AN ANALYSIS OF BEHAVIOR IN CAPTIVE SOUTHERN SEA OTTERS (*ENHYDRA LUTRIS NEREIS*)

An Undergraduate Research Scholars Thesis

by

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Submitted to the LAUNCH: Undergraduate Research office at
Texas A&M University
in partial fulfillment of requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by
Faculty Research Advisor: Dr. Lene Petersen

May 2021

Major: Marine Biology

RESEARCH COMPLIANCE CERTIFICATION

Research activities involving the use of human subjects, vertebrate animals, and/or biohazards must be reviewed and approved by the appropriate Texas A&M University regulatory research committee (i.e., IRB, IACUC, IBC) before the activity can commence. This requirement applies to activities conducted at Texas A&M and to activities conducted at non-Texas A&M facilities or institutions. In both cases, students are responsible for working with the relevant Texas A&M research compliance program to ensure and document that all Texas A&M compliance obligations are met before the study begins.

I, Melody L. Antwiler, certify that all research compliance requirements related to this Undergraduate Research Scholars thesis have been addressed with my Research Faculty Advisor prior to the collection of any data used in this final thesis submission.

This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

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ABSTRACT

An Analysis of Behavior in Captive Southern Sea Otters (*Enhydra Lutris Nereis*)

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Enhydra lutris nereis, otherwise known as the Southern Sea Otter, has been listed as threatened since 1977. The initial reasoning for their listing was the population deficit due to hunting in the era of fur trading and the threats they faced due to ships and anthropogenic influences. However, recent studies have shown that the primarily imminent threat to the sea otter population is disease and pollutants entering their habitat from terrestrial sources. For example, *Toxoplasma gondii* has been found in an increasing frequency in the bodies of dead sea otters. *T.gondii* are most commonly found in cats or mice, as the parasite causes the fear response in mice to dampen and go near the cats. This muted instinct allows the mice to get close to the cats and infect them so that the parasite can complete it's life cycle. The growing cat population in North America combined with anthropogenic runoff is the cause of infection in the marine environment. The results of this study and others like it will provide an example of otter behavior in captivity so that we may better understand their native population's behaviors. This information can be used to help determine the boundaries of protected areas to preserve natural behaviors beyond the bare minimum needed for mating and foraging.

ACKNOWLEDGEMENTS

Contributors

I would like to thank my faculty advisor, Dr. Lene Petersen for their guidance and support throughout the course of this research. I am truly grateful and blessed that she agreed to be my advisor and I can not imagine completing this project with anyone else in her position.

I would also like to say thanks to my parents for their encouragement, love, and patience during my research. I would also like to thank them for proofreading this paper, they had many helpful notes on my grammar. To my siblings, I am grateful for their patience as I was typing well into the early hours of the morning.

Funding Sources

Undergraduate research was supported by the Aggies Committed to Excellence Scholarship (ACES) at Texas A&M University.

1. INTRODUCTION

1.1 The General Ecology of the Southern Sea Otter

Enhydra lutris, otherwise known as the sea otter, is typically located within ten kilometers of shore and within that range the depth does not exceed 125 meters (Pearson, 2005). This limited range from shore is eclipsed by their multiple populations across the northern half of the Pacific Ocean, notably in California and Alaska. Another group is located at the Kamchatka Peninsula in the Asian part of Russia. These three epicenters are indicative of the geographic distribution of the three subspecies of *E.lutris*, the Alaskan variant being *E.lutris kenyoni* the Asian species is *E.lutris gracilis,* and the third identified subspecies the southern sea otter is *E.lutris nereis* (Watson, 1996).

Across all three subspecies their territorial, mating, foraging, and nurturing behaviors are mostly the same with minor variations due to anthropogenic factors and available resources. For example, sea otters utilize tools such as rocks for eating hard shelled crustaceans, bivalves, gastropods, and echinoderms. A study was conducted on populations in Alaska and California which found that the Alaskan otters used tools on less than one percent of observed food items while the Californian otters used tools sixteen percent of the time (Fujii, 2015). An isotopic study was performed on the southern sea otter's diet. Isotopes are the different forms of a single element with different numbers of neutrons. By examining the amount and form of different elements in the animal's muscle tissue, or in this scenario the vibrissae or whiskers, one can determine what has been the primary dietary intake. The results of the study suggests that the diets of these animals do not change seasonally, but that in roughly twenty two percent of the individuals there was a change in the chemical composition of their diet during winters. The difference in the chemical composition of what the otters ate was not due to their food choices, but rather what their food ate. Sea otters are omnivorous and have a wide range of possible food sources from urchins and clams to smaller invertebrates like worms and small fish. The authors of this study determined that in cases of seasonal difference it was what the fish and urchins consumed during that time period that changed the isotopic signature (Newsome, 2009).

This diet often includes eating things with a hard shell, which can wear down teeth over time and eventually effect their life expectancy. Tooth wear and damage was analyzed to discover the maximum life expectancy of wild animals. The maximum lifespan of males was thirteen to fifteen years while females lasted fifteen to seventeen years (Nicholson, 2020). An additional difference between male and female life histories is that males tend to be significantly larger than females (Ralls, 2009).

