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Regional Differences in Wild North American River Otter (Lontra canadensis) Behavior and Communication

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REGIONAL DIFFERENCES IN WILD NORTH AMERICAN RIVER OTTER (*LONTRA CANADENSIS*) BEHAVIOR AND COMMUNICATION

by

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ABSTRACT

This study focuses on the vocalization repertoires of wild North American river otters (*Lontra canadensis*) in New York and California. Although they are the same species, these two established populations of river otters are separated by a significant distance and are distinct from one another. River otters are semi-aquatic social predators that can be found throughout North America. This is the first study to examine the vocalizations of wild river otters, and results are compared across field sites in the different regions. River otter vocalizations and behaviors in New York were recorded using Bushnell Aggressor trail cameras that were placed in areas of moderate to high river otter activity. The River Otter Ecology Project, a nonprofit organization studying river otter populations in Marin County, provided the otter videos from California. Recorded vocalizations were separated into categories based on their appearance on a spectrogram and parameters including frequency and duration were measured for each call. Behaviors were identified in all New York videos and during vocalizations in both New York and California videos. Four call types (*chuckle, hah, chirp, and whine*) were recorded in both California and New York otters. An additional call (*chirpwhine*) was recorded only in the California population. Otters in both populations produced *chuckles* while traveling, scentmarking, and investigating. *Hahs* were produced during disturbance, food, play, and rub behaviors. Otters were most likely to produce *chirps* when they were stationary and alone. *Hahs* were most likely to occur in pairs, and *chuckles* and *whines* were more likely to occur among groups of 3 or more otters. This study not only contributes to the limited knowledge that exists on the North American river otter vocalization repertoire, but also bridges the gap between animal acoustics and

behaviors, providing behavioral context for this elusive species' most common call types in the wild.

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LIST OF ABBREVIATIONS

USM	The University of Southern Mississippi
km	Kilometer
cm	Centimeter
Hz	Hertz
kHz	Kilohertz
dB	Decibels
NY	New York
CA	California
WPRR	Ward Pound Ridge Reservation
MRG	Mianus River Gorge
AP	Arshamomaque Preserve
LF	Low Frequency
HF	High Frequency
MF	Max Frequency
FQF	First Quartile Frequency
CF	Center Frequency
TQF	Third Quartile Frequency

CHAPTER I - INTRODUCTION

Otters

Otters are members of the Mustelidae family which includes animals such as weasels, minks, badgers, fishers, wolverines, and martens. Mustelidae are known for their strength, long bodies, insulating fur, and use of olfactory signs. Within the Mustelidae family, there are thirteen species of otter in the subfamily Lutrinae. The Lutrinae live on every continent except Australia and Antarctica and while they vary somewhat in appearance and behavior, all have strikingly similar life styles. All species occupy habitat near water and have adapted to it with webbed feet and long tails. Some species occupy salt water habitats while others prefer fresh water. Many otters, including the North American river otter (*Lontra canadensis*) (hereafter referred to as river otter) and the Eurasian otter (*Lutra lutra*), are able to occupy either type of water habitat. Otters are under two meters in length, with the giant otter (*Pteronura brasiliensis*) measuring on average 1.8 meters and the Asian small-clawed otter (*Aonyx cinerea*) measuring 0.9 meters (Yoxon & Yoxon, 2014). Otters are known to be opportunistic eaters that pursue a variety of prey, often depending on the species but especially on the habitat. These prey include fish, crustaceans, mollusks and a variety of small to medium-sized birds, reptiles, mammals, and amphibians. There are some reports of otters eating aquatic plants and berries (Kruuk, 1995).

Threats to Otters

Otters are considered an important indicator species of both aquatic and land habitats on the many continents they inhabit. However, their populations are declining worldwide due to pollution, habitat loss, and trapping. Of the thirteen otter species, river

otters are the only species identified as least concern for extinction (Serfass, Evans, & Polechla, 2015) by the International Union for Conservation of Nature (IUCN).

Near threatened otters include the four African otter species, the spotted necked otter (*Hydrictis Maculicollis*) (Reed-Smith, Jacques & Somers, 2015), Congo clawless otter (*Aonyx congicus*) (Jacques, Reed-Smith, Davenport & Somers, 2015), neotropical otter (*Lontra longicaudis*) (Rheingantz & Trinca, 2015) and African clawless otter (*Aonyx capensis*) (Jacques, Reed-Smith, Davenport & Somers, 2015), as well as the otter most similar to the North American river otter, the Eurasian otter (Roos, Loy, de Silva, Hajkova & Zemanová, 2015). Two Asian otter species, the smooth coated otter (*Lurogale perspicillata*) (de Silva, Khan, Kanchanasaka, Reza Lubis, Feeroz, & Al-Sheikhly, 2015) and Asian small claw otter (Wright, de Silva, Chan, & Reza Lubis, 2015), are both identified as vulnerable. The remaining otter species are endangered: Asia's hairy nose otter (*Lutra sumatrana*) (Aadrean, Kanchanasaka, Heng, Reza Lubis, de Silva, & Olsson, 2015), North America's sea otter (*Enhydra lutris*) (Doroff & Burdin, 2015), and all three of South America's otter species- marine otter (*Lontra felina*) (Valqui & Rheingantz, 2015), southern river otter (*Lontra provocax*) (Sepúlveda, Valenzuela, Pozzi, Medina-Vogel & Chehébar, 2015), and giant otter (Groenendijk, Duplaix, Marmontel, Van Damme & Schenck, 2015).

When discussing North American river otter vulnerability, it's important to keep in mind the status of other otter species as all thirteen face similar threats. These threats include hunting and trapping for fur, trapping for pet trade, habitat loss, and pollution (Yoxon & Yoxon, 2014). The North American river otter in particular is threatened by the fur trade as their pelts can sell for $200 (Yoxon & Yoxon, 2014). In the 1900s,

unregulated trapping in the United States led to the extinction of river otters in many states- between Pennsylvania and northern Georgia, and through parts of Michigan to Minnesota and Utah (Yoxon & Yoxon, 2014). Beginning in the 1970s reintroduction projects began throughout the southern states. Otters were trapped in northern areas where their populations remained more stable and released further south (Yoxon & Yoxon, 2014). This reintroduction was effective to the point of trapping being legalized once more in 11 of the 20 states they were reintroduced (Yoxon & Yoxon, 2014).

In 2013, Illinois relegalized trapping after 80 years when populations were reported to have increased from less than 100 in 1990 to 11,000 in 2009 (Yoxon & Yoxon, 2014). It's been estimated that currently over 40,000 otters are hunted or trapped in the US and Canada annually. It's possible these numbers are not sustainable – and it's therefore important that river otter populations continue to be monitored despite their current status of least concern for extinction (Yoxon & Yoxon, 2014).

North American River Otters

The focus of this study is on river otter vocalizations and their behavior associated with vocal communication. However, much of wild river otter behavior in still unknown or under studied. In order to best interpret the behavioral results of otters in this study, our current knowledge of river otter reproduction, diet, habitat use, range, and general behavior in the wild must first be summarized.

Life History

River otters live across the United States and Canada and can be found near fresh water rivers, ponds, lakes, swamps as well as along coast lines utilizing salt and brackish water. They have dark fur on their back and lighter fur on their neck and underside

(figure 1). Male river otters are larger and can weigh 17% more than adult females (Melquist & Hornocker, 1983). Adult females measured an average of 7.9 kg and ranged between 1.1-1.13 meters in length while adult males measured an average of 9.2 kg and had a range between of 1.15-1.2 meters in length. The same study found that tail length remained consistent across the sexes at 39% of total body length (Melquist & Hornocker, 1983). River otter tails are important to their aquatic lifestyle as they act as a rudder to help them steer when swimming.

Figure 1. River otter at Ward Pound Ridge Reservation, photo taken by a Bushnell no glow aggressor trail camera, Walkley, 2019

River otters are considered to be highly opportunistic feeders, like many other carnivores. However, the majority of their diet is fish. Fish was found in at least 93% of 1,902 scat samples analyzed across seasons in Idaho (Melquist & Hornocker, 1983). Melquist & Hornocker (1983) also discovered other prey including invertebrates, birds (waterfowl or suspected young or hurt birds), mammals (often muskrat), and reptiles (exclusively garter snakes). Diet is important in the current study because prey

availability may affect otter presence at study sites. Greater prey availability may be associated with more otter groups in the same area, while an area with reduced prey availability may result in some or all otters choosing to leave.

River otters often mate in late winter or early spring after a female gives birth to that year's litter. River otters are capable of delayed implantation and begin a two-month gestation period up to eight months after mating (Kruuk, 1995). After mating, males leave the female and have no involvement in the raising of young. In fact, females are very protective of young otters against males, even if the male is thought to be the father.

River otters are altricial and when pups are born between February and April they are blind and helpless, not emerging from their den until five weeks old (Larivière & Walton, 1998). They are weaned at three months but continue to rely on their mother until they are eight to thirteen months old. The mother teaches pups how to swim and hunt (Kruuk, 1995). River otter litters typically consist of two or three pups, but can have up to six pups (Yoxon & Yoxon, 2014). One study observed otters dispersing in April and May at thirteen months of age (Melquist & Hornocker, 1985). They reported that dispersal took about 30 days and was complete by mid-May. The otters would disperse both upstream and downstream. The furthest a male yearling traveled was 42 kilometers (km) and the furthest a female yearling travelled was 14 km (Melquist & Hornocker, 1985).

Several studies have investigated the individual range of male and female river otters (Melquist & Hornocker, 1985; Boege-Tobin, 2005; Wilson, 2012). Home ranges can vary by gender and season, and are likely affected by prey availability, habitat, weather, reproductive cycle, and conspecific presence (Melquist & Hornocker, 1985).

The home range area, where the otter spent at least 10% of their time, depended on the abundance of food and shelter and would change depending on the season (Melquist & Hornocker, 1985). The largest home range found when monitoring otters for a full year was a yearling male who traveled 63 km. The smallest home range over a full year of monitoring was an adult female who traveled 31 km. Using a conservative method of range calculation, a study in Nebraska (Wilson, 2012) found male otter ranges to average 21.8 square km and female ranges to average 8.5 square km. Wilson (2012) also found that overnight, otters would travel an average of 3.6 km. Studies from two different states (Nebraska (Wilson, 2012) and Missouri (Boege-Tobin, 2005)) found that male home ranges are generally larger than female home ranges. In addition to being larger, Boege-Tobin (2005) found that the home ranges of male otters would overlap more with both males and females, while females' home ranges would typically not overlap with other females.

Behavior

When not in transit, otters spend time at latrine sites, resting areas, and dens. Latrine sites are often more accessible to humans than dens. Latrine sites are areas of land that often jut out into the water; otters use them habitually to defecate, urinate, and deposit anal sac secretions. These sites simultaneously serve to communicate presence and personally identifiable information (such as age, sex, and reproductive status) to conspecifics (Kean, Müller, & Chadwick, 2011). Resting areas and dens are typically in more remote or harder to access locations for humans. They vary in appearance but include open or enclosed habitable areas, such as an open clearing in vegetation or an enclosed area such as a hole in a tree or among roots (Elbroch, 2003).

Otter latrine and resting sites are identified by the presence of tracks, scat, scrapes, and mounds. Otter scat, or feces, is recognizable by its size, composition, and proximity to water. River otter scat is 1-2.5 centimeters (cm) in diameter/7.6-15.2 cm in length and likely to contain fish scales, crayfish shells, or bird feathers but rarely berries or fur (Elbroch, 2003). River otter scrapes are scratches in the dirt, sometimes to create mounds, or small piles of leaves or dirt that have been pushed together. Often scat or secretions are found on top of mounds. River otter front track dimensions are 5.4-8.3 cm x 4.8-7.6 cm and their rear track dimensions are 5.4-10.2 cm x 5.4-9.5 cm (Elbroch, 2003). Tracks are asymmetrical with five toes and have mesial webbing and claws which may or may not register in the track. Front tracks are slightly smaller than rear tracks with toe one being the smallest. Toe one is long and pronounced in the rear track (Elbroch, 2003). Slides are easily recognizable otter tracks that are caused by otters gliding on their bellies on mud or snow, sometimes into water (Elbroch, 2003).

