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in Two Human Care Populations**

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Vocalizations of North American River Otters (*Lontra canadensis*)
in Two Human Care Populations

by

Sarah N. Walkley

A Thesis

Submitted to the Graduate School,
the College of Education and Psychology
and the Department of Psychology
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Master of Arts

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ABSTRACT

There is a dearth of information regarding the vocal repertoire of North American river otters (*Lontra canadensis*). This indicator species is cosmopolitan yet elusive, making recordings methodologically difficult in the wild. Therefore, this exploratory study uses video and audio recordings of two populations of North American river otters in human care to broaden the known vocal repertoire of river otters in various social contexts. The populations consist of a male-female pair at the Stamford Museum and Nature Center and a male-male pair at The Maritime Aquarium at Norwalk. This study is the first to examine the vocalizations produced in a male-male pair of river otters. Data collection took place June through August of 2015. Approximately 766 minutes and 347 minutes were recorded respectively in each location using a Tascam DR40 recorder and a Sennheisser ME67 directional microphone. Video recording took place simultaneously with a Fujifilm FinePix XP80 digital camera. Call types were acoustically distinguished based on their appearance on a spectrogram. Parameters including average duration, frequency (high, low, max, 1st quarter, center, and 3rd quarter), and power (max and average) were measured for each call type. Because vocalizations are the focal point of this study, only behaviors co-occurring with vocalizations were included in the chi square analysis that showed a significant relationship between call type and behavior. *Squeaks* and *whines* were present during agonistic behaviors while *chirps* were produced during non-agonistic behaviors including investigating, stationary, and grooming. Results support that behavior likely plays a role in the type of calls produced by river otters in human care.

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DEDICATION

To my parents, Steve and Rebecca Walkley, thank you for your infinite support in all ways towards helping me discover my role in the sciences and in the world.

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CHAPTER I - INTRODUCTION

Otters

There are thirteen species of otter, spanning five continents, that vary in appearance and behavior. Otters range in size from the 1-meter-long Asian small-clawed otter (*Aonyx cinereus*) to the 2-meter-long giant river otter (*Pteronura brasiliensis*), and eat a range of prey animals including fish, crustaceans, reptiles, amphibians, insects, and small mammals. They are often very social animals, and communicate in many ways, including through scent and sound.

North American river otters (*Lontra canadensis*), or river otters, are small to medium sized, weighing an average of 15 kg and reaching 1.5 meters long. River otters in the wild have a large range, living coast to coast throughout North America. They were heavily hunted in the last century, and even though their numbers have increased, they are still threatened by pollution, habitat loss, and trapping. River otters are listed by the IUCN (International Union for Conservation of Nature) as a species of least concern for extinction. However, as many as 40,000 river otters are trapped and hunted per year for their fur in the United States and Canada (Yoxon & Yoxon, 2014). Usually considered a solitary species in the wild, there are many reports of river otters in groups (Yoxon & Yoxon, 2014). These groups are most likely family groups (mother and pups) or groups of all males (Yoxon & Yoxon, 2014). However, in human care, otters are often housed in male-male pairs, male-female pairs, groups with one male and many females, or in groups of equal sex pairings (Owens, Alm, Helten, Shelley, & Reed-Smith, 2009). River otters can be found living in rivers, lakes, ponds, estuaries, swamps and along coastlines (Yoxon & Yoxon, 2014). They are considered crepuscular and are therefore most active

at dawn and dusk (Yoxon & Yoxon, 2014). This is at odds with human care schedules, as otters in human care are often active during daytime hours and resting at night. Much is known about river otter life history, however, we still know little about their communication.

Otter Communication

Otters communicate in many ways, but most notably by sound and scent. As members of the mustelid (weasel) family, otters utilize scent communication extensively. Research suggests that otters can detect individually identifying information such as sex, age, and reproductive status from the spraints of conspecifics (Kean, Müller, & Chadwick, 2011). Spraints include an otter's defecation as well as a secretion from two anal sacs on either side of the rectum. Sprainting likely plays a critical role in otter communication, limiting agonistic encounters and aiding in the search for a reproductive mate (Kean, Bruford, Russo, Müller, & Chadwick, 2017). Over short distances and in real time however, vocal communication is necessary and has been observed during varying interaction types in otters.

Research on otter acoustic communication is extremely limited, and the vocalizations of many species are still unstudied. Some species of otter that have been investigated for their vocalization repertoire include giant river otters, sea otters (*Enhydra lutris*), European otters (*Lutra lutra*), Asian small-clawed otters, and the North American river otter.

A sea otter vocalization study found a total of ten vocalization types in four groups of otters: two managed care groups and two wild groups temporarily in human care (Mcshane, Estes, Riedman, & Staedler, 1995). *Screams* were produced by both

young and adult sea otters when mother and pups were separated. *Whines, squeals, squeal-whines, squeal-screams, whimpers, and squeaks* all appeared in distressed contexts (Mcshane et al., 1995).

A study of giant river otters in the wild found five distinct calls (Bezerra, Souto, Schiel, & Jones, 2011). These calls were labeled *HAH, scream, snort, purr, and cub long call*. The majority of these call types appear to also be found in another study of wild giant otters in 2014 (Leuchtenberger, Sousa-Lima, Duplaix, Magnusson, & Mourao, 2014). It's unclear if *cub long call* was also found in other giant river otter studies.

Leuchtenberger and colleagues (2014) found fifteen distinct calls in nine groups of wild otters. The authors labeled these calls *coo, coo-hum, coo-call, hum, purr, snort, hah, adult call, growl, scream, begging scream, high scream, scream-gurgle, cub begging scream, and cub high scream*. Leuchtenberger and colleagues found many of these call types were correlated with behaviors. *Hums, purrs*, and the three types of *coo* calls were found to occur at similar times during affiliative close contact events such as grooming or swimming together as well as during scent marking (Leuchtenberger et al., 2014). *Purrs* were most frequently used during close contact events while *snorts* and *hahs* appeared to be types of alarm calls (Leuchtenberger et al., 2014). *Adult calls* were emitted as a call to other groups or in conjunction with *screams* and *snorts* in intra-specific agonistic encounters (Leuchtenberger et al., 2014). *Growls* were produced in displacement and defense contexts and *screams* were produced as a warning during agonistic interactions, or to get the attention of other otters (Leuchtenberger et al., 2014).