1.2 Known Behaviors in Southern Sea Otters

1.2.1 Territory Behaviors

Similarly to several other marine mammals, such as odontocetes, the female southern sea otters will form groups of multiple adult females and pups called a raft. However, when the male pups in that group are successfully weaned from the mother at an average of six months, they will leave the group and proceed to join a male only group or remain isolated (Cohn, 1998). The latter is significantly less likely to occur, as sea otters often utilize the safety in numbers strategy to deter predators such as orcas. Males tend to congregate further from shore with the sexually mature adults tending to move around with the goal of establishing territories around groups of females (Lafferty, 2014). Most rafts tend to range from four to forty individuals with an average of twenty per group, but there have been reports in otter affluent areas of rafts of over a hundred individuals present (Lubina, 1988). Typically, female specific rafts will remain at the lower end of the spectrum with less than twenty adult females per group, but males will be more numerous with twenty to thirty individuals on average. Additionally, females with pups have been spotted splitting into smaller groups in the same region to account for increased numbers, and likely an increased foraging demand (Loughlin, 1980).

There has been an alternative strategy for male specific rafts noted that after roughly five years, if the male otters remain in the same location, females will eventually migrate to the area and change the predominantly male territory to a mixed sex one, and eventually a female and pup only area as males establish mating territories and push their cohorts out of the zone (Lafferty, 2014). These territories can shift due to the death or leaving of the individual who previously established it.

1.2.2 Mating and Maternal Behaviors

Female sea otters reach sexual maturity between four and five years, while males reach it at five to six years (Jameson, 1993). Sea otter mating is often described as violent, with the male biting the nose during copulation to keep the female in place, often leading to scarring which is used in photo capture studies (Finerty, 2007). However, if the female attempts to break free, she may scratch back and cause the male significant injuries, it has also been noted by physiologists that the mating behavior resulted in dental fractures in a small number of males (Winer, 2013). Mating episodes can last for several minutes but the pairs may stay together for a couple of days after mating before they part ways and the male will leave to find another mate while the female often returns to a female raft (Mesnick, 2009).

Females will have one pup every year, with a gestation term of six to seven months and an additional six months of maternal care for the pups. Pups can be born at any time during the year, but the majority are born between March and September. There is also an average 1 to 3 day turnaround between the end of a weaning period and an instance of mating. However, if the mother lost the pup prematurely it could take ten days or more for another reproductive cycle. Furthermore, the weaning period increases with a female's age which coincides with a lower overall rate of offspring production (Reidman, 1994).

Males have shown to be interested in both females with pups and without for the purposes of mating. Additionally, males may interact with females caring for pups by taking advantage of the mother's foraging habits. These males will threaten the pups that are left on the surface to cause the female to abandon her food in exchange for the safety of her offspring, this has been dubbed hostage behaviors (Pearson, 2005).

The successful theft of the food is detrimental to the survival of the female and her offspring. Pups are nursed for six months and during that time the mother's lactating is decreasing all energy stored in her fat layer. To counter this loss, the female will increase food intake and eventually provide food for her young during the weaning process. In this timeline the female often loses more than thirty percent of their body mass. In certain scenarios, such as fewer available resources, the female might be forced to wean the pup early or completely abandon them in favor of starting to prepare for the offspring, they will produce next year (Thometz, 2014).

1.3 Endangered Status and Threats to Population

During the eighteenth and nineteenth centuries all sea otter subspecies and populations were subject to hunting by fur traders for their coats, which takes the place of blubber in this marine mammal for the purpose of retaining heat. The extensive hunting of these animals has led to the severe population depletion before they were placed under international protections in 1911. Some reports state that over ninety percent of the population was removed by hunting in multiple areas on the North American coast (Szpak, 2012). Canada's western coastline was devoid of sea otters until they were reintegrated in the seventies. With the aforementioned protections in place this population has grown significantly over the past several decades, in some years showing upwards of a twenty percent increase (Powles, 2000). The initial lower population of white abalone and the sudden increase in populations of sea otters has caused the North American population of white abalone to face an overall loss. This loss initially occurred as recently as the nineties which has presented the idea that the Northern Sea Otters could soon face removals to allow the abalone to catch up (Chades, 2012).

Population deficits are not the only lasting consequences of the fur trade. There are concerns that the extensive hunting of all subspecies decreased the available gene pool to the point where an uptick in birth defect statistics is possible in several regions where sexually mature individuals were sparse. The study in question did not have access to animals exterminated during the fur trade harvesting and chose to use bones from prior to the eighteenth century to compare with the current sample individuals. There was found to be a small amount of variation in the mitochondrial DNA, far less than one would expect after three centuries and over a dozen generations (Larson 2002).

Southern sea otter geographic expansions to pre fur trade designations and further genetic diversity is largely dependent on the survival of adult individuals. Many scientists endeavor to predict the natural expansion of existing with the intention of expediting the process through conservation efforts. Some choose to monitor progress over time for later use of the data. One distinct age class has caused estimates to be incorrect. Animals during the sub-adult stage in life were responsible for the most uncertainties in the data. Alternatively, the study in question found that while males may be sighted in an area it is the presence of females that are a good indicator of a population’s longevity and further research into the habits of sub adult females would be beneficial to management efforts (Tinker 2008).

Under the endangered species act, southern sea otters have been classified as threatened since 1977. The original reason for listing was the threat they face from ships and possible oil spills which could corrupt their habitat and potentially wiping out numerous rafts at once (U.S Fish and Wildlife, 2020). However, one study stated that roughly forty percent of performed necropsies on otters showed cause of death attributed to disease and parasitic infection leading to recent population deficits (Jessup, 2004).

A common cause is the parasite *Toxoplasma gondii,* an organism commonly found in mice that dampens the fear response so that they will approach cats. The cats eat the infected mice. The parasite then infects the predator for the purpose of completing its life cycles. In humans and other terrestrial mammals, this parasite is a contributing factor in still births. However, in farm animals and monkeys the parasite is sometimes a cause of neurological issues like seizures (Torrey, 2003). Transmission to sea otters is not easily explained or known since they do not feed on any part of the parasite’s known hosts. It is suspected that early-stage oocytes, or early ovary cells, deposited in the feces of animals are the cause. Runoff into the ocean would transport these cells into a place where otters could be infected, this theory becomes more likely with an ever increasing domesticated and feral cat population within the United States (Conrad, 2005).