River otters are most active at night between dawn and dusk (Yoxon & Yoxon, 2014). One study of populations living on Martha's Vineyard, New York analyzed 1,912 trail camera visits and found 73% of visits were at night, 15% during the day, 8% at dawn, and 4% at dusk (Baldwin, 2013). Similarly, otter activity in Idaho peaked during nighttime hours, including dawn and dusk, and became increasingly diurnal in the winter months (Melquist & Hornocker, 1985).

The current study recorded behaviors at latrine sites in New York. Latrine site behaviors have been investigated previously in other parts of the United States (Baldwin, 2013; Green, Monick, Manjerovic, Novakofski, & Mateus-Pinilla, 2015). A study in Illinois that examined river otters at two latrine sites over the course of a year found

solitary otters spending an average of 15.6 seconds at latrine sites, while groups of two or more otters would visit for an average of 33.6 seconds (Green et al., 2015). Of 2,207 recorded behaviors, the most common behaviors were standing (20.5%) and sniffing (18.6%). Behaviors like rubbing (10.5%) allogrooming (5%), wrestling (4.4%), mounting (0.4%), feeding (0.4%), and traveling (16.5%) were also observed. Surprisingly, defecation comprised only 1.4% of the total behaviors exhibited at latrine sites (Green et al., 2015). Another study in Martha's Vineyard, New York found similar results; otters spent less than a minute at latrine sites 80% of the time and group visits would last longer than solitary visits. At these latrine sites, smelling/investigating (36%) and rubbing (19%) were the most time consuming behaviors, but scent marking (14%), playing (10%), eating (7%), traveling (7%), resting (3%), self-grooming (3%), and group grooming (2%) were also present (Baldwin, 2013).

Determining the sex of an otter in the wild while using noninvasive methods is difficult. Because river otters are often not individually identifiable, even if their sex is discovered in one observation, it will not necessarily be known in future observations. Therefore, having multiple methods of visually determining sex is useful. At times during grooming, identifying sex by genitalia is possible. One study of giant otters found that males and females appear differently if the individual is defecating and urinating simultaneously (Groenendijk & Hajek, 2014). Due to male urethra being farther forward from the anus than female urethra, male scat and urine cross in an X formation, while female scat and urine fall parallel (Groenendijk & Hajek, 2014). Because it was so infrequent that sex of an otter could be determined, sex was not used as a factor in this study.

Juveniles are otters in their first year of life and are still reliant on their mother (Melquist & Hornocker, 1985). Yearlings are otters between one and two years old (Melquist & Hornocker, 1985). Adults are over two years old and have therefore reached sexual maturity (Melquist & Hornocker, 1985). River otters grow quickly in the first year of life and are therefore difficult to distinguish from adults by appearance once a year old and independent.

River otters are often solitary. When groups are observed they are thought to comprise a mother and pups or all males (Yoxon & Yoxon, 2014). A year-long study in Martha's Vineyard, New York using trail cameras at 20 latrine sites found that 70% of latrine visits were by a solitary otter with the remainder of visits consisting of groups of two to eight otters (Baldwin, 2013). A year-long study in Illinois at two latrine sites found similar results with 73% solitary visits and 27% group visits (Green et al., 2015).

Otter Vocal Communication

Otters communicate through physical contact, sight, smell, and sound. Several studies have explored how river otters might be able to communicate their sex, mating status, and age by scent-marking at latrine sites (Kean et al., 2011, Kean, Bruford, Russo, Müller & Chadwick, 2017). Otter acoustic communication has been explored in sea otters (Mcshane et al., 1995), Eurasian otters (Gnoli & Prigioni, 1995), Asian small clawed otters (Lemasson, 2014), giant otters (Leuchtenberger et al., 2014; Mumm et al., 2014; Bezerra et al., 2010), and North American river otters (Almonte, 2014; Walkley, 2018). The acoustic repertoire of the remaining eight species have not been studied. Discussed below are many of the call types identified in otters, the broad categories these call types fit into, and which species have been reported producing these call types.

Chirps

Chirps are high frequency calls that are short in duration, similar to a single bird chirp. River otter *chirps* contain one to seven harmonics each usually frequency-modulated, with a concave contour (Walkley, 2018). *Chirps* are extremely common and have been found in six different human care populations of river otters (Almonte, 2014; Walkley, 2018). They were found to be the most common call type in a male-male pair, and in two populations, were observed during investigating and stationary behaviors and never during agonistic behaviors (Walkley, 2018). Almonte (2014) reported that *chirps* were present in the river otter vocal repertoire since birth.

Chirps have been called *contact calls* (Mumm et al., 2014) and *adults calls* (Leuchtenberger et al., 2014) in giant otters. Leuchtenberger (2014) found the most common context for *adult calls* was when an otter was separated from other group members and the *adult call* was produced as they looked around for them. In a sea otter study this call type may have been referred to as *squeaks* type 1 (McShane et al., 1995) and in a study of Asian small-clawed otter vocalizations as *U3 call* (Lemasson et al., 2014). If the sea otter *squeak* type 1 is analogous to a *chirp*, it's of interest that it was observed being produced by only two individuals in the study (McShane et al., 1995). Lemasson found the *U3 call* to occur during social isolation, affiliative interactions, and during exploration (Lemasson et al., 2014).

Chirps have been observed happening in quick succession (Almonte, 2014; Walkley, 2018). Almonte (2014) referred to this as a *chatter*, and found them to have a duration of 1.8 seconds and occur in aggressive contexts. They were labeled *chatterchirps* by Walkley (2018). The call was possibly also found in a Eurasian otter

study (Gnoli & Prigioni, 1995) and labeled a *staccato call.* The *staccato call* was also produced in antagonistic interactions, often involving food or territory (Gnoli & Prigioni, 1995). Lemasson et al. (2014) may have also found this call type in Asian small-clawed otters and labeled it *RE2*.

Hahs

Hahs are alarm calls that sound like air being exhaled loudly from the nose. Sometimes called *blows*, they've been found in six different populations of river otters in human care (Almonte, 2014, Walkley, 2018). Almonte (2014) found the *blow* to be produced when otters were moderately agitated. Calls similar to *hah* have been found in other species as well. In giant otters, the *snort* and a *hah* call have been identified as alarm calls (Leuchtenberger et al., 2014; Bezerra et al. 2011; Mumm & Knörnschild, 2014; Duplaix, 1980). These were both exhaling sounds that were alarm calls, but the *snort* was longer in duration. The *hah* call has been described as the call used at the initial sighting of a possible threat, rarely repeated by a single otter but often produced by several. If the threat continued, otters would begin producing a *growl* (Duplaix, 1980). The *snort* call was used for more severe threats and group members would react to it immediately (Duplaix, 1980). The *hah* was also found by Gnoli and Prigioni (1995) in Eurasian otters and was described as an immediate reaction to danger.

Variable Frequency Calls

Whines are a frequency modulated call with an average duration of 1.4 seconds that can be harmonic or nonharmonic (Almonte, 2014). Like *chirps*, Almonte (2014) found *whines* to be present from birth. Almonte (2014) found that *whines* were produced in different arousal states and Walkley (2018) found that whines were used only in

agonistic or displacement behaviors. Other variable calls that Almonte (2014) found in river otter populations were *creek, swish, hiss,* and *scream*. These calls were produced by only one otter, who was blind and would vocalize in defense (Almonte, 2014). *Whines* were also observed in sea otters (Mcshane et al., 1995). They described *whines* as a low frequency, low amplitude calls with pronounced frequency modulation.

Screams were similar to *whines* but would increase in amplitude as they progressed (Almonte, 2014). With an average duration of 1.5 seconds, the *scream* was used by female otters to successfully deter male otters from approaching when pups were present (Almonte, 2014).

Mcshane (1995) also reported a *scream* call in sea otters, which was produced when mother and pups were separated. *Screams* were harmonic, first increasing in frequency and then decreasing. Mcshane et al. (1995) also reported the variable calls *squeals, squeal-whines, squeal-screams, whimpers* and *squeaks* type 2 in sea otters. Gnoli & Prigioni (1995) reported *cries* in populations of Eurasian otters. They described a *cry* as a high and prolonged scream. This *cry* would have variable frequencies and would reach more than 16 kHz. It was observed when conspecifics were separated but nearby and during physical confrontations (Gnoli & Prigioni, 1995)**.**

Leuchtenberger et al. (2014) found several different *scream* calls in adult giant otters including *scream, high scream,* and *begging scream*. The *scream* was harmonic with a wavering quality that was often produced in conjunction with catching large prey or being caught trying to steal conspecifics' prey. The *begging scream* occurred during begging behaviors, and had a highly modulated tonal frequency. The *high scream* was produced along with *screams,* sometimes in the context of begging. *High screams* had a

nonlinear fundamental frequency that would include harmonics in only part of the call. A *wavering scream* has also been reported in a giant otter population (Mumm & Knörnschild, 2014). The modulated *wavering scream* was loud and piercing, and was observed during serious threats such as a caiman. The *wavering scream* was sometimes also observed during begging (Mumm & Knörnschild, 2014).

Low Frequency Calls

Several different low frequency calls have been identified across species. Most are produced in affiliative contexts when otters are in close contact. One low frequency call that is agonistic in nature is the *growl* in giant otters (Leuchtenberger et al., 2014) and sea otters (McShane et al., 1995). The giant otter *growl* was harmonic, pulsed and produced in warning and defense contexts (Leuchtenberger et al., 2014). The sea otter *growl* was harmonic with one to five peaks (McShane et al., 1995).

Leuchtenberger et al. (2014) also reported a variety of affiliative low frequency calls. These harmonic calls were *coo*, *coo-hum*, *hum*, and *purr*. These vocalizations would often be produced together and would occur during events such as greeting, taking care of cubs, scent marking, and grooming. These calls had a duration of 0.5 seconds or less. *Coo-hums* are a combination call and are discussed below in the combination call section. In addition to the above behaviors, *coos* were observed during activity changes. *Hums* had at least five harmonics. *Purrs* were the longest in duration and were the most frequent call of the four. *Coos* were also observed in sea otters and described as low-amplitude, low-frequency calls affiliative in nature (McShane et al., 1995).

An unidentified call recorded in river otters (Walkley, 2018) labeled *unclassified call A* is possibly analogous with Leuchtenberger et al.'s (2014) giant otter *purr*. Both calls have a low fundamental frequency with harmonics that extend to about 6 kHz.

Almonte (2014) described *grunts* as low frequency calls in river otters with a mean duration of 0.7 seconds. *Grunts* were produced in moderately agitated arousal states. A *grunt* call was also described by Mcshane et al. (1995) in sea otters, but this *grunt* may be closer to the *purr* recorded in giant otters. It was observed during non-stressful grooming and feeding (McShane et al., 1995).

Gnoli and Prigioni (1995) recorded a call they labeled *murmur* in Eurasian otters. The *murmur* was low frequency and produced when in close contact. They thought it might serve a reassuring or greeting function.

In this study the *chuckle* call is a low frequency pulsed call produced frequently at latrine sites. The *chuckle* is likely analogous to the *murmur*, *grunt*, or *growl* described in previous studies.