A giant river otter study published the same year found thirty-three distinct calls (twenty-two if neonate-only calls are excluded) in five wild and three managed care otter

groups (Mumm & Knörnschild, 2014). *Barks, close calls, hums, hum graduations,* and *hum snorts* were found to occur during close contact behaviors such as otters moving together or scent marking while *growls, hah!s, snorts,* and *wavering screams* were identified as alarm calls (Mumm & Knörnschild, 2014). *Whistles* were used to call group members or beg (Mumm & Knörnschild, 2014). Many of these calls are likely analogous to calls identified in the previously mentioned study by Leuchtenberger and colleagues, notably: *contact calls* (Mumm & Knörnschild, 2014) and *adult calls* (Leuchtenberger et al., 2014), *wavering screams* (Mumm & Knörnschild, 2014) and *screams* (Leuchtenberger et al., 2014) and *growls* (Mumm & Knörnschild, 2014) and *growls* (Leuchtenberger et al., 2014). *Barks, close calls, hums, hum graduations,* and *hum shorts* (Mumm & Knörnschild, 2014) are also likely variations of the calls of *coo, coo-call, hum, or purr* (Leuchtenberger et al., 2014).

European otters have at least eight call types including *blow, mew, cry (staccato and scream), murmur, feeble whistle, loud whistle,* and *twitter* (Gnoli & Prigoni, 1995). *Blows* found in this study were similar structurally to the *blow, snort, or hah* vocalization from other studies. *Mews* in this study were a low frequency wavering sound associated as an agonistic or warning call. The *staccato cry* (Gnoli & Prigoni, 1995) appears to be a similar call to Leuchtenberger's and colleagues (2014) *adult scream*. Both types of *cries* in this study occurred during aggressive quarrels for food or territory, but also once during mating and at times while pups were rough playing (Gnoli & Prigoni, 1995).

Asian small-clawed otters have seven recorded vocalizations (Lemasson, Mikus, Blois-Heulin, and Lodé, 2014). In this study, four structurally discernable vocalizations were discovered and separated into call types by whether they occurred in lone units (*UI*,

U2, *U3*, *U4*,) were repeated (*RE1* & *RE2*), or were combined (*CO*). The *U1* call was produced during exploration and was dubbed an alarm call (Lemasson et al., 2014). It is unclear but this call may be similar to a *blow*, *snort*, or *hah!* vocalization in other studies. The *U2* call, *U4* call, and *CO* call all occurred in a food related context (Lemasson et al., 2014). *U2s* were produced as a food request and *U4s* occurred when an otter had food in its possession (Lemasson et al., 2014). *U3s* was referred to as a contact call produced during social isolation, affiliative interactions, and during exploration (Lemasson et al., 2014). Likely this call is analogous with *contact calls* (Mumm & Knörnschild, 2014) and *adult calls* (Leuchtenberger et al., 2014). *RE1s* were rare and produced at least once in many contexts (Lemasson et al., 2014). *RE2s* were seen during exploration and affiliative interactions (Lemasson et al., 2014).

In the only published study on North American river otter calls, Almonte (2014) found four distinct call types and seven sub-call types in five different, small populations of North American river otters in human care. The call types emerged through the use of a discriminant analysis, after which they were labeled *whine*, *chirp*, *grunt*, *blow*, *chatter*, *creek*, *squeak*, *scream*, *hiss*, *swish*, *whistle*, and *hiccup* (Almonte, 2014). Differences in the call repertoires between pups and adults were found, with *whistles* being unique to pups under 8 weeks of age (Almonte, 2014). The study also distinguished between low, moderate, and high agitation states depending on the behavior of the vocalizing otter. High agitation states consisted of aggressive, physical altercations, moderate agitation states consisted of stereotypical behaviors, submissive behaviors, and defensive behaviors, and low agitation states consisted of grooming, playing, sleeping, and swimming behaviors (Almonte, 2014). *Chirps* were produced most commonly during low

agitation states and *chatters* (*chirps* or *whines* that are repeated continuously) were produced most commonly during high agitation states (Almonte, 2014). During moderate agitation states, Almonte (2014) found that otters used a variety of other call types.

Current Study

This study explored the vocalization repertoires of two groups of North American river otters living in human care. The results elucidate the call repertoire of a male-female otter pair living at Stamford Museum and Nature Center (Stamford Museum) and for the first time describe the call repertoire of a male-male otter pair living in human care. The male-male pair was housed at The Maritime Aquarium at Norwalk (The Maritime Aquarium).

CHAPTER II – METHODS

Animal Participants

The Maritime Aquarium housed two male otters. Data collection occurred when the otters were 16 months old and 12 years old. The older male (Lew) was rescued from the wild as a pup after being found with external wounds, and was rehabilitated at Clearwater Aquarium in Florida before being brought to The Maritime Aquarium. Lew was housed with a female otter since his arrival until she passed at age 18 in 2014. The younger male otter, Levi, was one of four pups in a litter born at the Beardsley Zoo in Bridgeport, CT and was transferred to The Maritime Aquarium in 2014 at ten months old.

Stamford Museum housed two otters, an adult male (Bert) and an adult female (Edie) age 9. Bert was wild-caught as an adult in 2007 in Dupoint Parish, Louisiana before being brought to Stamford Museum in 2008. Edie was born at a facility in Slidel, Louisiana and was transferred to Stamford Museum at thirteen months old. Edie lived alone on the exhibit for approximately two years before being joined by Bert. The otters are a reportedly non-mating pair.



Figure 1. Levi and Lew in their exhibit at The Maritime Aquarium.



Figure 2. Bert and Edie in their exhibit at Stamford Museum.

Procedures

Otters were observed between the months of June and August in 2015. At both facilities, recording sessions were between one and three hours in length. At Stamford Museum, otters were observed at varying times between the hours of 10:00 AM and 5:00 PM in their outdoor enclosure. The enclosure included a small pond surrounded by grassy, rocky land and many small shrubs (Figure 3). At The Maritime Aquarium, otters were observed at varying times between the hours of 7:00 AM and 10:00 AM in their off-exhibit enclosure. The off-exhibit enclosure had bedding and drinking water, but no pools for swimming. Often, recording was done before their first feed of the day. The otters were recorded continuously during each session as long as they were active. At times the otters at The Maritime Aquarium were inactive during the morning recording sessions and the microphone would remain off.

The differences in recording time (early morning versus morning and afternoon) and location (on exhibit versus off exhibit) were due to space and time limitations of the facilities, and most likely played a role in the differences in the vocalizations and behaviors recorded at each facility. Calls were recorded in-air using a Tascam DR40 recorder and a Sennheisser ME67 directional microphone (frequency range of 40 – 20,000 Hz \pm 2.5 dB). The sampling rate was 44.1 kHz .wav format 16 bit. Behavior was recorded with a Fujifilm FinePix XP80 digital camera.



Figure 3. Stamford Museum's otter exhibit.

Acoustics

Vocalizations were analyzed using Raven Pro 1.4 and 1.5 (Charif, Waack, & Strickman, 2010) and separated into discrete categories using Almonte's (2014) terminology and definitions as a guide (Table 1). Calls were distinguished solely based on their visual appearance on the spectrogram. Acoustic parameters duration, frequency (high, low, max, first quarter, center, third quarter), and power (average, max) were measured for each call. Calls were considered separate and distinct with an inter-call interval of at least 0.03 seconds. A total of 766 minutes at Stamford Museum and 347 minutes at The Maritime Aquarium were analyzed for calls.