Toxoplasma gondii has often been found in otters together with the parasite *Sarcocystis neurona*. Transmission is similar, with runoff transporting the feces of a terrestrial mammal, in this case a kind of opossum, to the water where it can infect the otters. In 2004, numerous dead otters were reported in the same area. There were a small number found alive and suffering severe neurological issues. They did not last more than two days without being euthanized or dying. The necropsies on the deceased showed that they had been exposed to *S.neurona* with a smaller number being exposed to *T.gondii*. These animals were also shown to have been exposed to high levels of domoic acid, a toxin already known to cause problems in pinnipeds in high concentrations. Domoic acid intoxications can cause brain lesions that are often undiagnosed unless the necropsy is performed on a newly dead animal (Miller, 2010).

Histoplasmosis is a disease caused by the fungus *Histoplasma capsulatum*. In human subjects onset of the disease will present with shortness of breath, pneumonia, coughing up blood, narrowing of air pathways, and obstructions were found in the superior vena cava (Mathisen, 1992). Fungal infections of this type are typically only found in terrestrial animals. In 2005 a dead northern sea otter was located far outside of the fungus' natural range. The cause of death was discovered to be histoplasmosis. This otter suffered from lymph node abnormalities, atrophy of the thymus gland, extreme swelling of the liver and spleen, and swollen bronchi with mucous. The exact cause of transmission was unknown in this instance, but theories include transmission via migratory sea birds that can carry it on their feet and feathers. An alternative theory is that spores were transmitted via air from China or Russia, but that would not explain how it could infect an otter located in North America (Burek-Huntington, 2014).

1.4 Justification of Study

As previously mentioned, the research regarding southern sea otter behavior is largely limited to grouping and mating behaviors. Other marine mammals like the Orca have similar biases towards the research that have caused a lapse in the understanding of intraspecific social behaviors. An analysis of the social interactions of captive Orcas was performed in the Loro Parque Zoo in Spain. Their methodology consisted of observation intervals of fifteen minutes a day for three months. Behaviors were divided into categories such as sexual interactions, antagonistic behavior and affiliative interactions then further divided into specific behavior. An interesting method choice was the classification of behaviors that could be counted as either behavioral subgroup, where context of the behaviors was used to determine categories. Using these techniques, the scientists were able to observe things such as the integration of a new female into the social group, male affiliative interactions, and antagonistic displays between both sexes that were not previously described (Sánchez–Hernández 2019).

A study with *E.lutris* in a captive environment could be enlightening to their social interactions when dealing with individuals that are not familial relations, mates, or competition. Without the geographic distances between the sexes and no territories to maintain, introspects into the daily lives of sea otters in captivity could lead to further research with more subjects and ideas into the management of rescued animals from wild habitats. The purpose of this study is therefore to observe the interaction between unrelated individuals in an aquarium setting to assess different behaviors exhibited by captive animals. Understanding these behaviors can help assess when animals in their natural environment are displaying abnormal activity due to changes in the habitat like diseases or exposure to pollutants.

2. METHODS

2.1 Experimental Animals

The Georgia Aquarium, located in Atlanta Georgia, is one of the country's largest public aquariums. They have a collection of approximately 234 species of fauna in their care. Among their animals are five southern sea otters (Enhydra lutris nereis), which are housed in their "Cold Water Quest" wing. Most exhibits in the aquarium, including that of the southern sea otters, have the animals on rotation. Therefore, the otters can be present in any combination and number at any given time. The current lineup of otters includes adult male Cruz, adult female Bixby, adult male Brighton, adolescent male Gibson, and adolescent female Mara. Gibson and Mara are the most recent additions to the enclosure. They were welcomed in March of 2019 when Gibson was roughly five weeks old and Mara at ten weeks old. At the time of collection both individuals were under the age of two. They are be considered adolescent or late-stage juvenile as neither have reached sexual maturity. During initial observations the two could not be distinguished using available photographs, and any distinguishing characteristics were unreliable. Therefore, these two were collectively labeled as individual #1 to avoid mislabeling. The other three were all adults and therefore had variations in size and grizzle density. Grizzle is the amount of blonde or white fur on the animal's muzzle. As this animal grows older and reaches sexual maturity, the blonde hair will spread to the rest of the head and on the animal's ventral side. In addition, the hair will continue to get lighter as the animal ages, similar to how a human will develop grey hairs. Brighton, the younger of the two adult males judging by the grizzle, has been labeled as individual #2. His grizzle pattern goes down to past his shoulders on the ventral side and not passing his neck on the dorsal side. Bixby, the adult female, appears similar to Brighton in photographs and on camera. However, Bixby's grizzle patter extends closer to her midsection on the ventral side when compared to Brighton and on her dorsal side the grizzle extends further down. She has been identified as individual #3. Finally, individual #4 was identified as the oldest male, Cruz. He has a nearly entirely white ventral side and from the dorsal side he was identifiable by the whiter fur.

2.2 Preliminary Observations

Initial observations were utilized to classify behaviors and to construct an ethogram (Table 1). However, several behaviors that would occur in the sea otter's natural habitat are unavailable under the controlled conditions of the aquarium. For example, the animals are fed during training by aquarium officials. These feedings makes natural foraging responses unavailable. As a result, the only natural instances of foraging occurred when the otters chose to eat the ice available in the enclosure. Enrichment items did appear able to hold food items but the presence of this cannot be confirmed by visual analysis, so all such interactions were labeled with Enrichment (E) instead of Foraging (F). In addition, the otters are all given birth control to prevent mating behaviors (Table 1).