Combination Calls

Chirpwhines are a call first reported in river otters by Almonte (2014), labeled as *squeaks*, who described them as a shrieking *whine* with a duration of 2.1 seconds. The *squeak* in that study was a combination between *whines* and *chirps* that was produced by only one male in response to a human (Almonte, 2014). *Squeaks* were recorded in another river otter population (Walkley, 2018) and found to have a mean duration of 2.45 seconds and to be used in agonistic contexts between conspecifics. In this study, *squeaks* will be labeled *chirpwhines*.

Leuchtenberger et al. (2014) found a *coo-call* that appeared to be a combination of their adult call (possible *chirp*) and a *coo*. Their *coo-call* was observed when otters were calling to conspecifics and during high arousal, close contact events. Lemasson (2014) et al. found a very similar call to the *coo-call* but in Asian small-clawed otters. They labeled the call *CO* and it was comprised of their *U2* (possible *coo*) and *U3* (possible *chirp*) call.

Leuchtenberger et al. (2014) also identified a *coo-hum* call in giant otters, a combination call of *coo* and *hum*. The *coo-hum* was a low frequency, harmonic call with a mean duration of 0.2 seconds. The *coo-hum* was produced during close contact events such as swimming together and grooming.

Whistles

Whistles have been found in several species. Almonte (2014) found whistles in river otter pups before the age of eight weeks. Gnoli & Prigioni distinguished between two types of whistles in Eurasian otters - a feeble whistle and a loud whistle. The feeble whistle was short and quiet, and seemed to signal presence to conspecifics. The *loud whistle* was louder and longer, and was thought to be a long distance call. Mumm and Knörnschild (2014) found a *whistle* and *whistle double* in giant otters. They described the *whistle* as tonal, modulated, and likely a contact call, as it was produced by a mother whose cubs were following her. The *double whistle* was tonal but had two modulations. Mumm and Knörnschild (2014) observed *double whistles* occasionally during begging. McShane et all. (1995) found a *whistle* in sea otters. They described whistles as tonal and high frequency with three to four harmonics. The frequency would decrease throughout the call. *Whistles* were observed when young were separated from their mother and

sometimes during stressful otter grooming sessions with a human (McShane et al., 1995).

Current Study

This study explored the behavior and vocalizations of wild river otters from populations in New York and California. Results from three sites in New York (NY) were compared to sites in Marin County, California (CA). The following were this study's objectives:

(1) Describe behavior, group size, and season regardless of vocalizations between sites in New York.

(2) Compare the vocalization repertoire, vocalization parameters, and vocalization use between New York and California and between sites in New York.

My predictions of results are:

(1) I predicted similar use of latrines at all sites in the New York but that sites with the least human use (Mianus River Gorge) would have the most variety of otter use and that otters would be more diurnal when there is less threat of human interaction. I predicted that travel, scentmark, and investigate would be the most commonly observed behaviors but that rubbing and self-grooming would also be common behaviors across regions. I predicted that most observations would be of solitary otters, however all sites would have similar increases in group size once pups begin leaving the den with their mother in the spring. I was interested in discovering if certain locations would have more frequent, or larger, male groups. This would be a marker of the size of the overall population in the area.

(2) I predicted there would be variation of vocalization repertoire between regions. Based on reports from the River Otter Ecology on the high frequency of vocalizations and

prevalence of large family groups in the area, I predicted there would be more vocalizations present in the California populations as well as a larger repertoire. I predicted any calls that were found in both populations would have the same associated behaviors however, the parameters of the calls would differ by region.

CHAPTER II – METHODS

Participants

North American river otters living in New York and California that visited selected sites were the focus of this study. Recording at sites that were habitually and frequently visited by groups of otters were targeted due to the increased likelihood of vocalizations.

Procedure

Site Selection

Sites were chosen based on their location, accessibility, and presence of otters as determined by signs including scat, scrapes, slides, and tracks. Sites included latrines and resting areas. Once a likely otter site was identified, a camera was placed for one to three weeks to determine the frequency of otter use.

In New York, recording took place at three locations. Ward Pound Ridge Reservation (WPRR) in Cross River along the Cross River, Mianus River Gorge (MRG) in Bedford, NY along the Mianus River, and a fresh water pond in Arshamomaque Preserve (AP) in Southold, NY. Each location consisted of one, two, or three Bushnell Aggressor cameras that recorded video and audio in one minute segments.

Data collected by The River Otter Ecology Project at eight sites in Marin County, California were utilized in this study. Permits were received for placing cameras in Arshamomaque Preserve (Appendix B) and permission from Mianus River Gorge and Westchester County has been granted by email.

Trail Cameras

Once a site was confirmed to be actively used by river otters, one to three trail cameras were installed at the site to provide a wide viewing area of otter behavior both at the point of most activity and while otters are traveling to and from the site. Field sites were visited once every two to six weeks by a researcher. During each visit, data was downloaded from the memory cards and batteries were replaced as needed. Bushnell Aggressor Low Glow and No Glow Cameras were used. The motion activated cameras recorded video and audio for one minute after being triggered, and resumed recording if triggered again after a less than one second interval. The cameras were attached to trees or posts using a strap and further secured with a cable lock. Whenever possible, trees were used to avoid bringing extra equipment into the field site to reduce impact on the natural area, including the impact of leaving behind human related scents.

Behaviors of New York Otters at Latrine Sites

The number of seconds otters were observed in different behaviors were recorded for all videos of otters in New York in 2019. The behavioral ethogram (Table 1) was the same as used for analyzing behavior during vocalizations with the exception of two behaviors, visual scan and slide, described in results. In addition to specific behaviors, each visit by otters to a field site was analyzed for time of year (i.e., season) and number of otters in the group (i.e., group size).

Table 1 *Otter Behavioral Ethogram*

Behavior	Definition
Selfgroom	Otter is licking, biting, or scratching part of its body.
Rub	Otter is turning and twisting its body, encouraging contact between fur all over their body with a surface.
Allogroom	Otter is licking or biting part of another otter's body, or another otter is biting or licking part of theirs.
Play	Otter is running forward, laying body and head flat on the ground. Includes nonaggressive wrestling with conspecific.
Object Manipulation	Otter is grasping or manipulating an object other than food.
Agonistic	Otters are engaged in aggressive contact including biting, fleeing, or chasing. Other dominant behaviors such as when an otter "steps on" the less dominant individual included.
Displacement	An otter promptly travels away from a second otter to avoid conflict after receiving a signal, often a vocalization. Little to no physical contact.
Sexual	Otter is mounting or attempting to mount another otter. Can occur in water or on land.
Travel	Otter is walking or running in a manner to arrive at a new location, not actively smelling or exploring the area underfoot.
Swim	Otter is submerged in water and traveling.
Stationary	Otter is laying down or standing in one spot, mostly still. No other behavior in the ethogram is present.
Investigate	Otter is examining/exploring surroundings. A typical "investigation" will be an otter traveling, with nose pressed to the ground.
Scentmark	Otter is defecating, urinating, or depositing anal jelly. Often done in conjunction with scraping of the hind feet.
Disturbance	Otter is reacting to a perceived threat such as a predator or novel stimulus. Reactions vary and may include flattened ears, lowered body stance, lowered head, raised fur, or fleeing.
Hunt	Otter is fishing or foraging for food.
Drink	Otter is taking water into the mouth.
Eat	Otter is chewing or holding a food item in mouth.
Other	Otter is exhibiting behavior that is not seen in ethogram. Include behavior in comments.
Out of Sight/Partial View	Otter is not visible or only partially visible by the camera so that no behavior is discernable.

Vocalizations

Otter vocalizations were analyzed using Raven Pro 1.5 (Charif, Waack, & Strickman, 2010). Duration (delta) and six frequency measurements for each call were measured (table 2). Only calls collected on a trail camera with a sample rate of 44 kHz were used to determine parameters, as to include the lower frequency data would negatively skew the measurements. Calls were separated into categories used in previous otter studies based on their spectrographic parameters and contour (Walkley, 2018; Almonte, 2014). An effort was made to follow published call types and names whenever

it was the most practical to do so. Individual calls were considered separate when there was an inter-call interval at least .03 seconds (Walkley, 2018). Due to their pulsed nature, *chuckles* were considered a continuous call until separated by a 0.1 second interval.

Table 2 *Call Parameter Definitions*

Parameter	Abbreviation	Unit of Measurement	Definition (Charif, Waack, & Strickman, 2010)
Low Frequency	LF	Hertz (Hz)	The lower frequency bound of the selection.
High Frequency	HF	Hertz (Hz)	The upper frequency bound of the selection.
Max Frequency	MF	Hertz (Hz)	The frequency at which Max Power occurs within the selection.
First Quartile Frequency	FQF	Hertz (Hz)	The frequency that divides the selection into two frequency intervals containing 25% and 75% of the energy in the selection.
Center Frequency	CF	Hertz (Hz)	The frequency that divides the selection into two frequency intervals of equal energy.
Third Quartile Frequency	TQF	Hertz (Hz)	The frequency that divides the selection into two frequency intervals containing 75% and 25% of the energy in the selection.
Duration	Delta	Seconds (s)	The difference between Begin Time and End Time for the selection.

Behavior and Vocalization Interaction

In addition to vocalization parameters and repertoire, the context of calls was analyzed by studying the co-occurring behaviors of vocalizations in order to determine their behavioral and social significance. During all vocalizations at all field sites, the corresponding behavior of each call was analyzed using the ethogram in Table 1.

Behaviors assessed during vocalizations include selfgroom, rub, allogroom, play, object manipulation, agonistic, displacement, sexual, travel, swim, stationary, investigate, scentmark, disturbance, hunt, drink, eat, other, and out of sight. The ethogram used was adapted from a previous study investigating otters in human care (Walkley, 2018) to fit a wild population. Behaviors specific to captive otters, such as stereotypical pacing,

stereotypical scratching, stereotypical chewing, and begging, were removed. If otters displayed behaviors that were not present in the ethogram, they were marked as "other" and noted.

Data Analysis

Behavior

Data from all three NY sites between January, 2019 and December, 2019 was used to analyze the behavior, season, and group size. Data from before January, 2019 was not included in order to have consistency across seasons.

During a visit, otters sometimes triggered several cameras multiple times. Season and group size were included only once per visit to avoid double counting. However, all behaviors from every video were included in analysis.

Chi square tests for independence were conducted to determine if there was a significant relationship between group size and season, followed by an examination of adjusted residuals.

Differences in behavior, season, and group size between NY sites was reported but not analyzed due to very small data counts from MRG and AP compared to WPRR. Due to the timeline set forth for completion of the project by the University of Southern Mississippi, data collection could not continue at sites any longer than the 12 months originally scheduled.

Vocalizations

Because vocalizations are relatively uncommon, it was prudent to use to use all available data to determine the repertoire and use of calls in a site or region. Data from

WPRR since June, 2016, data from MRG recorded since September, 2018, and data from AP since June, 2018 were analyzed. Recording at all locations ended in December 2019.

A specific vocalization was only analyzed once, regardless of if it was recorded by more than one camera when it was produced. The camera closest to the animal was used to measure call parameters.

The vocalization repertoire of each region was reported. Mean call parameters were reported for every call type in both regions. Differences between the parameters in NY and CA were analyzed using a Kruskal-Wallis H Test for each call type.

Differences in parameters between sites in NY were not analyzed due to very limited vocalizations being recorded at MRG and AP. Due to the timeline set forth for completion of the project by the University of Southern Mississippi, data collection could not continue at sites any longer than the 12 months originally scheduled.

Behavior During Vocalizations

A chi square test for independence was performed to determine if there was a relationship between call type and corresponding behaviors and call type and group size, followed by an examination of the adjusted residuals. Due to low expected counts, the call types *whine* and *chirpwhine* and the behavior allogroom were not included in the analysis of vocalization and behavior.

Reliability

Because call type and behavior classification can be subjective, all call type and behavior classifications were made reliable with a second researcher. Classification was more than 80% reliable on behavior and more than 90% reliable on vocalizations using 10% of the data with a second researcher.

