fish in a particular direction and then capture them. Smaller fish were eaten in the water; however, larger fish typically were taken onto land and eaten.
Although hunting was mainly in packs, otter were not observed sharing their catch with each other. Otter at both DOW and Mt. View were observed foraging more often during the winter months. Additionally, during winter months, fewer otter were observed overall.

The otter behavior observed at both locations, for the most part, stayed consistent with that location. The otter population sizes changed from season to season (mainly summer, fall, and winter), suggesting that the observed families of otter likely combined and disassociated. Generally, most otter families consist of a mother, a female helper, and pups (OLROIFP 2010).

The largest groups of otter (six or more) generally occurred during the spring and summer seasons. These groups consisted of smaller otter with bodies less than approximately 1 meter (3.28 feet) in length. Based on this information, and the knowledge that female otter tend to group together with pups before they are large enough to be on their own, it was concluded that the larger groups of otter were females with juveniles.

At DOW, otter were observed barking and whining in the presence of the observer when the observer was close to the denning area. The otter also took advantage of the floats built for them by the Boy Scouts. Otter were observed eating, running, and playing on and around the floats during the day. A majority of the otter observations at DOW were of otter hunting and eating fish.
One to two large-sized otter, approximately 1.2 meters (4 feet) from head to tip of tail, were recorded during nighttime winter observations in 2005 and 2006. The gender of these otter most likely was male as they were large in size and solitary, which is typical of male otter behavior (OLROIFP 2010). These otter were observed “lap” swimming (in a repeating back and forth pattern) near their dens without the company of the smaller, more playful otter. This activity began at approximately 8pm at both sites and continued throughout the night until at least 2am. During this time, the otter were not observed hunting, eating, or performing other significant activities. This behavior was observed on three separate site visits.

Otter were also observed using spraint sites, hunting, and vocalizing (including barking, grunting, and the production of high-pitched whistling sounds). Families of otter at DOW were often seen returning home to their den late in the morning; likely from a morning hunt. The otter families observed at DOW appeared to have a variety of den locations. One den was located at the eastern pond within a set of reeds and vegetation (Photograph 5). Otter were observed leaving this location during the evening and returning to this location during the morning between 6am and 8am.

4. Discussion

This study, which included field observations, spraint analysis, and literature review, determined that the diet of the river otter, at both DOW and Mt. View, does shift according to season if the preferred prey is present. In other words, other factors being equal, the otter will predominately consume its food of choice independent of the season.
Spraint analysis showed a preponderance of mainly crayfish and fish in the diet, even when other food sources such as blackberries were available.

One explanation for not having a significant shift in food choice could be the ease of capture and the caloric density of the preferred prey. If crayfish and fish numbers, both of which provide high-caloric content, are abundant, the ease of capture is increased and the otter spends less energy obtaining food maintaining a caloric surplus that is not likely to be created capturing and eating an alternate prey such as rodents (which likely take more energy to capture), or blackberries, or insects (which are comparatively low in calories). Based on their knowledge and experience of their respective locations, both Mr. Diethelm of DOW and Dr. Bogaert of Mt. View confirmed that their sites have a complement of small, slow-moving ponds and abundant supplies of crayfish throughout the year.

Research has shown that the ease of capture and seasonal availability of prey determines the otter’s food habits and prey preferences (Erlinge 1968). Erlinge observed that hungry otter, which had gone without food for approximately 16 hours, attacked whatever prey they saw, including dead fish. Otter that had eaten 900-1,000 grams of food ignored less motile prey such as crayfish. In general, otters consume between 700-900 grams per day.

This study’s results support studies of Fairley (1972), Toweill (1974), and Larsen (1984) that indicated crustaceans were the second most important food source for otter.
These studies also support the hypothesis that if fish and crustaceans are not available, a shift in prey occurs.

Studies by Barbosa et al. (2001) on the European otter (*Lutra lutra*) were conducted to determine what caused the differences in distribution of otter throughout different provinces in Spain. The Barbosa study supports the idea that the seasonal availability of prey may have a direct correlation with the distribution of otter populations. As hinted at in their 2001 study, otter distribution might be attributed to “factors related to food availability, such as availability and local abundance of prey” (Barbosa et al. 2001). The Barbosa study also states “not all provinces were sampled in the same season” (Barbosa et al. 2001).

Toweill’s (1974) study found that the diet of the otter does indeed change according to season. Toweill attributed changes in diet from season to season to the seasonal availability of the food source. Additionally, the changes in diet tended to occur primarily in locations that experience major weather changes, such as yearly snowfall and snowmelt.