Table 2.1. Ethogram of the most commonly observed sea otter behaviors at the Georgia Aquarium

Code	Behavior	Description of Behavior
S	Swimming	Individual shows active swimming
C	Cubby	Animal sits in "cubby" located at the back of the enclosure.
G	Grooming	Animal shows grooming behavior
E	Enrichment	Animal interacts with enrichment placed in the enclosure
O	Offscreen	Animal is not visible
I	Ice bath	Animal utilizes ice bath
W	Wrestling	Wrestling with at least one other individual
T	Together	An additive, the animal showed this behavior with at least one other individual
L	Land	The animal was on land
H	Human Interaction	The trainer is interacting with this animal or their presence in the enclosure influences the animal
V	Visitor Interaction	The presence of an aquarium visitor influenced the animal
B	Barrel Roll	One individual causes another individual to roll over by swimming across them
R	Resting	Animal is either sleeping or not moving in this time frame
F	Foraging	Animal forages for ice and chews on it
P	Play	Animal shows unspecified play behavior

2.3 Methods of Recording

Due to their tendency to change behaviors rapidly, continuous sampling was determined to be the most appropriate method for capturing the behavior of sea. In addition, these observations were done on each individual animal, so sampling intervals were recorded, and the behavior of each individual was documented upon re-watching the collected videos. These collections were collected through a webcam published by the Georgia Aquarium on their website (https://www.georgiaaquarium.org/webcam/southern-sea-otter-webcam/). This camera's range shows their southern sea otter habitat's land portion, hiding space, and the majority of the aquatic space in the tank. However, this camera's range does not include the area beneath the water's surface or the glass wall that the aquarium guests look through. Observations of these animals took place three times a week on Monday, Wednesday, and Friday mornings at nine o'clock Central Standard Time. Although, at the aquarium the time would be 10AM in the morning Eastern Standard Time. The duration of these collections were 30 minutes and video footage was recorded utilizing a screen capture software available on Microsoft computers.

After the recordings were saved either to the computer or to an external drive, each recording was subject to a quality review and had to meet two criteria. Firstly, the recordings needed to be clear, there were several instances where the internet connection of the aquarium or observation computer were insufficient. Secondly, Mara and Gibson, the two otters labeled as individual one, were not to be in rotation at the same time. This decision was to prevent their behaviors from counting twice, if they had been at the enclosure at the same time there was a risk of a behavior done together counting twice. This was done because misidentifying the two was highly probable.

All the videos were watched for each individual in the enclosure and behaviors were observed using the ethogram shown in Table 1. Behaviors were collected using continuous sampling methods and this entailed recording the start and end times we along with the behavioral codes. Afterwards the duration was calculated. These codes could be combined if more than one behavior was exhibited, such as if the behavior was done on land or if the behavior was performed with another individual. For example, if an otter was swimming with another otter while holding an item of enrichment the codes recorded would be Swimming (S), Enrichment (E), and Together (T) in no particular order.

Data collections began on November 18th, 2020 and concluded on January 4th, 2021. Once observations were complete all of the data were entered into Excel where the durations of each individual behavior were summed, averaged, and the percentage of time spent doing each behavior was calculated. One-way ANOVAS were performed on the most frequently occurring behaviors. These behaviors were determined to be “Swimming”, “Together, “Cubby”, and “Enrichment”. A one-way ANOVA was performed on the average time spent on each of the four behaviors. Significant differences in duration of time on each behavior was determined to allow for comparison between the four individuals. Additionally, the percentage of time spent on all behaviors was calculated to determine which behaviors were most frequently used by each animal. The durations of each behavior were summed and used with total time observed to find the overall percentage an animal exhibited the behavior using the equation below.

$$\left(\frac{sum\ of\ behaviors}{sum\ of\ total\ observations}\right) * 100 \tag{2.1}$$

3. RESULTS

3.1 Behavior Duration Results

There were significant differences in the average time spent on swimming between the four otters (Table 2). The animal that spent the most time in the enclosure was individual #1 (with an average of 90 seconds swimming) while numbers #2 and #3 spent almost equal amount of time swimming. It should be noted that individual #1 was present the most often. Individual #4 spent the least amount of time swimming compared to the other three otters (Table 2, Fig 1).

Table 2 One-Way ANOVA on "Swimming" Behavior

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
#1	174	15803	90.82184	13427.23
#2	194	9088	46.84536	1720.95
#3	144	7881	54.72917	4085.849
#4	124	3919	31.60484	532.5011

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	299455.1	3	99818.36	19.08879	7.35E-12	2.619
Within Groups	3304829	632	5229.16			
Total	3604284	635				