CHAPTER III - RESULTS

Behaviors in New York at Latrine Sites

Three sites in New York were monitored through the year 2019, culminating in 222 total videos occurring over 126 latrine site visits. WPRR, MRG, and AP had 148, 44, and 29 total videos of otters and 80, 27, and 17 total visits respectively. These visits occurred in all four seasons, with the majority occurring in Winter (figure 2). Differences in seasonal behavior between New York sites was not analyzed due to very small data counts from MRG and AP compared to WPRR (figure 3).

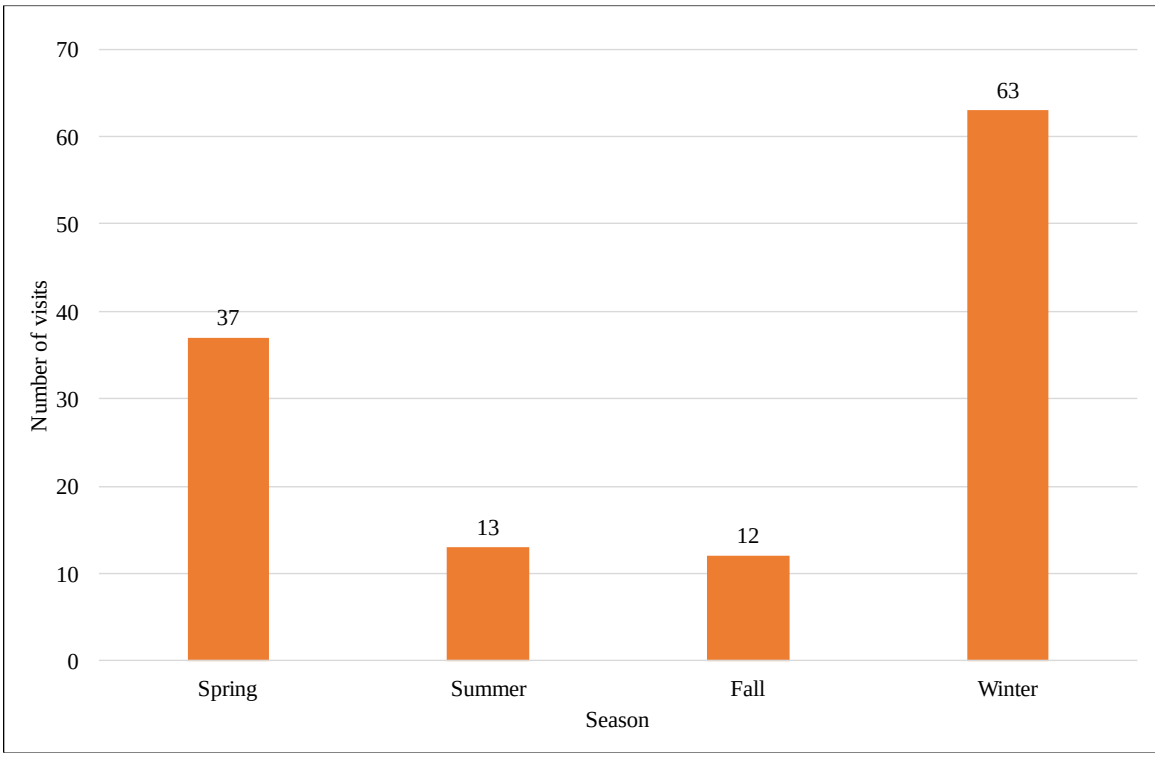

Figure 2. Number of otter visits to latrine sites in New York by season in 2019

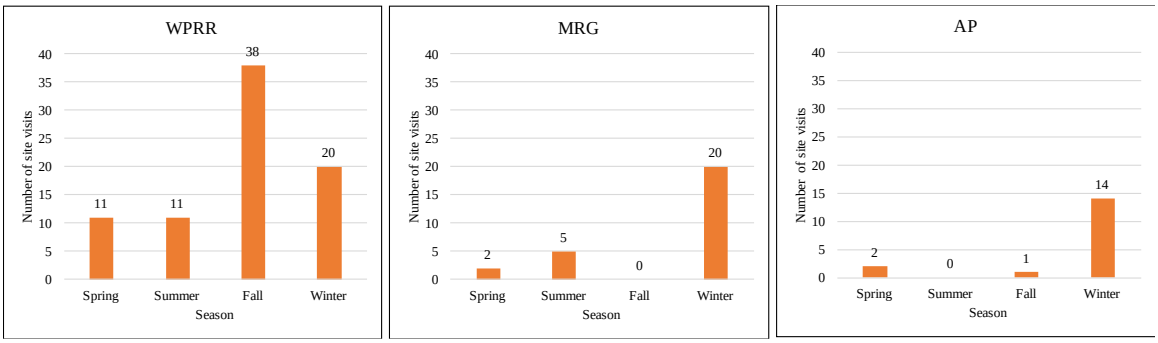

Figure 3. Number of otter visits to each latrine site in New York by season in 2019

Sixteen behaviors were observed during latrine site visits. These included investigate, visual scan, travel, stationary, scentmark, rub, disturbance, selfgroom, slide, shake, object manipulation, allogroom, play, displacement, sexual, and swim (figure 4). The four most common behaviors were investigate, scentmark, rub, and visual scan. Visual scan is a behavior added for this study as it was observed frequently at latrine sites. It was defined as a stationary otter with open eyes moving its head from side to side. Slide was another behavior added. A slide is a form of travel when an otter moves over a smooth surface, often snow, on its belly. Behaviors between sites was not analyzed due to very small data counts from MRG and AP compared to WPRR (figure 5).

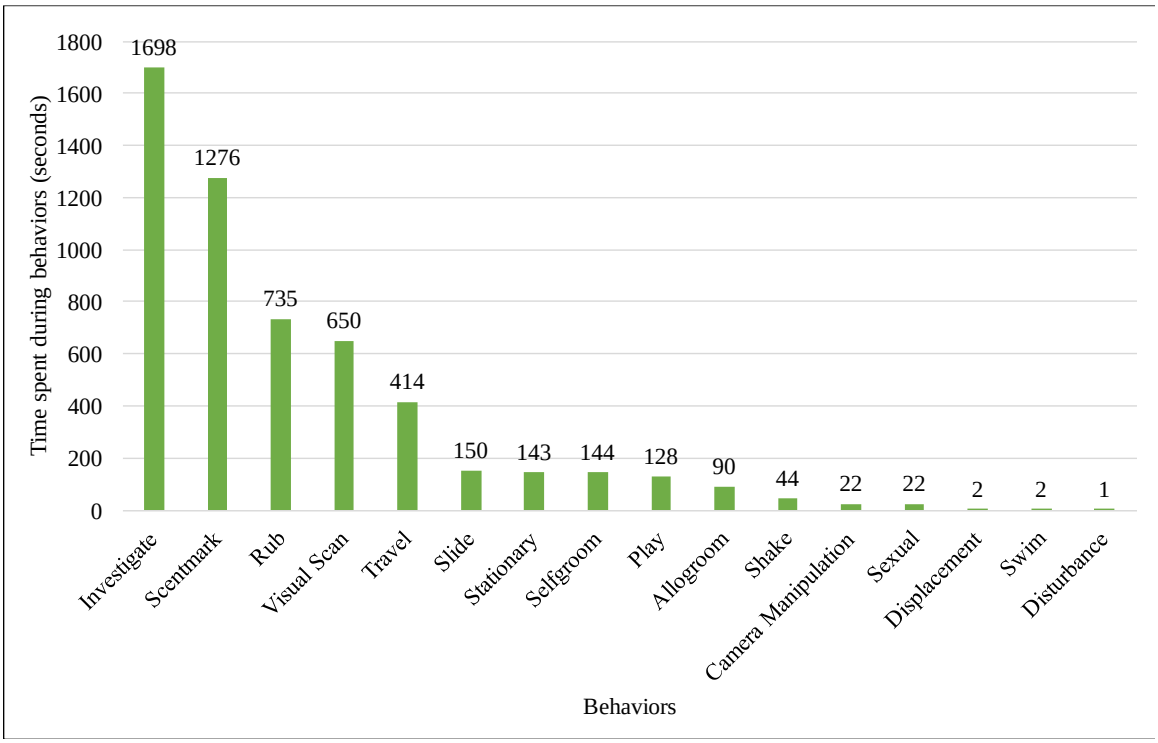

Figure 4. Number of seconds otters spent engaged in behaviors at latrine sites in New York in 2019

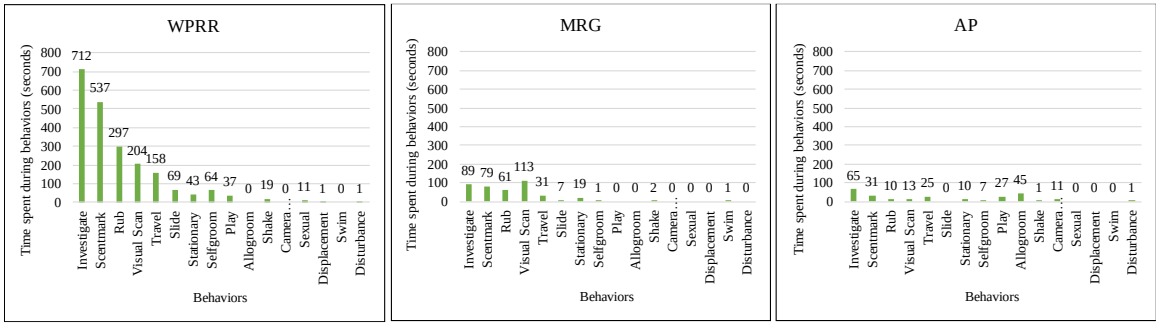

Figure 5. Number of seconds otters spent engaged in behaviors at each site in New York in 2019

Otters in New York were observed in group sizes between 1 and 6 otters. Solitary otters were the vast majority of visits at 77% (figure 6). A chi square test for independence found a significant relationship between group size and season, $X^2(3, 125) = 15.808$, $p = .001$. Otters were significantly more likely to visit latrine sites alone in the

Fall and groups of two or more in the Summer. Mean group size was 2.13 otters at its peak in the summer and 1.29 otters at its lowest in the winter. Group size between sites was not analyzed due to very small data counts from MRG and AP compared to WPRR (figure 7).