Larsen (1984) analyzed the gut contents of otter in coastal Southeastern Alaska. Larsen concluded that the otter diet consisted mainly of fish followed by crayfish, which is similar to the findings of this study. However, Larsen found that fish consistently made up the majority of spraint contents for all seasons, which was not the case in this study. Of the total spraints analyzed by Larsen (1984), fish were present in 100 percent of winter spraints; 95 percent of spring and summer spraints, and 98 percent of fall spraints.
Similar to this study, the remaining percentage of the diet consisted of crustaceans, in this case various types of crab of the order *Brachyura*. However, in the Larsen study, the percentage of crustaceans was low, which makes it difficult to distinguish between preference and availability of prey.

The results of the 1974 study by Toweill on river otter in Western Oregon, which analyzed the gut contents of otter killed by hunting, support the findings of this study. Toweill (1974) concluded that “fish were found to be the most important food item as indicated by high volume”. Fish occurred in 60 of the otter guts, or 80 percent of total otter guts analyzed (Toweill 1974).

Similar to this study, Toweill (1974) found that the next most important food source was crustaceans. One difference between Toweill’s study and this one is that the gut contents analyzed in Toweill’s study were from fall and winter months (November 15th through February 15th). Also, the data in the Toweill study was not separated by month but was combined. Since Toweill’s data was from November through February, it was compared to this study’s fall and winter season data. As in this study, when comparing the fall and winter seasons, fish content in spraints were highest in winter in comparison to other prey. The Toweill study attributes the high number of fish in winter months to the presence of coho coastal Salmon, *Oncorhynchus kisutch*, which were abundant in coastal streams and rivers during spawning.

Also similar to this study, Larsen (1984) found that there was a possible compensatory relationship between fish and crab in the diet of otter; as the occurrence of
fish decreased crab occurrence increased, and conversely, as fish increased crab decreased. In the Larsen (1984) study, seasonal changes in the occurrence of crab and fish in otter spraints were not significantly different. Larsen speculated that the increase in occurrence of crabs during spring and summer may have been due to increased availability; several species of crabs moved into shallow water in the spring and summer where they breed (Larsen 1984).

In Webb’s (1975) two year study of otter in the Somerset in southwest England, 86 percent of spraint samples contained fish remains, in that case eel (*Anguilla anguilla*) and stickleback (*Gasterosteidae sp.*). As in this study, Webb (1975) used the number of times an item was found in a spraint sample to create the percentage of occurrence for each prey item found. Also, as in this study, Webb (1975) provided the breakdown of spraint analysis by season and noted a drop in the occurrence of fish in spraints during the summer. A drop in fish prey during summer season was also observed in this study.

In his study on river otter on the Agivey River in Northern Ireland, J.S. Fairley (1972) found that the European otter (*Lontra lontra*) diet consisted mainly of fish with the following percentages of occurrences in spraints; salmonids were identified in 81 percent of spraints, perches in 15 percent, and freshwater eels of the family *Anguillidae* in 9 percent.

More recently, in a winter study in Kentucky from 2006-2009 examining the gut contents of 126 otter, Barding and Lacki (2012) determined that the main prey items of otter in the Kentucky area were fish and crayfish, respectively. Eighty-six percent of the
intestines contained fish and 27 percent contained crayfish. Barding and Lacki (2009) found no statistical variation of diets among males, females, or juveniles.

The above studies show that fish are the preferred prey of river otter, and that when fish are less abundant an alternate source, which seems to be crustaceans, will be substituted in the diet.

In the study presented here, the number of spraints collected at both DOW and Mt. View was the lowest during the spring season. This may be attributable to the tendency of otter to travel farther when waterway connectivity is increased. As the otter migrate along the waterways of the Delta during spring, the opportunities for finding food are increased. This timing also corresponds with the timing of salmonid migrations, which occur from spring to early winter, depending on the species (Penland 2009). In spite of this, spraint results showed that crayfish continued to be the otter's main food source throughout the year.

During the spring and summer seasons at DOW, the site's northern onshore area was overgrown with ripe blackberries. Three of the eight spraints collected in this area during summer contained blackberries (Figure 7). However, other spraint at this site still contained a majority of crayfish parts. DOW spraints analyzed from the spring season did not contain blackberries. This was likely because blackberries were not available outside of the summer season. Although otter spraints contained a majority of crayfish parts, otter were not observed hunting or eating crayfish.
During feeding observations, otter occasionally were observed hunting fish. During a 25 minute observation conducted at DOW on December 5, 2006, approximately nine otter were observed herding fish in one of the northern ponds. Two otter, approximately 1.2 to 1.5 meters (four to five feet) long were assumed to be male. The fish herding appeared systematic. The otter would herd the fish first from north to south, then east to west.

Erlinge’s hunting and feeding observations in his 1968 study were similar to those observed in this study. Erlinge also observed that larger fish were taken to the shore and eaten, while smaller fish were consumed while swimming (Erlinge 1968).