An ANOVA performed on the "Swimming" behavior comparing the four individuals

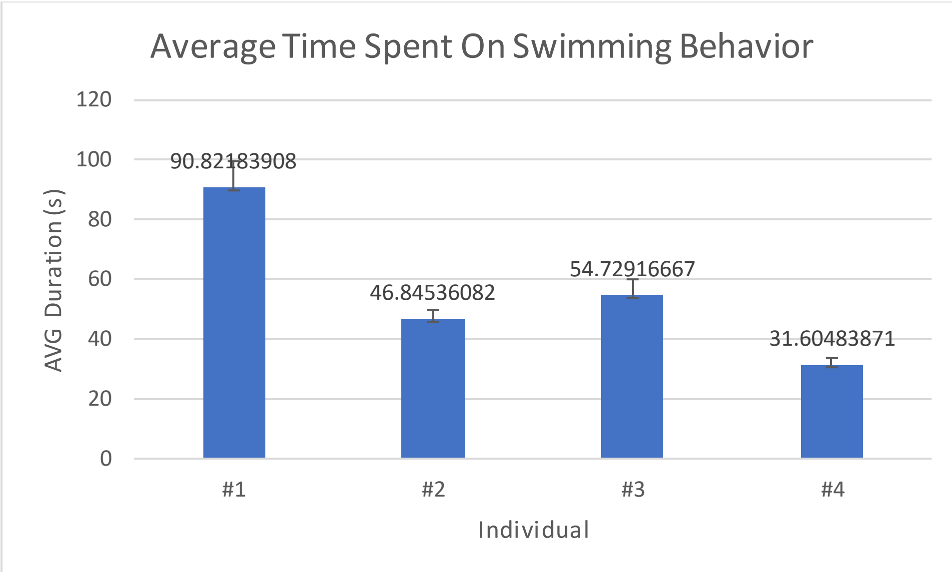

Figure 1 Average Time Spent in Seconds on "Swimming" Behavior Between Individuals.

The error bars in these graphics all represent the standard error mean of each average value.

Table 3 One-Way ANOVA on "Together" Behavior

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
#1	49	1211	24.71429	635.2917
#2	52	1107	21.28846	513.4642
#3	46	1149	24.97826	3898.955
#4	66	1866	28.27273	4267.001

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1426.957	3	475.6524	0.19512	0.899644	2.647801
Within Groups	509488.7	209	2437.745			
Total	510915.7	212				

An ANOVA performed on the "Together" behavior comparing the four individuals

There were no significant differences in the amount of time the four sea otters spent together (Table 3). All sea otters spend on average 21-28 seconds together during the observations (Table 3, Fig.2).

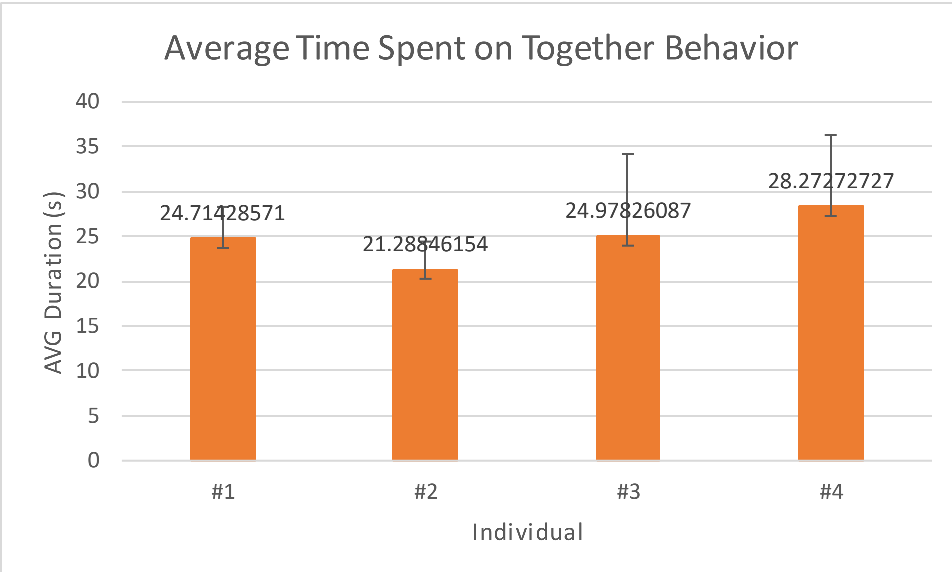

Figure 2 Average Time Spent in Seconds Comparing "Together" Behavior Between Individuals.

Table 4 One-Way ANOVA on "Cubby" Behavior

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
#1	49	569	11.61224	150.034
#2	160	2954	18.4625	781.5709
#3	134	1999	14.91791	1561.114
#4	130	3769	28.99231	2999.713

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	17738.12	3	5912.707	3.819312	0.010058	2.623918
Within Groups	726062.5	469	1548.108			
Total	743800.6	472				

An ANOVA performed on the "Cubby" behavior comparing the four individuals

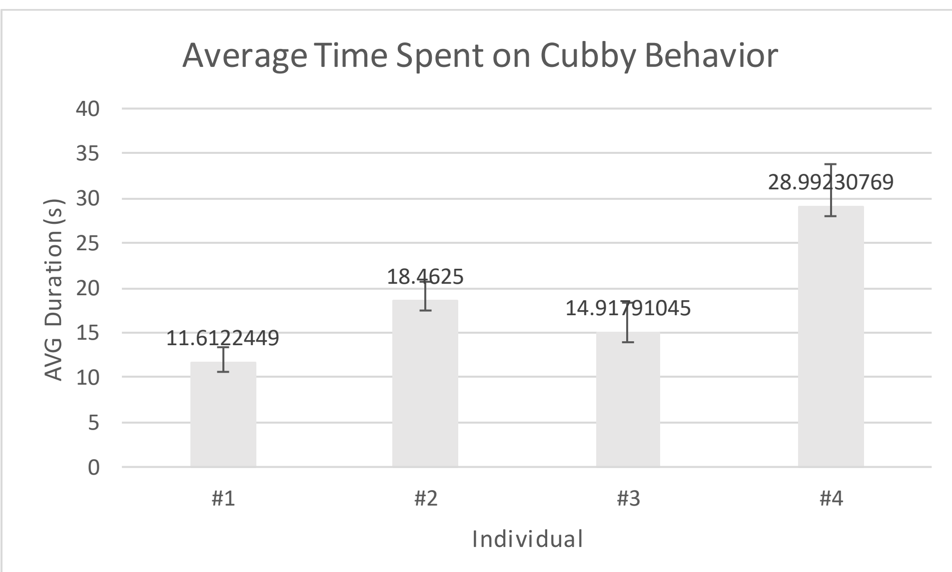

Figure 3 Average Time Spent in Seconds Comparing "Cubby" Behavior Between Individuals

There was a significant difference in the amount of time each animal spent on "Cubby" behavior. The cubby is the area at the back of the enclosure and individual #4 spent the most time in this area with #1 spending the least amount of time. These results correlate with the swimming data where #1 spent the most time swimming compared with the other three sea otters.