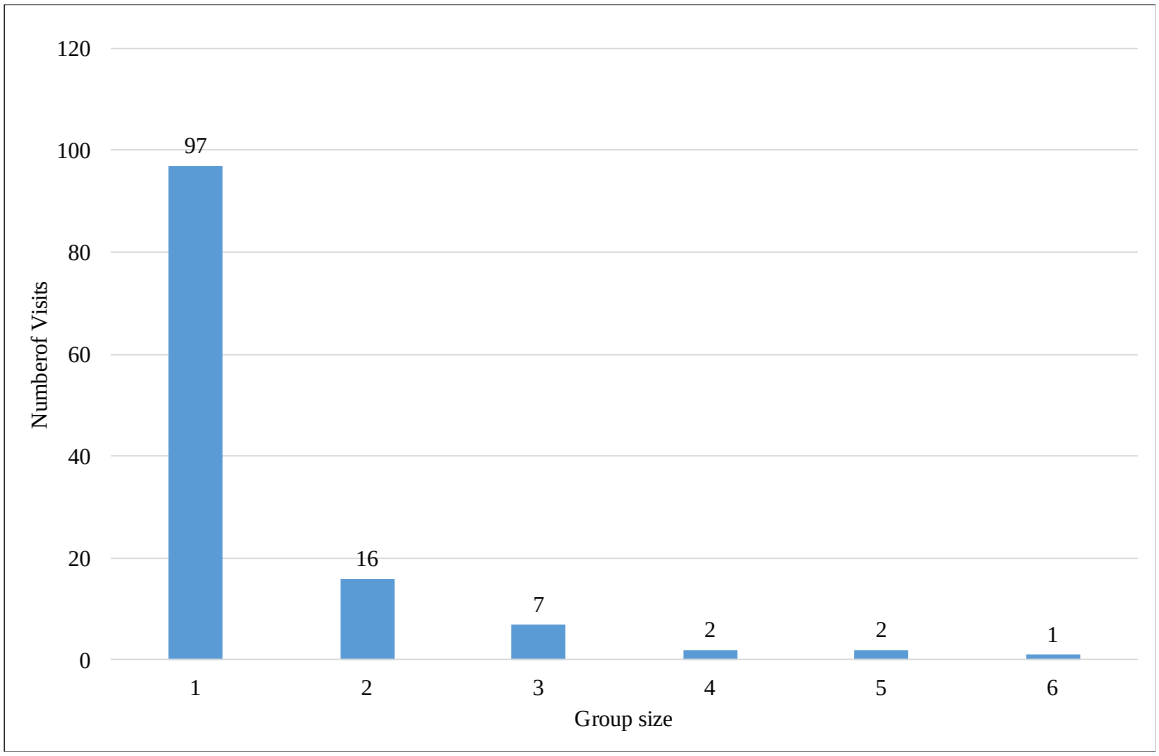

Figure 6. Group size of otters at latrine sites in New York in 2019

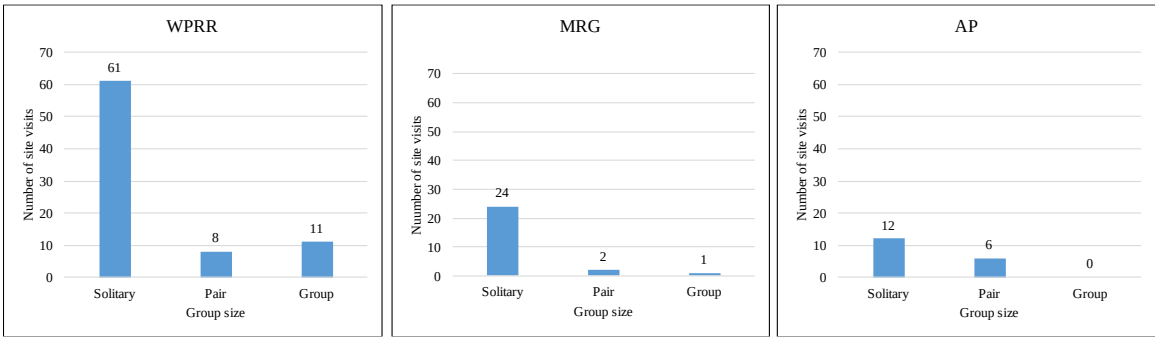

Figure 7. Group size of otters at each site in New York in 2019

Vocalization Repertoire and Associated Behaviors

Vocalization Repertoire

In all sites in all regions, a total of 997 recorded calls of wild otters were classified into five call types. These categories include *chuckle, hah, chirp, whine,* and *chirpwhine* (figure 8). The most common call types across both regions and all sites was *chuckle* (52.5%). The *hah* (23.3%) and *chirp* (20.3%) call were recorded at similar rates to each other. *Whines* (3.8%) and especially *chirpwhines* (0.2%) were the least frequent type of call (figure 9).

New York otters were responsible for 53% of vocalizations in this study. Over these 529 calls, 506 calls occurred in WPRR over 149 videos from 2016-2019, no calls were recorded in MRG between 2018-2019, and *chuckles*, *hahs*, and one *whine* were recorded in AP between 2018-2019 (figure 10). Vocalizations between sites was not analyzed due to very small data counts from MRG and AP compared to WPRR.