Table 1 *Call Types Produced by River Otters*

Call Type	Description (Almonte, 2014)	Associated Behavior
Whine	Universal to all populations studied. Moderately pitched with a mean duration of 1.4 seconds. Most variable call that can be both harmonic or nonharmonic.	Have been produced within 45 seconds of birth (Almonte, 2014). Produced by adults during a variety of arousal states, likely does not function as a marker of arousal state (Almonte, 2014).
Chirp	High frequency call with a mean duration of 0.2 seconds. Call is comprised of either convex or constant harmonic bands.	Produced at birth (Almonte, 2014). In adults, was the most predominant call type during non-aggressive states (Almonte, 2014). Otters chirped when self-grooming and when massaging body against substrate (Almonte, 2014). Giant otters emitted this call to other groups or in conjunction with screams and snorts in intra-specific agonistic encounters (Leuchtenberger, 2014). Also recorded by Mumm (2014) in giant otters and referred to as a contact call. May be recorded in sea otters (Mcshane, 1995). Referred to as a squeak, it was seen in the context of distress.
Grunt	Sounds like a human clearing their throat. Call is low pitched with a mean duration of 0.7 seconds. Call has little variation between individuals.	Otters produced call when in a moderately agitated arousal state (Almonte, 2014). A female grunted while she paced in the mornings before feedings and the male grunted at night while chewing his tail (Almonte, 2014).
Blow	Sounds like air blown from nose. Call has a mean duration of 0.9 seconds. Females have a higher frequency blow than males.	Produced when otters were in a moderately agitated state due to a human's approach (Almonte, 2014). Leuchtenberger (2014) found two similar calls, labeled the snort call and hah call. Both were found to be alarm calls, with the snort being longer in duration.
Chatter	A chirp or whine in quick succession with an average duration of 1.8 seconds. The chirp and whine chatter sound the same but appear differently on the spectrogram. The chirp chatter forms harmonic bands and the whine chatter appears nonharmonic.	Adults produced chatters in conjunction with aggression. Chatters were the dominant call during aggressive physical altercations (Almonte, 2014). The call was also described by Gnoli (1995) in Eurasian otters as the staccato call and was produced in antagonistic interactions over disputes regarding food, territory, or a painful bite during play.
Creek	Sounds like a wooden door opening, varying by individual. Call has a mean duration of 1.1 seconds.	Produced most often by an adult female who was blind. Otter would retreat to a corner and use creek call in conjunction with swishes and hisses (Almonte, 2014).
Squeak	Sounds like a shrieking whine. Call has an average duration 2.1 seconds. Call is comprised of whines and chirps together.	Produced by only one male otter who did so in response to human presence. Squeaks would be produced for the duration of the time the human was present (Almonte, 2014).

Table 1 (continued).

Scream	Very similar to a whine in appearance and sound except call becomes increasingly louder as it progresses unlike whines. Call is high pitched with a mean duration of 1.5 seconds.	Produced by two separately housed females during pregnancy. About one month before birth, females would start making screams if a male otter was present. After pups were born, this call was successful in deterring male otters from entering the den (Almonte, 2014). McShane (1995) reports this call in sea otters when mother otter and pups were separated.
Swish	Sounds like water swirling in container. Call is nonharmonic and similar to a hiss. Call is low frequency with a mean duration of 1.4 seconds.	Produced most often by an adult female who was blind. Otter would retreat to a corner and use swish call in conjunction with creeks and hisses (Almonte, 2014).
Hiss	Sounds like a snake hiss. Call is nonharmonic with a low frequency and a mean duration of 1.0 second.	Produced most often by an adult female who was blind. Otter would retreat to a corner and use hiss call in conjunction with creeks and swishes (Almonte, 2014).
Hiccup	Sounds like a human hiccup. Call was heard four times by one female.	Produced by a juvenile female otter while playing with a toy (Almonte, 2014).
Whistle	Call produced by pups only. Call looked like a chirp but has a down sweep of harmonic bands. Call has an average of two harmonic bands.	Produced by pups only while they explored the natal den or locating their mother. Pups stopped producing this call at 8 weeks after they left the den (Almonte, 2014).

Behaviors

Behavioral analysis was conducted only on behaviors that occurred simultaneously with vocalizations. Because vocalizations were the main focus of this study, behaviors that did not occur with vocalizations were irrelevant to the research question and were not examined. The ethogram (Table 2) contained 23 behaviors: self-grooming, rubbing, group-grooming, playing, object manipulation, agonistic, displacement, sexual, traveling, swimming, solo stationary, group stationary, investigating, scent marking, disturbance, eating, drinking, hunting, stereotypical

scratching, stereotypical pacing, stereotypical chewing, begging, other, and out of sight. Fourteen of the 23 behaviors were found in this study. However, out of sight behavioral events were ultimately removed for analysis. Therefore, thirteen of the 23 behaviors were utilized for analysis.

Table 2 *Otter Behavioral Ethogram*

Behavior	Definition
Self-Grooming*	Otter is licking, biting, or scratching its fur. Otter is not chewing or sucking on the body part in a stereotypical manner.
Rubbing	Otter is turning and twisting its body, encouraging contact between fur all over their body with a surface.
Group-Grooming*	Otter is licking or biting another otter's fur, or another otter is biting or licking theirs.
Playing*	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. Object often includes crate or clip on bucket.
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.
Traveling	Otter is walking or running in a manner to arrive at a new location, not actively smelling or exploring the area underfoot.
Swimming	Otter is submerged $\frac{3}{4}$ in water and traveling.
Solo Stationary	Otter is laying down or standing in one spot, mostly still. No other behavior in the ethogram is present. There is no physical contact with another otter.
Group Stationary	Otter is mostly still, but is in physical contact with another otter. No other behavior in the ethogram is present. Often, otters may be lightly nuzzling, but <i>not</i> group-grooming.
Investigating	Otter is examining/exploring around it. A typical "investigation" will be an otter traveling, with nose pressed to the ground. At other times an otter is resting while extending its head in different directions. An otter can "investigate" through sight or scent.
Scent Marking	Otter is defecating or urinating. Often done at a latrine site or specific area.
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 hair, or fleeing.

Table 2 (continued).

Hunting	Otter is foraging or hunting for food.
Drinking	Otter is taking water into its mouth or has its head extended into a water bowl.
Eating	Otter is chewing or holding a food item.
Stereotypical Scratching*	Otter is scratching at a gate or door more than five times in a row.
Stereotypical Pacing*	Otter is walking back and forth repeatedly.
Stereotypical Chewing*	Otter is chewing/sucking on a body part.
Begging	Otter is looking towards a human with a steady or frequently returning gaze while human has a desirable (food, toy, exposure to exhibit). Often accompanied by vocalizations.
Other	Otter is exhibiting behavior that is not seen in ethogram. Include behavior in comments.
Out of Sight	Camera is recording but otter is not visible during vocalization.
*Behavior from Almonte's (2014) ethogram.	