Table 5 One-Way ANOVA on "Enrichment" Behavior

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
#1	19	537	28.26316	1559.094
#2	13	547	42.07692	1454.244
#3	12	418	34.83333	5960.879
#4	26	607	23.34615	368.4754

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3383.684	3	1127.895	0.618815	0.605285	2.743711
Within Groups	120296.2	66	1822.669			
Total	123679.8	69				

An ANOVA performed on the "Enrichment" behavior comparing the four individuals

There were no significant differences in the amount of time each animal was engaged with "Enrichment" behaviors (Table 5). Animal #2, however, spent the most time on this behavior while #4 spent the least amount of time on enrichment behaviors.

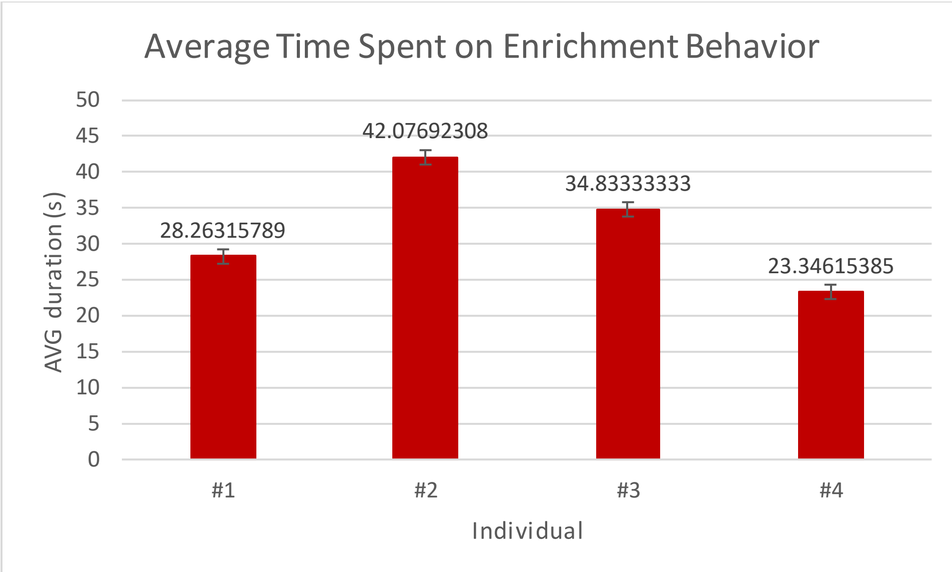

Figure 4 Average Time Spent in Seconds Comparing "Cubby" Behavior Between Individuals

3.2 Percent of Time Spent on Various Behavior for Each Animal

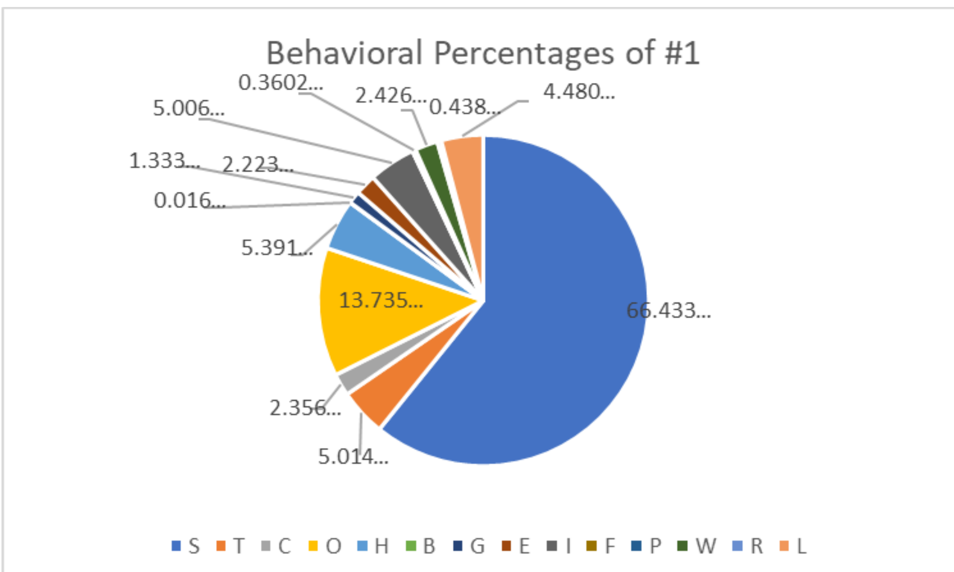

Figure 5 Time spent on different behaviors of individual #1.

Individual #1, the two juveniles, spent the majority of their time swimming. This correlates well with the data analyzed between all four individuals. As seen in Fig.5 the second most observed "behavior" was "Offscreen" which was not analyzed by an ANOVA since that often meant the animal was removed from the enclosure while a recording was in progress. On that note, one behavior was shown 0% of the time which was “Foraging” or F. Overall they were present in the enclosure the most with a sum of 24149 seconds recorded. Furthermore, these percentages may not add to 100 due to the combined codes making certain time intervals count twice in these calculations.