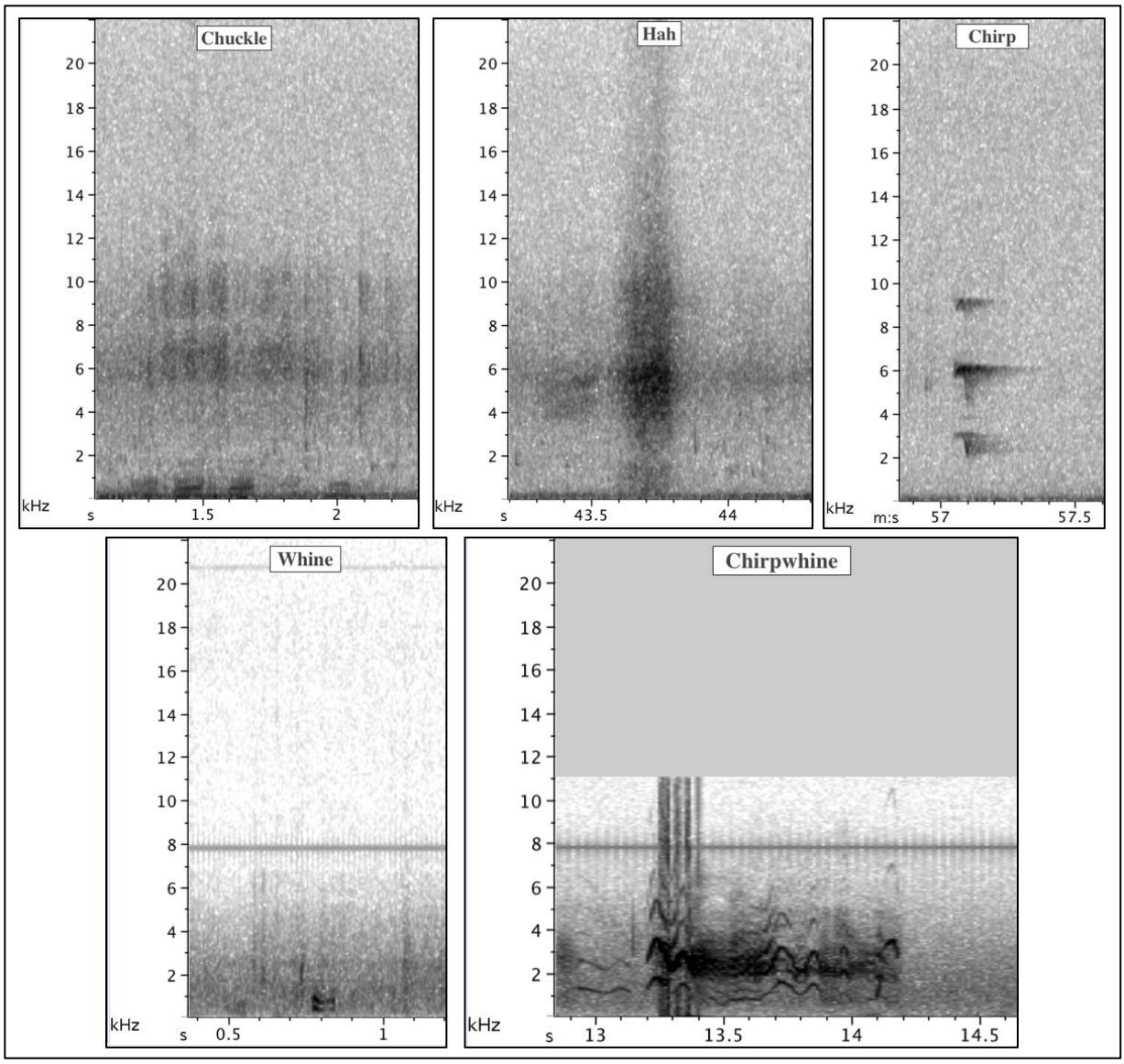

Figure 8. Spectrograms of the five river otter call types recorded in the wild

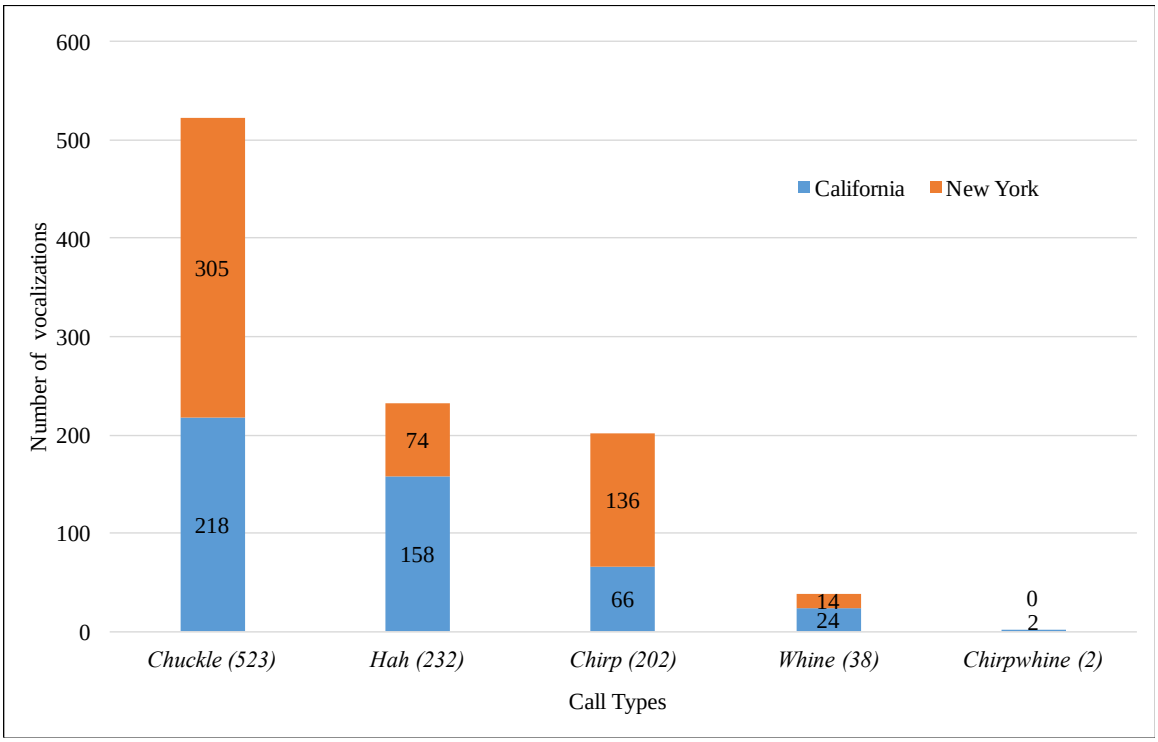

Figure 9. The number of each call type recorded across all locations

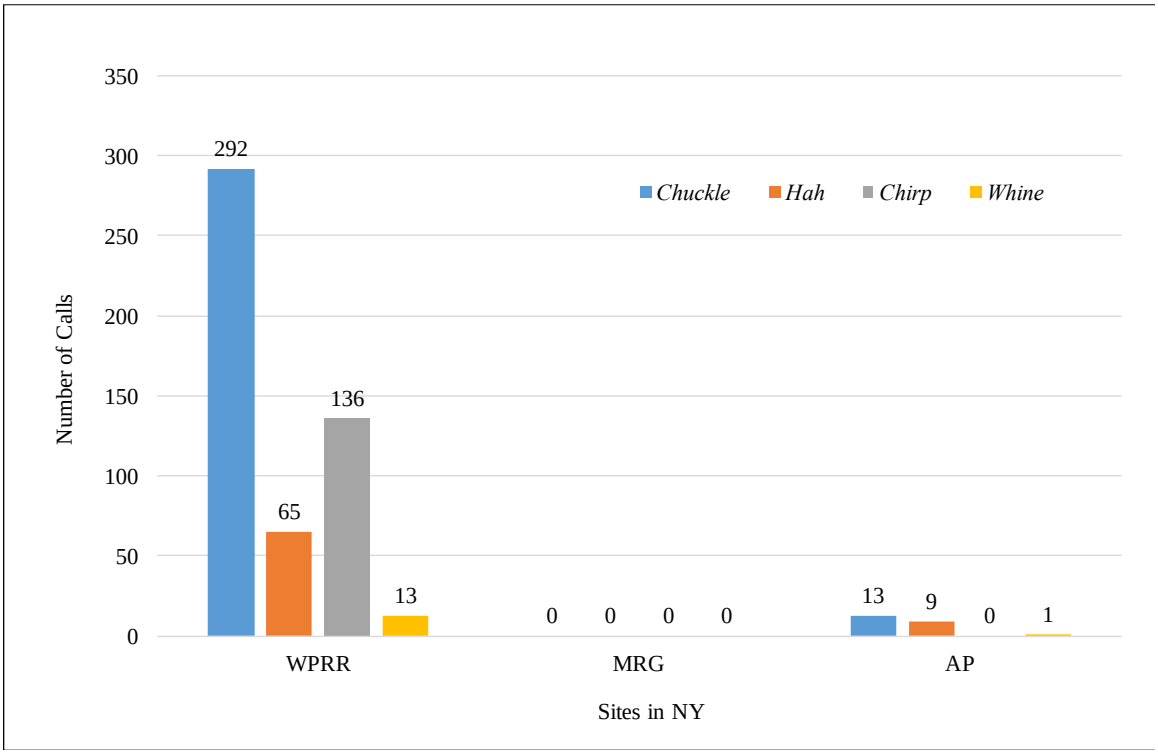

Figure 10. The number of each call type recorded at each site in New York

Chuckles were the most common call type in both regions, recorded a total of 523 times (figure 9). They represented 46.6% of the calls recorded in California and 57.7% of calls recorded in New York. Across regions, *chuckles* had an average frequency range of 29 Hz to 2,993 Hz and an average duration of 0.31 seconds (table 3). New York *chuckles* had lower frequency measures for every parameter tested including LF ($X^2(1) = 54.716$, $p < .0001$), HF ($X^2(1) = 90.537$, $p < .0001$), MF ($X^2(1) = 173.553$, $p < .0001$), FQF ($X^2(1) = 255.123$, $p < .0001$), CF ($X^2(1) = 245.725$, $p < .0001$) and TQF ($X^2(1) = 190.096$, $p < .0001$) (table 4). Other call types were considered distinct calls when separated by 0.03 seconds, however due to their pulsed nature, *chuckles* were considered continuous when pulses were less than 0.1 seconds apart. Chuckles had between one and nine pulses with an average of 2.25 pulses across both regions. The number of pulses between regions was similar with California having up to 6 pulses and New York having up to 9 pulses. New York *chuckles* had significantly longer duration than California *chuckles* ($X^2(1) = 6.164$, $p = .013$) (table 4).

Table 3 *Parameters (M ± SD) of Call Types in CA, NY, and Both Regions*

Location	Call Type(*n*)	LF (Hz)	HF (Hz)	MF(Hz)	FQF (Hz)	CF (Hz)	TQF (Hz)	Delta Time (s)
California	*Chuckle (168)*	55.57 ± 92.4	3783.41 ± 3101.37	1330.7 ± 1630.3	804.41 ± 778.46	1365.06 ± 1416.34	1994.39 ± 1896.55	0.29 ± 0.28
	Hah (64)	738.84 ± 902.37	13449.95 ± 4661.00	4169.37 ± 1959.41	3338.99 ± 1568.73	4267.61 ± 1701.44	4930.43 ± 1748.62	0.26 ± 0.13
	Chirp (21)	1411.52 ± 766.68	13197.02 ± 6240.94	3033.12 ± 993.2	2655.77 ± 1097.41	2895.70 ± 1009.53	3143.84 ± 961.45	0.07 ± 0.02
	Whine (15)	163.12 ± 114.85	1834.8 ± 1439.22	849.85 ± 247.64	557.01 ± 220.49	838.36 ± 327.92	1010.63 ± 459.79	0.13 ± 0.13
New York	*Chuckle (265)*	11.43 ± 46.89	2492.04 ± 3412.74	330.55 ± 484.76	204.11 ± 280.30	400.44 ± 529.43	807.05 ± 1028.24	0.32 ± 0.21
	Hah (40)	1601.98 ± 1702.23	14373.35 ± 4003.21	4791.14 ± 2359.15	4280.80 ± 1948.2	5286.40 ± 1684.09	6399.67 ±1032.53	0.24 ± 0.9
	Chirp (44)	2677.46 ± 1509.9	7917.43 ± 1991.18	4927.19 ± 1680.64	4312.52 ± 1708.32	4980.04 ± 1391.62	5788.52 ± 1224.26	0.12 ± 0.07
	Whine (14)	85.6 ± 87.79	1054.65 ± 136.76	615.24 ± 280.35	381.46 ± 193.24	547.56 ± 189.95	682.92 ± 152.84	0.12 ± 0.07
Both Regions	*Chuckle (433)*	28.55 ± 71.47	2993.08 ± 3351.51	718.60 ± 1187.08	437.02 ± 606.67	774.70 ± 1080.84	1267.73 ± 1540.17	0.31 ± 0.24
	Hah (104)	1070.82 ± 1331.63	13805.10 ± 4422.65	4408.51 ± 2132.61	3701.23 ± 1776.04	4659.45 ± 1758.58	5495.53 ± 1670.27	0.25 ± 0.12
	Chirp (65)	2268.46 ± 1439.24	9623.14 ± 4585.5	4315.26 ± 1732.88	3777.26 ± 1716.62	4306.64 ± 1607.67	4934.08 ± 1688.03	0.11 ± 0.06
	Whine(29)	125.7 ± 108.3	1458.17 ± 1096.25	736.59 ± 285.29	472.26 ± 222.74	697.97 ± 303.95	852.42 ± 379.9	0.12 ± 0.1

Table 4 *The Significance of Call Type Parameter Means (Significant values in bold*)*

Call Type	Parameter	*p-value*	Results
Chuckle	LF	**<.0001***	NY had a significantly lower LF than CA
	HF	**<.0001***	NY had a significantly lower HF than CA
	MF	**<.0001***	NY had a significantly lower MF than CA
	FQF	**<.0001***	NY had a significantly lower FQF than CA
	CF	**<.0001***	NY had a significantly lower CF than CA
	TQF	**<.0001***	NY had a significantly lower TQF than CA
	Delta	**.013***	NY had a significantly longer duration than CA
Hah	LF	.102	No significant difference
	HF	.069	No significant difference
	MF	**.009***	NY had a significantly higher MF than CA
	FQF	**<.0001***	NY had a significantly higher FQF than CA
	CF	**<.0001***	NY had a significantly higher CF than CA
	TQF	**<.0001***	NY had a significantly higher TQF than CA
	Delta	.728	No significant difference
Chirp	LF	**.001***	NY had a significantly higher LF than CA
	HF	**<.0001***	NY had a significantly lower HF than CA
	MF	**<.0001***	NY had a significantly higher MF than CA
	FQF	**<.0001***	NY had a significantly higher FQF than CA
	CF	**<.0001***	NY had a significantly higher CF than CA
	TQF	**<.0001***	NY had a significantly higher TQF than CA
	Delta	**<.0001***	NY had a significantly longer duration than CA
Whine	LF	.093	No significant difference
	HF	**.011***	NY had a significantly lower HF than CA
	MF	**.022***	NY had a significantly lower MF than CA
	FQF	**.041***	NY had a significantly lower FQF than CA
	CF	**.001***	NY had a significantly lower CF than CA
	TQF	**<.0001***	NY had a significantly lower TQF than CA
	Delta	.541	No significant difference

Hahs were the second most frequent call with a total of 232 recorded in total (figure 9). *Hahs* can be described as a sharp, often loud exhale of air from an otter's nose or mouth. They had an average duration of 0.25 seconds and an average frequency range of 1,071 Hz to 13,805 Hz (table 3). *Hahs* had lower frequencies in California than New York, significantly so for MF: ($X^2(1) = 6.904$, $p = .009$), FQF ($X^2(1) = 14.622$, $p < .0001$), CF ($X^2(1) = 19.428$, $p < .0001$), and TQF ($X^2(1) = 25.635$, $p < .0001$) (table 4).

Chirps, a short high frequency call, were recorded a total of 202 times in this study (figure 9). They had an average duration of 0.11 seconds and an average frequency

range of 2,268 Hz to 9,623 Hz (table 3). *Chirps* typically appear as several concave harmonics on a spectrogram. These concave contours will at times be flat, but never sinusoidal. In addition, many of the *chirps* recorded in New York had an extension, or flat tail, following the concave contour (figure 8). This gave the New York *chirps* a significantly longer duration than the California *chirps*: 0.19 seconds (NY) compared 0.07 seconds (CA) ($X^2(1) = 17.485$ $p < .0001$) (table 4). California *chirps* had a significantly higher HF ($X^2(1) = 12.155$, $p < .0001$). All other frequency measures were significantly lower in California including LF ($X^2(1) = 11.336$, $p = .001$), MF ($X^2(1) = 20.248$, $p < .0001$), FQF ($X^2(1) = 13.314$, $p < .0001$), CF ($X^2(1) = 23.189$, $p < .0001$), and TQF ($X^2(1) = 33.857$, $p < .0001$) (table 4).

Whines, recorded 38 times (figure 9), are defined as a wavering frequency call that can be short or long duration, harmonic or nonharmonic. In the current study, *whines* were very short with both populations having very similar average durations, 0.12 seconds (NY) and 0.13 seconds (CA) between the two regions, a mean frequency range of 126 Hz to 1,458 Hz (table 3). New York *whines* had lower frequency measures across all parameters, significantly so for HF ($X^2(1) = 6.411$, $p = .011$), MF ($X^2(1) = 5.217$, $p = .022$), FQF ($X^2(1) = 4.187$, $p = .04$), CF ($X^2(1) = 10.537$, $p = .001$), and TQF ($X^2(1) = 12.562$, $p < .0001$) (table 4).

Chirpwhines are a combination call composed of at least one *chirp* and one *whine* (figure 8). They were recorded twice in this study, both in the same video of five otters in California. The otters were out of view in the video during the recorded *chirpwhines.* The audio recording for this particular camera only had a frequency range of 22 kHz, and so parameters were not reported in table 3. The *chirpwhines* were similar in appearance to

one another (figure 12): both near 1 second in duration and containing 3 to 4 *chirps* in addition to *whines.*

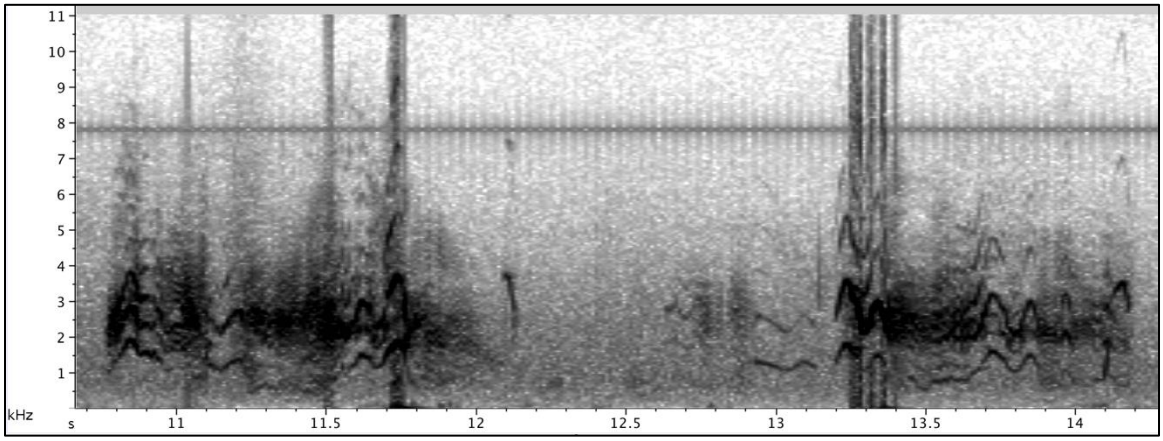

Figure 11. Two chirpwhines recorded in California population. Note the frequency range of 0-11 kHz only

Behaviors During Vocalizations

Excluding 257 out of sight or partial view categorizations, 591 behaviors were observed during a vocalization in both regions. The behaviors observed across all call types were selfgroom, allogroom, disturbance, swim, play, food, scentmark, rub, travel, stationary, investigate, and "other" (figure 12). The behaviors from the ethogram (table 1) that were not observed at either location during a vocalization include object manipulation, agonistic, displacement, sexual, hunt, and drink. There were 23 counts and 1 count of "other" behaviors in California and New York respectively. These behaviors included one instance of a "shake" from an otter in New York and 23 instances of otters digging in California. A shake is recognizable by an otter pausing and quickly moving its body from side to side. The digging consisted of otters moving dirt with their front paws in a manner that appeared to be inconsistent with scentmark behaviors.