Data Analysis

Inter-observer reliability for the coding of vocalization and behavior types was established using 10% of the data. Observers were 95.7% reliable on call type and 91.7% reliable on behavior.

Two chi square tests for independence were run to determine the relationship between call type and behavior. In both tests, only the most common call types (*chirp*, *squeak*, and *whine*) were included in analysis. To reduce low cell counts, the less common call types were not included in analysis and behaviors were collapsed into broader categories.

The first chi square analysis collapsed the behaviors into the following categories: group stationary, solo stationary, agonistic (agonistic and displacement), grooming (self-grooming, group-grooming, rubbing), and active (investigating, traveling, object

manipulation, chewing, drinking). In the second chi square analysis, behaviors were collapsed into the categories agonistic and non-agonistic. The agonistic behavior category included agonistic and displacement behaviors and the non-agonistic behavioral category included all other behaviors.

CHAPTER III - RESULTS

Vocalizations

Classified Call Types

The majority of calls were classified into the categories *chirp*, *chatterchirp*, *blow*, *squeak*, and *whine* (Figure 4) following Almonte's (2014) definitions. The male-male pair at The Maritime Aquarium produced 1,422 calls (Figure 5) over the 347 recorded minutes. The majority of calls (97%) were *chirps*. Other calls that were recorded in the male-male pair were *blows*, *whines*, and *chatterchirps*. In contrast, the male-female pair at Stamford Museum produced 216 calls (Figure 5) in 766 recorded minutes, of which only 8 were *chirps*. *Whines* were the most common call type. Other calls recorded in the pair included *squeaks*, *chatterchirps*, and *blows*.

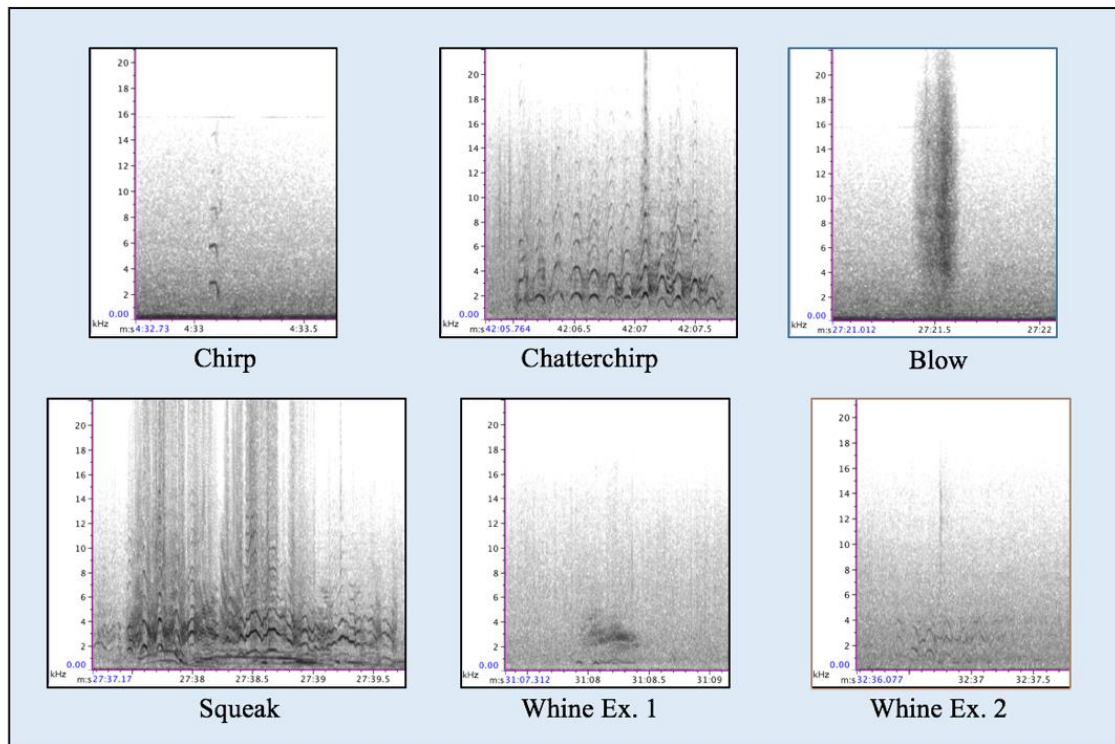


Figure 4. Spectrograms of the five classified call types.

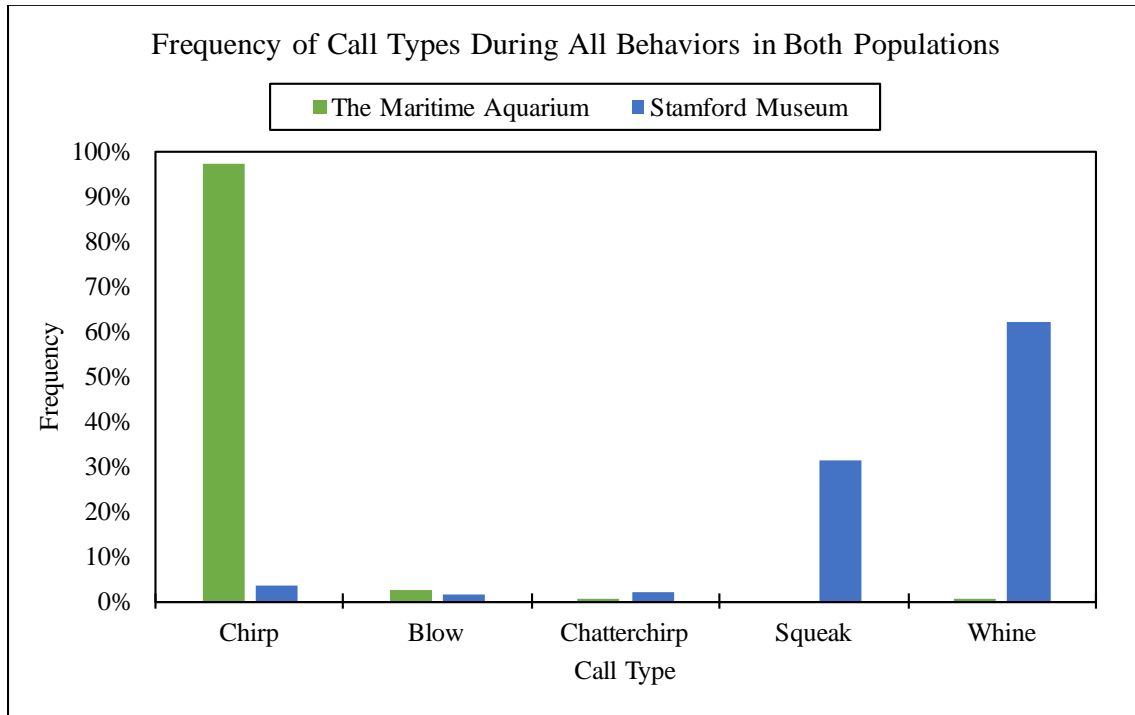


Figure 5. Frequency of classified call types during all behaviors in both populations.