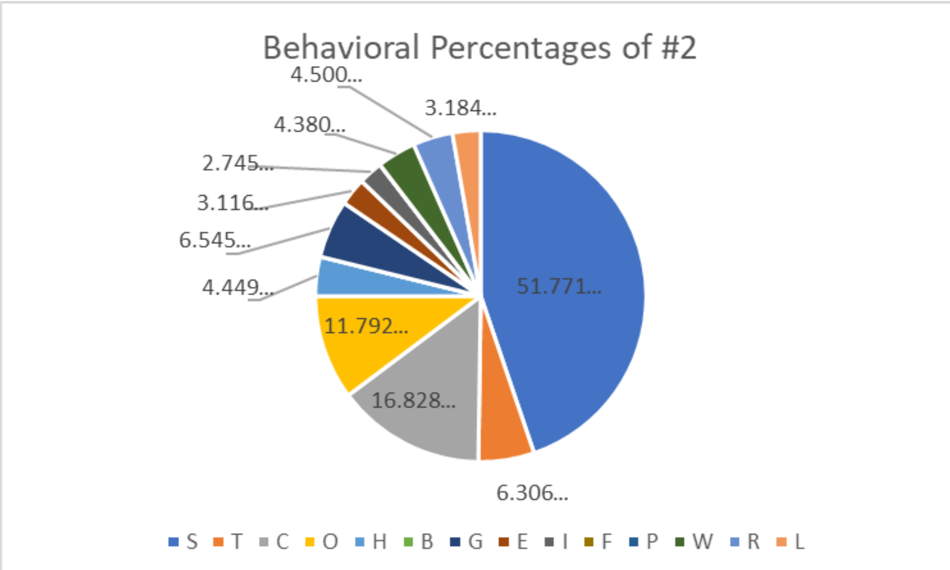

Figure 6 Time spent on different behaviors of individual #2.

Individual #2 never exhibited behaviors “Barrel Roll” (B), “Foraging” (F), or “Play” (P) throughout all observations. They were observed in the enclosure for a total of 17554 seconds. Compared to all other behaviors observed for individual #2, this animal spent the most of their time swimming in the enclosure.

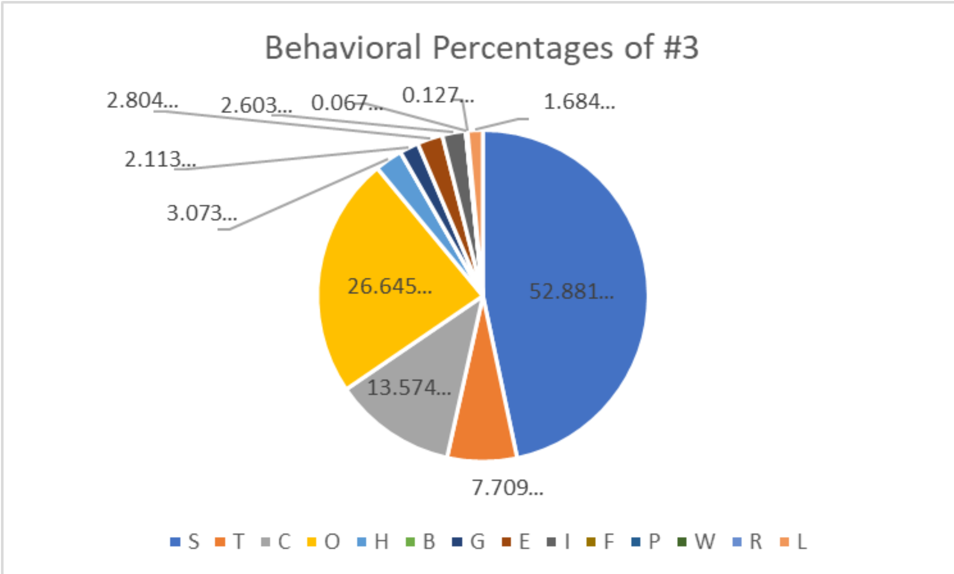

Figure 7 Time spent on different behaviors of individual #3 quantified.

Individual #3 never displayed "Barrel Roll" (B), "Foraging" (F), or "Play" (P). Overall, they were observed for 14903 seconds. Similar to individuals #1 and #2, animal #3 also spent the majority of their time swimming.

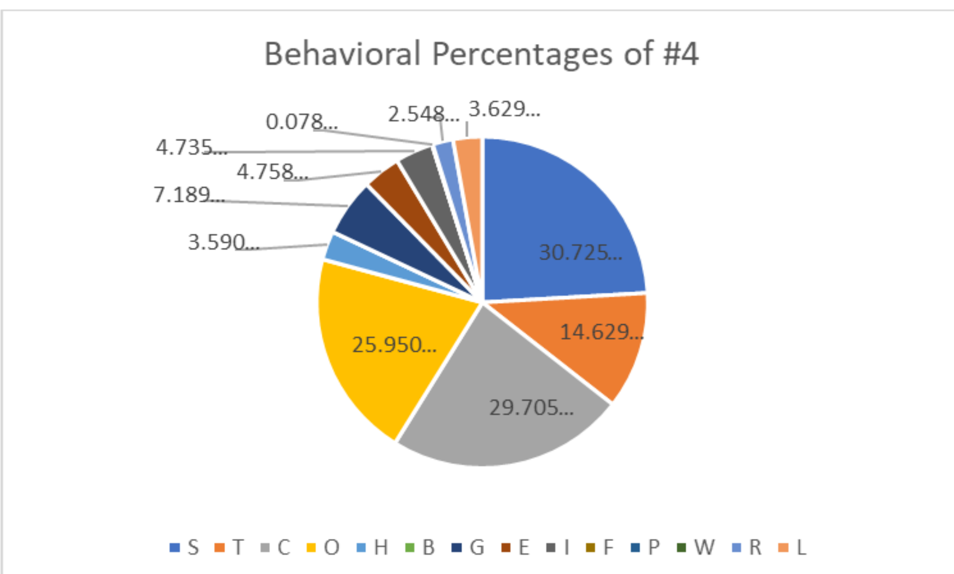

Figure 8 Time spent on different behaviors of individual #4.