Investigate, stationary, travel and food were the most common behaviors in California. In New York investigate and stationary were the most common, followed by

scentmark and rub. Swim, play, food, allogroom, and selfgroom were not observed in New York otters during vocalizing and disturbance was not observed in California (figure 12).

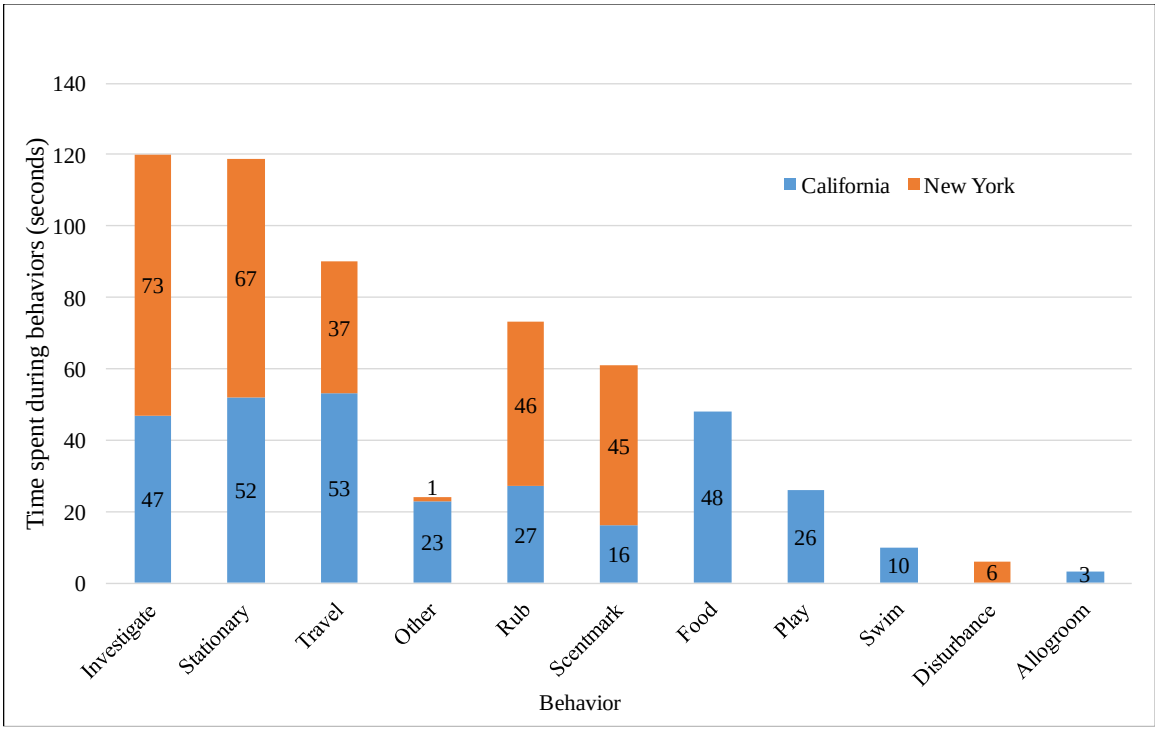

Figure 12. Total number of behaviors in California and New York that occurred during a vocalization

In addition to behaviors, group size was also examined during vocalization events. The majority of vocalization events in New York took place within a video with only 1 otter visible. The majority of calls recorded in California took place within a video with 2 otters visible. The maximum group size observed in California during a vocalization was 7, and in New York it was 6 (figure 13).

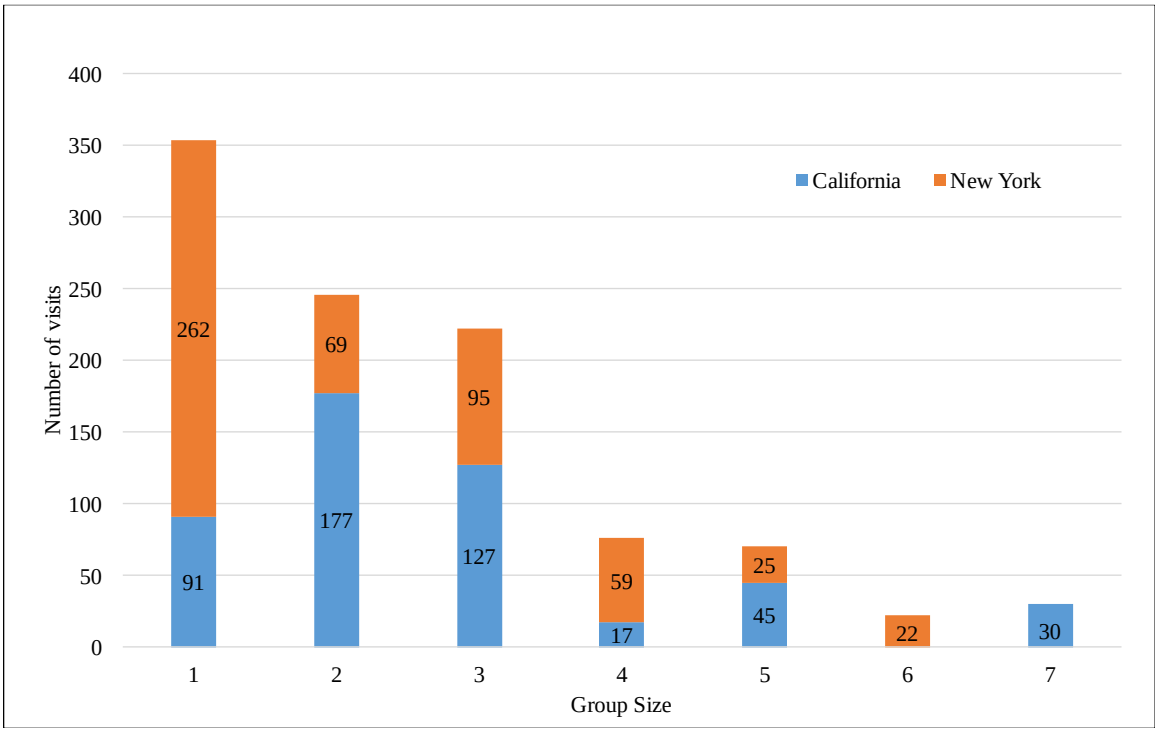

Figure 13. Total number of group sizes in California and New York that occurred during a vocalization

Vocalization and Behavior Interaction

Four of the five vocalization types occurred during behaviors (table 5). *Chirpwhine*, a call recorded only twice, was the only call type to occur only during out of sight behaviors.

Table 5 *Percentage of Vocalizations During Behaviors (Behaviors with Z-scores above 1.96 in bold and red)*

Behavior	*Chuckle (258)*	*Hah (161)*	*Chirp (95)*	*Whine (18)*
Travel	**24.42%**	2.48%	14.74%	50.00%
Play	0.00%	**9.94%**	6.32%	22.22%
Stationary	8.14%	22.36%	**52.63%**	16.67%
Selfgroom	0.00%	0.00%	0.00%	5.56%
Shake	0.00%	0.00%	0.00%	5.56%
Investigate	**28.68%**	14.29%	21.05%	0.00%
Scentmark	**20.54%**	3.11%	3.16%	0.00%
Swim	2.71%	0.00%	1.05%	0.00%
Allogroom	0.00%	0.00%	1.05%	0.00%
Food	0.00%	**27.95%**	0.00%	0.00%
Rub	15.50%	**16.15%**	0.00%	0.00%
Disturbance	0.00%	**3.73%**	0.00%	0.00%
Total	100.00%	100.00%	100.00%	100.00%

Chuckles occurred during six behaviors in both states (investigate, travel, scentmark, rub, stationary, and swim) (table 5). They occurred most frequently during investigate (28.7%), travel (24.4%), and scentmark (20.5%) behaviors. They were the most common call to occur during investigating behaviors (table 3). Following a chi square test for independence test between call type and behavior, *chuckles* were significantly more likely to occur during travel, scentmark, and investigate behaviors, $X^2(16, 487) = 277.838$, $p < .0001$ (table 5). Following a chi square test for independence test between call type and group size, *chuckles* were most significantly likely to happen in groups of 3 or more, $X^2(8,995) = 185.89$, $p < .0001$.

Hahs occurred during food, stationary, rub, investigate, play, disturbance, scentmark, and travel behaviors. Despite travel being one of the most common behaviors to occur during a vocalization, *hahs* only co-occurred with travel 2.5% of the time. *Hahs* co-occurred most often with food (28%) and stationary (22.4%) behaviors. They were the

only call to co-occur with food and disturbance behaviors (table 4). Following a chi square test for independence test between call type and behavior, *hahs* were significantly more likely to occur during disturbance, food, play, and rub behaviors ($X^2(16, 487) = 277.838$, $p < .0001$) (table 5). Following a chi square test for independence test between call type and group size, *hahs* were significantly more often in pairs ($X^2(8,995) = 185.89$, $p < .0001$) than alone or with larger groups.

Chirps co-occurred with stationary, investigate, travel, play, scentmark, swim, and allogroom behaviors. They occurred most frequently during stationary (52.6%) and investigate (21.1%) behaviors and were the majority of the calls during stationary behaviors. *Chirps* were the only call to occur during allogrooming (table 5). Following a chi square test for independence test between call type and behavior, *chirps* were significantly more likely to occur during stationary behaviors ($X^2(16, 487) = 277.838$, $p < .0001$) (table 5). Following a chi square test for independence test between call type and group size, *chirps* were significantly more likely to occur when an otter was alone than in a group of two or more ($X^2(8,995) = 185.89$, $p < .0001$).

Only 18 *whines* were recorded in this study. They occurred during travel, play, stationary, selfgroom, and shake. *Whines* were the only calls to occur during shake and selfgroom behaviors. The majority of *whines* occurred during travel (50%) and play (22.2%) behaviors (table 5). Following a chi square test for independence test between call type and group size, *whines* were significantly more likely to happen in groups of 3 or more ($X^2(8,995) = 185.89$, $p < .0001$).

CHAPTER IV – DISCUSSION

North American river otters are unique in that they are the only species of otter to be listed as of least concern by the IUCN. The healthy population is an opportunity for researchers to learn about the behavior of this species of otter, including a completely unstudied aspect of their behavior in the wild: their vocalizations.

Behavior in New York

My prediction that travel, scentmark, and investigate would be the most common behaviors was correct. More common than travel (7.5%) was rub (13.3%) and visual scan (11.8%) behaviors. Selfgroom was infrequent (2.6%) and the majority of behaviors were investigate (30.8%) and scentmark (21.1%). The most common river otter behavior, investigate, is consistent with previous literature in that it points to the use of latrine sites by otters not just as toilets but as communication stations (Green et al., 2015).