Mean parameters were measured and reported for the male-male population at The Maritime Aquarium, and the male-female population at Stamford Museum, and for both populations combined (Table 3). The parameters reported for each call type include low frequency (LF), high frequency (HF), max frequency (MF), first quartile frequency (FQF), center frequency (CF), third quartile frequency (TQF), max power (MP), average power (AP), and duration (Delta).

The call type *blow* was recorded a total of 36 times and was found in both populations during non-agonistic behaviors. The *blow* sounded like a loud, quick exhale of air. *Blows* in the male-male population had a greater frequency range than those in the male-female population (Table 3). *Blows* in both populations had a similar duration with a mean duration of 0.16 seconds (Table 3).

The most common call type, *chirp*, was recorded 1,385 times in this study and found during non-agonistic behaviors. *Chirps* are short, high pitch calls. In this study, *chirps* were found to have between 1 and 7 harmonics. They were longer in duration in the male-female population than the male-male population by 0.13 seconds (Table 3). *Chirps* had a higher low frequency and a higher high frequency in the male-male population than in the male-female population (Table 3).

Chatterchirps were recorded a total of seven times and was found in both populations. A *chatterchirp* in this study is defined as a series of *chirps* that are within 0.03 seconds from one another. In the male-male population, this call was recorded during investigating behaviors. The *chatterchirp* had a longer mean duration in the male-female population than the male-male population by 1.01 seconds (Table 3). Like the *chirps*, the *chatterchirp* in the male-male population had a higher low frequency and a higher high frequency than the male-female population (Table 3).

Squeaks were found in the male-female pair at Stamford Museum during agonistic encounters. The *squeak* call consisted of both *chirps* and *whines*, with no break in the call longer than 0.03 seconds. The *squeak* had the longest mean duration of any call type (2.45 seconds) and had the highest average power (76.27 dB) and highest max power (104.78 dB) of any call type (Table 3).

Whines, the most variable call, were found in both populations. In this study, *whines* were found almost exclusively during agonistic or displacement behaviors. The *whine* occurred most frequently in the male-female population where it had a longer duration by 0.7 seconds and lower frequency range than in the male-male population (Table 3). *Whines* could be both harmonic or nonharmonic (Figure 4). Almonte (2014)

found three other sub-type calls including *creek*, *swish*, and *hiss* that, if present, were not distinguished from *whines* in this study.

Table 3 Mean Parameters of Classified Call Types in Both Populations

Population	Call Type (n)	LF (Hz)	HF (Hz)	MF (Hz)	FQF (Hz)	CF (Hz)	TQF (Hz)	MP (dB)	AP (dB)	Delta (s)
The Maritime Aquarium	Blow (33)	2536.93	19957.14	3612.35	3445.30	4446.27	6112.81	69.16	50.99	0.16
	Chirp (1377)	2089.68	11111.89	3194.20	2776.51	3106.96	3869.53	79.51	58.33	0.08
	Chatterchirp (3)	1919.07	18602.77	2612.70	2555.30	2612.70	2756.23	81.30	52.20	0.13
	Whine (3)	2089.27	13380.73	2727.53	2655.77	2756.23	3990.83	96.00	73.03	0.09
Stamford Museum	Blow (3)	434.83	21966.47	832.63	2009.77	4536.33	7134.67	86.07	66.67	0.20
	Chirp (8)	850.60	6416.65	1588.06	1291.99	1738.84	2260.99	92.10	73.65	0.21
	Chatterchirp (4)	753.35	13018.93	1862.63	1765.75	2067.20	3003.88	98.88	72.78	1.14
	Squeak (67)	416.23	17425.94	2578.84	2127.62	2630.90	3145.77	104.78	76.26	2.45
	Whine (134)	672.40	10187.98	2267.74	1722.35	2314.66	2863.26	91.86	71.62	0.79
Both Populations	Blow (36)	2361.76	20124.58	3380.71	3325.67	4453.78	6197.97	70.57	52.29	0.16
	Chirps (1385)	2082.52	11084.77	3184.92	2767.94	3099.06	3860.23	79.58	58.42	0.08
	Chatterchirp (7)	1252.94	15412.00	2184.09	2104.13	2300.99	2897.74	91.34	63.96	0.71
	Squeak (67)	416.23	17425.94	2578.84	2127.62	2630.90	3145.77	104.78	76.26	2.45
	Whine (137)	703.42	10257.89	2277.81	1742.79	2324.33	2887.96	91.95	71.66	0.77

Unclassified Call Types

In addition to these classified calls, three vocalization types were recorded at The Maritime Aquarium that could not be classified (Figure 6). Unclassified call A was recorded 23 times (Table 4). Aurally, the call sounded like a low frequency *chirp*. Visually, it had two low frequency harmonics below 2 kHz and, often, would have a lower amplitude component at a higher frequency. Unclassified call B was recorded three times. Aurally, it sounded like an animals' bark (Figure 6, Table 4). Unclassified call C was observed once and was the only down-sweep vocalization recorded in this study (Figure 6, Table 4).

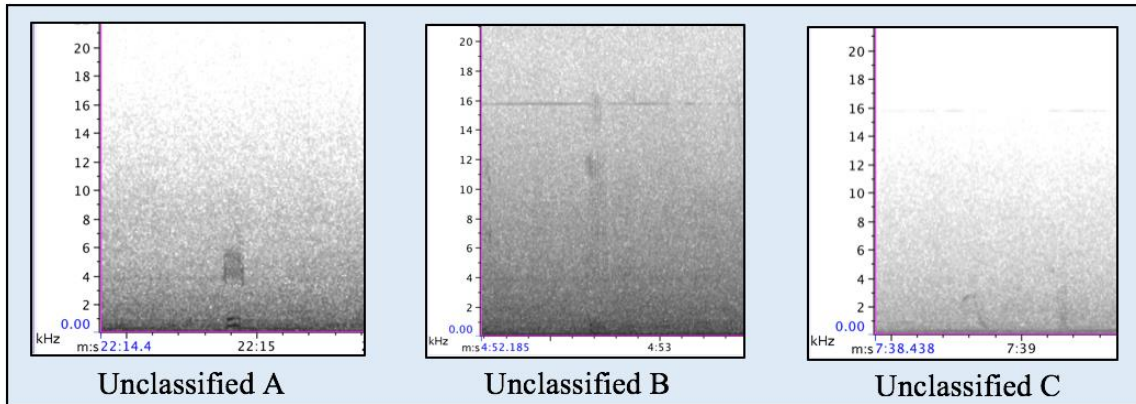


Figure 6. Spectrograms of three unclassified call types.