Spraints taken from DOW on December 5, 2006, following the hunting observation, contained small bones but no scales. This is indicative of stickleback. Sticklebacks are smallish fish approximately 10.2 centimeters (four inches) long. They lack scales giving them a shiny appearance (McGinnis and Alcorn 2006). Occasionally, larger fish of approximately 30.5 centimeters (12 inches) long, possibly crappie, were observed being captured, generally by the larger (male) otter. These fish were taken on land by the captor otter and eaten. Although the otter worked together herding fish, the otter were not observed sharing their prey, regardless of the prey's size.

As stated in the Results, nematodes were found in winter spraints. Hoberg et al. (1997) determined that marine intestinal parasites ingested were indicative of otter with relatively extensive home ranges, while the helminth was indicative of eclectic food habits. The fact that this study found parasitic worms, or helminthes, in spraints during
the winter at Mt. View could indicate more opportunistic feeding habits. However, it is more likely the helminth was ingested during the consumption of fish because the otter at Mt. View (where the helminth was found) have a continuous supply of fish.

Additionally, aside from the helminth, fish and crayfish were the only food items found in spraint samples during the 2005 winter season at Mt. View. Because the helminth was found only during the winter season at Mt. View, it can be concluded that it was likely from the intestine of one individual otter, or perhaps was from one particular group of otter. In the Hoberg (1997) study, the data collected were not broken-down by season and the details of the spraints contents were not provided.

Panesar and Beaver (1979) found the larval stages of the helminth *Eustrongylides sp.* in the intestine of an infected otter that was assumed to have ingested the larvae a few hours earlier from eating an infected fish. Similarly, this study assumes this likely was the method of ingestion of this parasite for the otter at Mt. View as well and therefore the nematodes were not included in the spraint analysis.

In this study, observations showed that group associations among otter changed seasonally, particularly at Mt. View. Previous otter studies have documented seasonal changes in group associations. One particular study, Blundell et al. (2004), concluded that social males leave their group and make long breeding migrations before the arrival of pelagic fish. Also as in this study, the Blundell study noted that individuals which were together during summer/fall months disappeared during the winter months, possibly due to migration, only to return and change their group association.
The repetitive swimming behavior noted in lone male otter during observations at Mt. View was not referred to in other studies reviewed. During this repetitive swimming the otter seemed thoroughly relaxed and calm as if swimming for enjoyment. It was not determined exactly why the otter was doing this, but speculations include patrolling the site for predators including other otter, or “play” as exhibited by older adult males.

Winter observations at DOW and Mt. View in 2005 and 2006 revealed highly social otter swimming and hunting in groups. The largest numbers of otter (approximately 5 to 10) were sighted during winter observations. Otter viewed during the spring and summers were often in smaller groups (approximately 2 to 4). Since no tagging was involved in this study, the individual behavior of each otter is not known.

According to Barbosa (Barbosa et al. 2001), for ecosystem management and biological conservation, otter studies examining a broad geographical range of study areas including waterways, wetlands, and associated riparian areas may provide context for other local studies. This researcher has found through observations that the following determinations made of other otter populations hold true for both otter populations in this study; prey consists mainly of fish and crayfish; the group dynamic of the otter varies according to sex, age, and season; and when water levels are higher the range of the otter increases.

Otter were observed vocalizing using high-pitched squeals, barks, and grunts. According to a previous study, otter barks can signify irritation (Van Zyll de Jong 1972). Considering that this researcher was located adjacent to one of the otter denning locations
as they were returning from hunting, it is logical to assume that they were irritated for this reason. High-pitched squeals were associated with swimming and wrestling play among larger groups of otter of approximately four or more. Vocalizations may help otter to keep track of each other, avoid predators, and prevent separation.

This study utilized spraint analysis and observations. Although the data were as accurate as possible, some inaccuracies may have occurred due to data errors. Possible sources of inaccuracy, which may have contributed to errors in data or unrepresentative samples, include:

- Spraint samples were generally collected from easily accessible locations which varied slightly throughout the study due to changes of otter activity and overgrowth at the collection site which may not have been a representative sample of a whole (Webb 1975);

- Since otter tend to consistently leave spraints in the same locations, most of which are deposited on top of heaps consisting of previous spraints with mud and grass scraped together (Erlinge 1967), it is sometimes difficult to obtain a single selected sample without additionally including portions of previous spraints;

- Visually the otter at DOW did not resemble the individuals at Mt. View and were treated as separate populations or groups. The sites were approximately 22 kilometers (13.7 miles) apart. Otter can travel up to 160 kilometers. Further studies would need to be completed to determine if the two sites do indeed draw from the same population. Otter at DOW consisted of family groups, that is, smaller-bodied otter indicative of female groups
with helpers and pups. Mt. View otter were mainly larger and more solitary, indicative of adult males.