The instance of mating behavior observed occurred in late April. This observation follows previous literature that mating will occur after pups are born in late winter. Play behavior was only observed in the spring and winter and allogrooming was only observed in the winter.

My prediction regarding group size in NY was also correct. The majority of latrine sites were visited by one otter (77.6%) however groups as large as six were recorded. Summer had the largest average group size compared to other seasons which is likely explained by family groups beginning to travel further from natal dens. A decrease in group size in the Fall and Winter can be explained by the dispersal of otter pups typically occurring after eight months of age (Melquist & Hornocker, 1983).

During all 222 videos of otters in NY in 2019, no food behavior was observed. This is in stark contrast to 48 instances of food behavior observed in CA, in just the subset of videos containing vocalizations. It is unclear why food consumption at latrine sites appears to be more frequent in CA than NY.

Vocalizations in NY and CA

Repertoire and Behaviors

My prediction that CA would have a larger vocalization repertoire due to having anecdotally more otter activity and larger group sizes was correct, with an additional call (*chirpwhine*) being recorded in CA and not in NY. With continued monitoring, it's possible that *chirpwhines* would eventually be observed in NY wild otters as well.

Chuckles were the most common call in this study, consisting of more than 50% of all recorded calls. This is inconsistent with previous research on river otters, all of which were in human care: *unclassified call A* (i.e. *chuckles*) comprised only 1.4% of the vocalizations recorded in two human care populations (Walkley, 2018) and *grunts* (i.e. *chuckles*) only comprised 5.1% of calls in a study of five human care populations (Almonte, 2014). Almonte (2014) found *grunts* (i.e. *chuckles*) to occur during non-aggressive behaviors. This is consistent with the current study, with *chuckles* being most likely to occur during travel, investigate, and scentmark behaviors. Despite occurring significantly more often in groups, *chuckles* were the only vocalization not observed during play behaviors in this study.

Hahs were the second most common call (23%) in this study. Considered an alarm call in other species of otters (Leuchtenberger et al., 2014; Bezerra et al. 2011; Mumm & Knörnschild, 2014; Duplaix, 1980), and a call river otters used in moderately

agitated states in human care (Almonte, 2014), it aligns with previous literature that *hahs* were the only vocalization that occurred during disturbance events in the current study. *Hahs* were also the only vocalization during food related events, possibly being used as a warning to conspecifics to not approach during eating. Many *hahs* in this study were also recorded during low agitation behaviors such as stationary, rub, and investigate; this is similar to what was observed in two populations in human care (Walkley, 2018). *Hahs* were most likely to occur when there were two otters present, likely due to the repeated instances where an otter was approached by just one conspecific while engaged in a food related behavior.

Chirps were 20% of the recorded calls. A significant number of *chirps* occurred during solitary and stationary behaviors. In these instances, the otter would be lying flat, and producing multiple *chirps* in a row. For these reasons, the *chirps* appear to be a contact call with other conspecifics which is consistent with previous literature (Mumm et al., 2014; Leuchtenberger et al., 2014). In addition to stationary behaviors, *chirps* occurred during other nonagonistic behaviors such as travel and investigate. This follows previous literature that *chirps* occur during nonagonistic behaviors (Walkley, 2014) and non-aggressive behaviors (Almonte, 2014) in general.

Whines consisted of only 4% of the recorded calls. *Whines* were associated with agonistic behaviors (Walkley, 2018) and with moderately aggressive behaviors (Almonte, 2014) in previous literature. In the current study, *whines* were significantly more likely to occur when otters were in groups and, while not significant, the most common call type to occur during play behavior.

Chirpwhines were recorded just two times in the study. They occurred in the same video with a family group of five otters. The otters were out of sight when making the vocalizations. In a previous study, *chirpwhines* were associated with agonistic behaviors within a group of otters (Walkley, 2018), so the finding that *chirpwhines* occurred in a larger group aligns with previous literature.

All calls found in the current study have been observed in human care populations (Walkley, 2018; Almonte 2014). However, one call recorded in human care populations, *chatterchirp*, was not recorded in the current study. *Chatterchirps* (i.e. *chatters*) were associated with highly aggressive states in human care (Almonte, 2014). It's possible that due to wild otters being less likely to have physical confrontations due to latrine site signaling and larger habitats, *chatterchirps* are a less common call in the wild than in human care.

Frequency Parameters

NY *chuckles* had a lower frequency than CA *chuckles* with all six frequency measurements being significantly lower in NY than CA (table 4). *Whine* frequencies were also significantly lower in NY than CA for every frequency measurement except for LF, which was lower but not significant. In contrast, NY *hahs* and *chirps* had significantly higher frequencies than CA, with the exception of the HF measurement of *chirp* (table 5). As this study did not differentiate between individual otters, due to the difficulty of this in the wild, factors such as individual differences and sex could possibly be an underlying cause for these significant differences. Almonte (2011) found that a female otter had higher frequency *chuckles* (i.e. *grunt*) and *hahs* (i.e. *blows*) than male otters and that *chirps* were consistently higher frequency when produced by females.

Almonte (2011) did not find any significant differences in the frequencies of *whines* between the sexes. If these trends were consistent with wild otter populations, males could be responsible for the majority of *chuckles* recorded while females may be producing the *hahs* and *chirps*. Environmental factors such anthropogenic (traffic) or natural (water flow) noise could cause this significant difference as well by altering the ideal frequency range for signal strength in a location.

Duration

Hahs and *whines* in this study did not have significant differences in their durations between regions. This consistency in duration could mean that this parameter is a key component of the signal. With *hahs* being a call more likely to happen in high arousal contexts such as food, disturbance, or play behaviors (table 5), one would hypothesize that a clear and concise delivery, to both known and unknown conspecifics, would be very important. Following previous literature, *whines* are also high arousal calls occurring during agonistic interactions between otters (Walkley, 2018). In both CA and NY, *whines* were short in duration compared to previous research in human care populations: 0.12 seconds in the current study in the wild compared to 0.77 seconds (Walkley, 2018) and 1.4 seconds for adult otters (Almonte, 2014) in human care. Like *chatterchirps*, this may be due to a smaller habitat and the increased possibility of conflict. While infrequently recorded in the wild, 22% of the *whines* that occurred were during play behavior and could signify the same social urgency at times as *hahs.*

Chuckles and *chirps* both had longer durations in NY than CA. *Chirps* in NY had a longer duration due a flat "tail" following the vocalization's concave contour (figure 1). This appearance of a *chirp* is similar to the *chirps* made by pups recorded by Almonte (2014) and could signify that it was predominantly pups producing *chirps* in NY. *Chuckles*, a pulsed call that had up to nine low frequency pulses in quick succession, had the largest standard deviation of any call for duration. This large variation may speak to individual differences or possibly be affected by environmental factors. *Chuckles* most frequently happened during investigate behaviors, and perhaps the length of the call was affected by the length of time it took the otter to explore the previously left scents at the latrine site.

Limitations

Limitations of this study include a relatively small sample size. Due to the difficulty of obtaining videos of wild otters, and the infrequency of vocalizations during these videos, more data collection is required to continue to understand this topic.

Trail camera audio technology is still developing. Parameters from trail cameras are sometimes below the 44 kHz sample rate, and because of this, 17% of *chuckles*, 55% of *hahs*, 68% of *chirps*, 24% of *whines*, and 100% of *chirpwhines* were removed prior to measuring the average parameters of the calls.

Future Directions

Different regions may have evolved higher or lower call frequencies due to a number of factors, potentially environmental, morphological, or social. Future research exploring the differences between various populations of river otters, including their distinct latrine sites within the same region to determine differences between local groups

of otters, should continue. Studying individual differences in wild river otter calls is difficult due to the similar appearance between individuals. Possible future research could confront this difficulty by utilizing more invasive methods such as ear tagging as a visual marker or implanting a tag to track not just location in front of a camera but travel patterns as well. Recognizing individual otters would elucidate the possible differences in vocalization repertoire and parameters between otters and possibly identify patterns based on age and sex. Continued comparison of river otters in various regions of North America and in human care will undoubtedly continue to expand the knowledge of river otter vocalization use, and in turn our understanding of animal communication as a whole.

APPENDIX A – IACUC Approval

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

118 College Drive #5116 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | iacuc@usm.edu | www.usm.edu/iacuc

NOTICE OF COMMITTEE ACTION

The proposal noted below was reviewed and approved by The University of Southern Mississippi Institutional Animal Care and Use Committee (IACUC) in accordance with regulations by the United States Department of Agriculture and the Public Health Service Office of Laboratory Animal Welfare. The project expiration date is noted below. If for some reason the project is not completed by the end of the approval period, your protocol must be reactivated (a new protocol must be submitted and approved) before further work involving the use of animals can be done.

Any significant changes should be brought to the attention of the committee at the earliest possible time. If you should have any questions, please contact me.

PROTOCOL NUMBER:	17101207
PROJECT TITLE:	Context Specific Vocalization of North American River Otters (Lontra canadensis)
PROPOSED PROJECT DATES:	10/2018 – 09/2020
PROJECT TYPE:	Modification – Sites added/duration of study through valid IACUC approval
PRINCIPAL INVESTIGATOR(S):	Heid Lyn
DEPARTMENT:	Psychology
FUNDING AGENCY/SPONSOR:	N/A
IACUC COMMITTEE ACTION:	Designated Review Approval
PROTOCOL EXPIRATON DATE:	September 30, 2020

July 5, 2018

Jake Schaefer, PhD
IACUC Chair

Date

APPENDIX B – Permit for Arshamomaque Pond Preserve

COUNTY OF SUFFOLK

STEVEN BELLONE
SUFFOLK COUNTY EXECUTIVE

DEPARTMENT OF
PARKS, RECREATION AND CONSERVATION

PHILIP A. BERDOLT
COMMISSIONER

PERMIT FOR RESEARCH IN SUFFOLK COUNTY PARKLANDS (1st RENEWAL)

Applicant: **Sarah Walkley & Mike Bottini** Date: **1/14/2019** Expiration Date: **1/31/2020**

Address: **34 Chapel Lane, East Hampton, NY 11037**

College/University Department affiliation, if applicable: **University of Southern Mississippi (Sarah)**

Contact Information: **Sarah Walkley – (914)-806-7929, Sarahnwalkley@gmail.com**
Mike Bottini – (631)-267-5228, Mike@mikebottini.com

RESEARCH PROJECT SUMMARY: Please describe to an extent sufficient to determine scope and magnitude of project including environmental impacts, materials to be used, commitment of park personnel needed, and park where research is to be conducted.

This project is researching the vocalization repertoires of wild North American river otters (*Lontra canadensis*) in New York and California. These regions are home to established river otter populations and are separated by significant distance so as to make populations in each region distinct from one another. River otter vocalizations and behaviors in New York and Connecticut will be recorded using infrared and motion activated trail cameras that are placed in areas of river otter activity. Cameras will be monitored every month and remain in place throughout the year. Results of this study will elucidate the complexity, purpose, and variation of vocal communication systems of otters living in different regions of North America, as well as teach us about the evolution of communication systems of nonhuman mammals.

Please check applicable blank:

1. Undergraduate		3. Post-Doctoral	
2. Graduate		4. Professor	
Master's Thesis		5. Other	
Doctoral Thesis	X	6. Research Scientist	X

(FOR OFFICE USE ONLY)

APPROVED: X
DENIED:
COMMENTS:

Nicholas Gibbons, Principal Environmental Analyst

MONTAUK HIGHWAY – P.O. BOX 144 WEST SAYVILLE, NEW YORK 11796-0144 (631) 854-4949 FAX: (631) 854-4977

SUFFOLK COUNTY PARKS

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