Table 4 Mean Parameters of Unclassified Call Types

Call Type (n)	LF (Hz)	HF (Hz)	MF (Hz)	FQF (Hz)	CF (Hz)	TQF (Hz)	MP (dB)	AP (dB)	Delta (s)
Unclassified A (23)	268.53	3797.45	507.43	389.47	528.03	734.00	81.71	68.60	0.10
Unclassified B (3)	268.53	3797.45	507.43	389.47	528.03	734.00	81.71	68.60	0.10
Unclassified C (1)	408.30	3021.70	602.90	602.90	861.30	1550.40	92.60	77.70	0.12

Behavior

A total of 728 behaviors (Figure 7) were observed during vocalizations in the two otter populations. The behaviors observed include drinking, displacement, agonistic, self-grooming, rubbing, group-grooming, investigating, object manipulation, traveling, solo stationary, group stationary, stereotypical chewing, and other. During instances where the otter was off camera (112 events), or not recorded (798 instances), behaviors were not analyzed. Behaviors when otters were not vocalizing were not included in this study.

Three behaviors were added to the original ethogram early in behavioral analysis, and one behavior (stationary) was split into two categories. The added behaviors were displacement, drinking, and object manipulation.

The displacement behavior was added when it became clear that not all agonistic encounters involved a physical interaction. Often, instead of the physical interaction, the

approaching otter would change direction upon hearing a vocalization. The drinking behavior was added because Levi in the male-male population would produce *chirps* while extending his head into the water bowl. Object manipulation was originally coded as other, but as the most common behavior in its category, object manipulation quickly emerged as its own category (24 events). During object manipulation, Levi in the male-male population would jostle and move either a large animal crate or a metal clip connected to the side of the enclosure.

The behavior stationary was split into the behaviors group stationary and solo stationary. This distinction became important because the instances of stationary behavior were very high in the male-male population. Upon examining the many stationary behaviors, it became clear a distinction between the two types of stationary was needed. Group stationary (193 events) emerged as more common than solo stationary (44 events).

The two otter populations exhibited differences in their most common behaviors. The male-male pair at The Maritime Aquarium engaged in a total of 11 different types of behaviors during vocalizing (Figure 7). Their most common behaviors were investigating (254 events) and group stationary (193 events). In contrast, the male-female pair were observed engaging in fewer types of behavior. The observed behaviors include investigating, traveling, agonistic, and displacement (Figure 7). The latter two behaviors were observed in the male-female pair only and not in the male-male pair. It's important to note that the male-female pair exhibited many pro-social behaviors which were free of vocalizations and therefore not included in this study. During their relatively rare agonistic and displacement behaviors, the otters were more likely to vocalize.

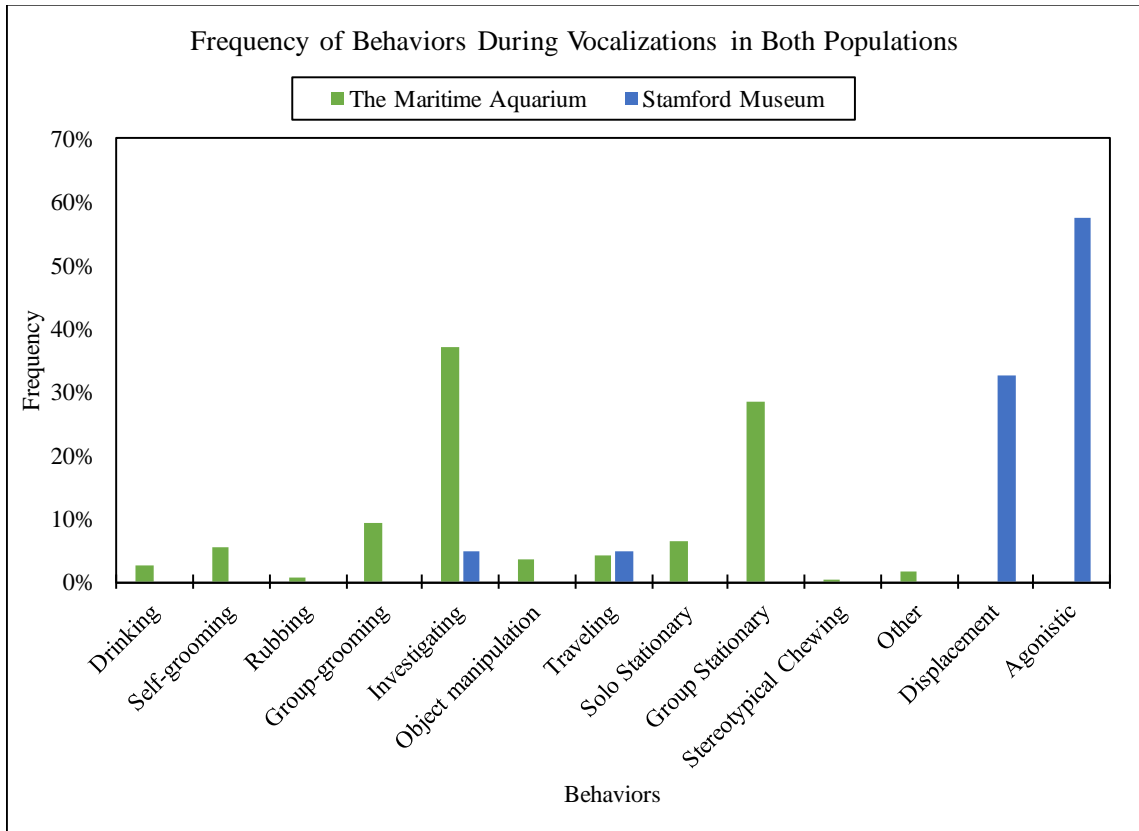


Figure 7. Frequency of behaviors produced during classified call types in both populations.

Vocalization and Behavior Interaction

At the start of this study, I predicted that there would be a relationship between the type of vocalizations produced and their co-occurring behaviors. Specifically, that *squeaks* and *chatterchirps* would be highly correlated with agonistic behavior and that *chirps* would be highly correlated with stationary behaviors and stereotypical behaviors (chewing, pacing, and scratching). While a relationship was found between type of vocalizations and behavior, not all of the specific predictions were supported.

Results showed that *squeaks*, as predicted, were correlated with agonistic behaviors. There was not enough data to determine if *chatterchirps* were as well. Of the seven *chatterchirps*, only three had a co-occurring behavior recorded. Results also

showed that while *chirps* did co-occur frequently with stationary behaviors as predicted, they were more highly correlated with investigating behaviors. Lastly, results showed that not only were *chirps* not correlated with stereotypical behaviors but that stereotypical behaviors during vocalizations were rare, with only two instances of stereotypical chewing recorded in total.