- The proportion of fleshy to bony parts varies in different prey species and soft-bodied prey such as fish, jellyfish, or bivalves can easily be overlooked, especially if the bones are small and there are few within the sample unlike crayfish parts, which are often large and easily distinguishable.

Nevertheless the spraint analysis method employed in this study has been used on multiple occasions in past studies (Stephens 1958), and is believed to give a reasonable indication of the diet (Webb 1975).

Investigations of otter diets in other parts of the world have shown some differences. A study completed in Norfolk, Virginia (Weir and Banister 1971), determined that eel (*Anguilla unguilla*) and stickleback comprised the majority of the otter diet, while Fairley and Wilson (1972) and Stephens (1958) found the majority of remains in the otter diet consisted of approximately 81 percent salmon (*Oncorhynchus sp.*). Studies in Yorkshire England, and Scotland (Radley and Simms 1971, Hewson 1973) found percentages of mammal and bird remains to be approximately 20 percent. Another study (Webb 1975) found a diet consisting of fish prey with smaller quantities of bird and amphibian remains. This would agree with the results obtained by Erlinge (1967) in his comprehensive study of the food habits of the European otter in Swedish habitats.
Weir and Banister (1971) noted that during the summer months, cyprinids, (i.e., minnows and carp), were less present in the diet, but birds rather than crayfish replaced the fish during this season. Crayfish do not occur on the Somerset levels. Additionally, Erlinge (1968) mentions a reduction in the proportion of cyprinids in the diet during the summer season, which, during this period, are replaced in the diet with birds and crayfish.

In conclusion, the food preferences of the otter show slight variations among local populations and show a consistency around the consumption of fish and often crayfish. Apart from this, their food preferences are difficult to determine. Studies consistently show that the otter can eat a wide variety of species, taking what is available in their locality. For example, in this study fish and crayfish were readily available, but blackberries, insects, and small mammals were also eaten. The results support the results of this study that fish and crayfish are the preferred prey of the river otter and that if there is an abundance of the preferred prey throughout the year, there should be no seasonal shift in the otter diet.

4.1 Study Importance and Applicability

At present, each site is patrolled regularly by volunteers, onsite workers, and security, which limits even humans as potential predators. Mt. View is located on private property at a fenced-in location. Additionally, the gates at DOW are closed to the public after sunset. Hunting is not allowed at either location and both sites are regularly patrolled to ensure species protection. The absence of any predators and an abundant food supply creates habitat for the otter throughout the year.
It is important to note that future environmental changes in the Delta, including human development, most likely will be the deciding factor of the continued health of the river otter population. The effect of salt-water intrusion and levee failure continues to cause problems among documented fish populations (MVSD 2011). Yearly declines in native fish species are more common each year. The reductions in fish populations may contribute to a future shift in food choices, for example, to an increased consumption of berries and insects during the spring and summer seasons.

Over the past few decades (possibly due to climate change), rising sea levels and increased salt-water intrusion threaten to turn the Delta into a salty marshland and contaminate available fresh water resources (MVSD 2011). Currently, the approximately 1,000 miles of levees in the Delta act to keep the surrounding land dry and decrease saltwater intrusion. Additionally, water rights and usage of Delta water are a constant controversy affecting the health of the Delta and its associated otter populations. Cities and farmers unsatisfied with their water allocations are demanding more water decreasing Delta water levels and decimating aquatic habitats.

Mustelids, such as the river otter, are considered an indicator species. The health and sustainability of their populations are directly dependent upon the health of their surrounding habitat, in this case the Delta and its associated riparian areas. Fish and crayfish are main staples in the otter diet. If the presence of fish and crayfish at DOW and Mt. View remains consistent, these locations should continue to support a healthy otter population. Continued observation and monitoring of these two otter populations,
including using spraint analysis to assess the presence of fish and crayfish, is a good way to assess the health of the Delta.
5. References


Figure 1- DOW vicinity map
1 inch = 4 miles
Figure 2 - DOW aerial map. North is up, relative to this caption. Total scale yields ~ 2 kilometers (~1.2miles) width of this view.
Figure 3 - Mt. View vicinity map
1 inch = 4 miles
Figure 4 - Mt. View aerial map. North is up, relative to this caption. Total scale yields ~2 kilometers (~1.2 miles) width of this view.
Figure 5
Winter Spraint Composition
Figure 6

Spring Spraint Composition
Figure 7
Summer Spraint Composition
Figure 8
Fall Spraint Composition
Photograph 2: DOW (The majority of otter spraints at the DOW site were collected from this dock).
Photograph 3: Mt. View Sanitary District/ Moorhen Marsh, with Shell Oil refinery in background.
Photograph 4: Spraint samples soaking overnight in denture solution.
Photograph 7: Example of otter den