The first chi-square test of independence was performed to examine the relationship between call type (*chirp*, *whine*, and *squeak*) and the combined behavioral categories group stationary, solo stationary, agonistic (agonistic and displacement), grooming (self-grooming, group-grooming, rubbing), and active (investigating, traveling, object manipulation, chewing, drinking). The relationship between these variables was significant, $X^2 (8, N = 717) = 677.46, p < .001$. To reduce low cell counts, behaviors were then collapsed into two behavioral categories for a second chi square analysis.

The second chi-square test of independence examined the relationship between call type (*chirp*, *whine*, and *squeak*) and agonistic behavior versus non-agonistic behavior. The relationship between these variables was significant, $X^2 (2, N = 717) = 677.29, p < .001$. *Squeaks* and *whines* were more likely to occur during agonistic behavior, and *chirps* were more likely to occur during non-agonistic behavior (Figure 8).

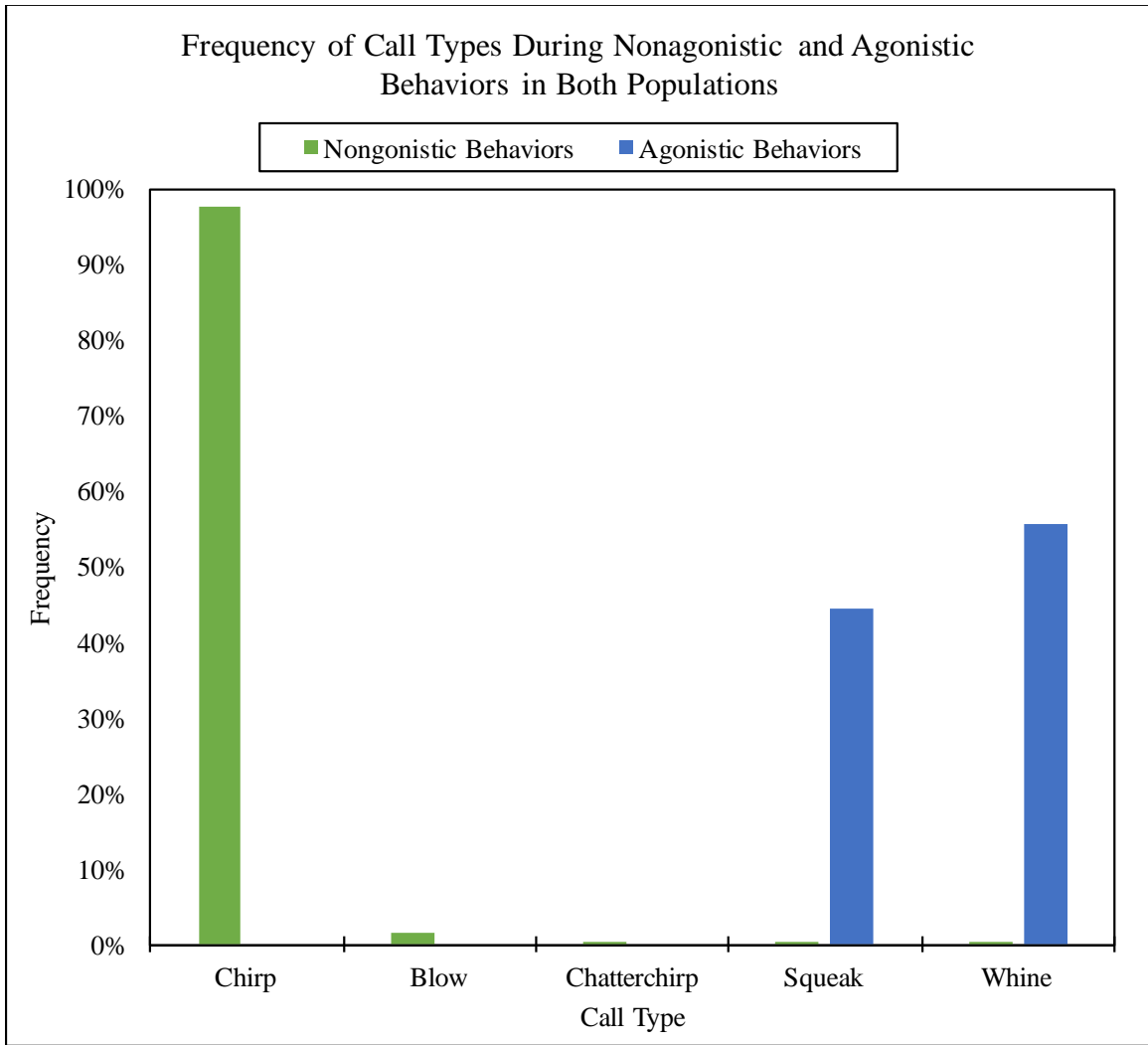


Figure 8. Frequency of classified call types during agonistic and non-agonistic behaviors in both populations.

CHAPTER IV – DISCUSSION

Vocalization Repertoire and Behavioral Context

Chirps were the most frequently recorded call type in this study. *Chirps* in river otters are likely analogous with *contact calls* (Mumm et al., 2014) and *adult calls* (Leuchtenberger et al., 2014) in giant river otters, *squeaks* in sea otters (Mcshane et al., 1995), and *U3s* in Asian small-clawed otters (Lemasson et al., 2014). In Asian small-clawed otters *U3* was produced during social isolation, affiliative interactions, and during exploration (Lemasson et al., 2014). In river otters, the *chirp* was previously found to be a low agitation call (Almonte, 2014). Results of the current study were similar, *chirps* occurred most often during investigating and stationary behaviors and never during agonistic behaviors.

Seven *chatterchirps* were recorded in this study. This call has been identified in other river otter populations (Almonte, 2014). Almonte labeled *chatterchirps* as *chatters*, and noted that while *chatters* could appear on the spectrogram as both repeated *whines* or *chirps*, they had the same sound aurally (2014, pp.510). Almonte (2014) found *chatters* to be the dominant call type during high agitation states during physical altercations. The call was also found in Eurasian otters, referred to as a staccato call, and was produced in antagonistic interactions over disputes regarding food, territory, or a painful bite during play (Gnoli & Prigioni, 1995). Only three *chatterchirps* in this study had an associated behavior. Likely, with more behavioral data, the populations in the present study may have also been using *chatterchirps* in agonistic contexts.

Blows were recorded 36 times in this study. *Blows* were also found in Almonte's (2014) river otter research when otters were moderately agitated due to a human's approach (Almonte, 2014). Similar calls to a *blow*, labeled *snort* and *hah*, have been recorded in giant river otters (Leuchtenberger et al., 2014). These calls were also produced through an exhalation of air. In this giant river otter study, both calls were found to be alarm calls, with *snort* being longer in duration (Leuchtenberger et al., 2014). *Blows* in this study were recorded during non-agonistic behaviors including investigating, object manipulation, drinking, self-grooming, solo stationary, and group stationary. This result is contradictory to the literature and more research is needed to understand when and why *blows* may be used not as a warning or agonistic call in certain human care populations.

Squeaks were recorded 67 times in this study. *Squeaks* were also reported by Almonte (2014) in one male river otter in response to human presence. In this study, *squeaks* occurred during agonistic or displacement behaviors from a conspecific, indicating that *squeaks* in river otters may communicate agitation particularly at being displaced by another creature (e.g., human or conspecific). Results indicate that *squeaks* may play an important role in allowing otters to avoid or limit costly physical altercations with other otters as well as animals from other species.

Whines were recorded 137 times in this study. *Whines* were also recorded by Almonte (2014) who found they were produced during a variety of behavioral states in river otters and that they likely did not function as a marker of agitation. In contrast, the results of this study found that the majority of *whines* occurred during agonistic or

displacement behaviors. More research is needed to determine when *whines* are used in a low versus high state of agitation.

In addition to the call types above, three calls were recorded at The Maritime Aquarium that could not be classified (Figure 6) into previous categories set forth by Almonte (2014). More research is needed before classifying these calls under their own category. Unclassified call C was produced by the 16-month old male otter at The Maritime Aquarium. This vocalization may be analogous to the *whistle* recorded by Almonte (2014). *Whistles* were recorded only in pups (Almonte, 2014). A down sweep call, *cub long call*, was also found to be produced by a giant river otter juvenile (Bezerra et al., 2011). More research is needed to determine until what age North American river otters produce the whistle call, and if this down-sweep call could be a more mature version of a pup's whistle.

Limitations

A small sample size limits the degree to which these results can be extrapolated to other populations. In addition, 49% of events were not video recorded and 7% of events were categorized as out of sight, leaving 44% of behaviors (728 events) included in analysis. The restricted number of behaviors decreases what could have been learned about the relationship between vocalizations and behavior had all behaviors been recorded on camera.

Observations took place at different times of day and in different enclosure types. The male-male pair was recorded in their off exhibit enclosure early in the morning while the male-female pair was recorded at different times of day in the large outdoor enclosure. The difference in time and location likely influenced the different behaviors

and vocalizations observed between the populations and limits the ability to compare vocalizations and behaviors between the populations.

Future Research

A comparison between the findings here and the findings in other wild and human care populations will allow researchers and caregivers to better understand the use of vocalizations in otter communication. This would serve the greater purpose of elucidating what we know about communication system evolution, as well as help secure the survival of otters.

Studying variations in vocalization repertoire use across different regions of North America and in different facilities could help demonstrate how a communication system changes across geographic barriers, or in isolated human care populations. Studying variations in call repertoires in human care may show the ability of otters to generate new call types, or discontinue old call types, depending on their environment and on novel situations they encounter. Studying this communication adaptability will increase our understanding of how animal communication evolves, as well as provide evidence of which call types are learned versus innate.

The majority of the 13 species of otters worldwide are vulnerable, near threatened, or endangered (Yoxon & Yoxon, 2014). While North American river otters are currently classified as least concern for extinction, they are very common in North American zoos and aquariums, some of which participate in breeding the species. As such, these facilities could benefit from increased knowledge of river otter behavior and communication. In addition, in the event that the increasing trapping/hunting of otters, pollution of habitats, and deforestation decrease river otter populations in North America,

we may find that river otters once again require human assistance in rehabilitation and repopulation. Understanding how otters communicate can help facilitate species survival during acts of relocation and introduction for breeding purposes by humans.

APPENDIX A – IACUC Approval Letter



THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

118 College Drive #5116 | Hattiesburg, MS 39406-0001
Phone: 601.266.6791 | 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: 15051402
PROJECT TITLE: Context Specific Vocalizations of North American River Otters in Captivity
PROPOSED PROJECT DATES: 05/2015 - 09/2017
PROJECT TYPE: Modification
PRINCIPAL INVESTIGATOR(S): Stan Kuczaj
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: N/A
IACUC COMMITTEE ACTION: Full Committee Approval
PROTOCOL EXPIRATION DATE: September 30, 2017

Frank Moore, PhD
IACUC Chair

12/1/15
Date

REFERENCES

- Almonte, C. (2014). Classification of Captive North American River Otters (*Lontra canadensis*) Vocal Repertoires: Individual Variations, and Age Class Comparisons. *Animal Behavior and Cognition*, 1(4), 502-517.
doi:10.12966/abc.11.07.2014
- Bezerra, B. M., Souto, A. S., Schiel, N., and Jones, G. (2010). Notes on vocalizations of giant otters in the flooded Igapo forests of Jau National Park, Amazonas. Brazil. *Journal of Ethology*, 29(1), 169–175. doi:10.1007/s10164-010-0218-0
- Charif, RA, AM Waack, and LM Strickman. 2010. Raven Pro 1.4 User's Manual. Cornell Lab of Ornithology, Ithaca, NY.
- Gnoli, C., and Prigioni, C. (1995). Preliminary study on the acoustic communication of captive otters (*Lutra lutra*). *Hystrix*, 7(1–2), 289–296. doi: 10.1121/1.4896518
- Kean, E. F., Bruford, M. W., Russo, I. M., Müller, C. T., & Chadwick, E. A. (2017). Odour dialects among wild mammals. *Scientific Reports*, 7(1).
doi:10.1038/s41598-017-12706-8
- Kean, E. F., Müller, C. T., & Chadwick, E. A. (2011). Otter Scent Signals Age, Sex, and Reproductive Status. *Chemical Senses*, 36(6), 555-564.
doi:10.1093/chemse/bjr025
- Lemasson, A., Mikus, M-A., Blois-Heulin, C., and Lode, T. (2014). Vocal repertoire, individual acoustic distinctiveness, and social networks in a group of captive Asian small-clawed otters (*Aonyx cinerea*). *Journal of Mammology*, 95(1), 128–139. doi: 10.1644/12-MAMM-A213.1

- Leuchtenberger, C., Sousa-Lima, R., Duplaix, N., Magnusson, W., & Mourao, G. (2014).
Vocal repertoire of the social giant otter. *Acoustical Society of America*, 136(5),
2861-2875. doi: 10.1121/1.4896518
- McShane, L., Estes, J. A., Riedman, M. L., and Staedler, M. M. (1995). Repertoire,
structure and individual variation of vocalisation in the sea otter. *Journal of
Mammalogy*, 76, 414–427. doi: 10.2307/1382352
- Mumm, C. A. S., Urrutia, M. C., and Knörnschild, M. (2014). Vocal individuality in
cohesion calls of giant otters, *Pteronura brasiliensis*. *Animal Behavior*, 88, 243–
252. doi: 10.1371/journal.pone.0112562
- Owens, M., Alm, V., Helten, B., Shelley, S., & Reed-Smith, J., (2009). Summary of
Husbandry Guidelines for North American (aka Nearctic) River Otters (*Lontra
canadensis*) in Captivity. IUCN/SSC Otter Specialist Group, Otters in Captivity
Task Force.