Individual #4 never showed "Barrel Roll" (B), "Foraging" (F), or "Play" (P). They were observed for 12755 seconds. Unlike individuals #1, #2, and #3 individual #4 spent almost the same amount of time swimming as well as in the cubby at the back of the enclosure. This finding correlates well with the differences in "cubby" behavior between all four animals (Table 4, Fig.3).

3.3 "Wrestling" Behaviors

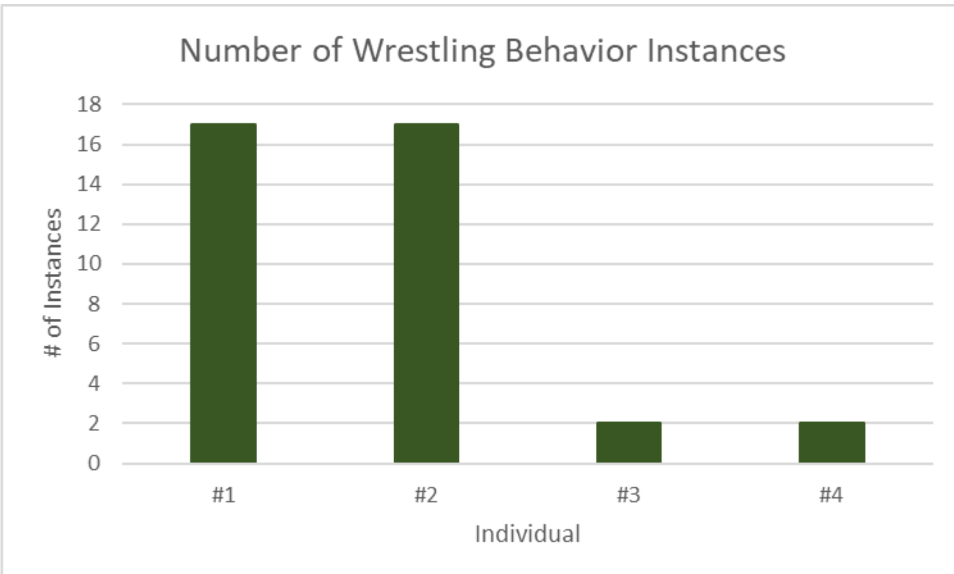

Figure 9 The number of times "Wrestling" was observed by the 4 sea otters.

Wrestling behavior was of interest but there were not enough data points for individuals #3 and #4 to perform a one-way ANOVA. However, an entirely descriptive analysis shows that animals #1 and #2 performed this behavior much more frequently than #3 and #4.

4. DISCUSSION

4.1 Differences in Behaviors Between Individuals

This study showed that there were significant differences in the average time spent on swimming behaviors of the individual otters observed. For example, the juvenile otters (known as individual #1 as they were never observed on exhibit at the same time) had the highest average value for swimming. They had a collective average time of 90.82184 seconds. This is drastically different from individuals two and three, a male and female respectively, who swam for an average 46.84536 and 54.72917 seconds. However, individual #4, the oldest male known as Cruz, had an average of 31.60484 seconds, which is lower than his two adult cohorts but not as drastic a difference as with individual 1. Age is possibly a contributing factor since the two sub-adults had the higher average swimming time compared to the oldest individual (Fig.1). Gender of the animal does not appear to matter since both individuals #2 and #3 had similar average time spent on swimming.

"Cubby" behavior was denoted as when an animal sat in the small enclave in the back of the enclosure, which doubled as a door at times and led to a secondary holding area behind their primary enclosure. Often this behavior meant the animal sat in the cubby quietly, or with another behavior like "Together" or "Enrichment" if they were in the cubby with another otter or brought an item in there with them (Tab.4). These indicate that overall the otters spent less time in the cubby compared to swimming (Fig.3). On the other hand, individual #4's average was very similar to the average for swimming and so it spent equal time in the cubby and on swimming. The cubby behavior being a stationary activity further supports the hypothesis that this is due to the age of the animal, although this cannot be confirmed since the older female (individual #3) spent less time in the cubby compared with the adult males.

These animals are being kept in close proximity to each other and are on birth control, which makes episodes of territorialism between the males unlikely. The data showed no statistical significance in the time spent on the “Together” behavior which means that none of the otters spent more time with another otter than the others did (Tab.4). This is odd given that otters in their natural habitat form rafts to protect them from predators like orcas (Cohn, 1998, Lafferty, 2014). This finding does make sense though, as these otters are kept in captivity and are not under the threat of predators and do not need to rely on one another for that added protection. My observations from the aquarium show that captive otter behavior differs from observations in the wild. I will further show that the distribution of their activities is different than animals living in their natural habitats below. A larger group of subjects would be required to determine if this is “normal” behavior in captive sea otters or just this isolated group.

“Enrichment” behavior entailed any time that the otter interacted with the provided toys or fake kelp. The data showed there was not a difference between individuals when it came to playing with the enrichment devices provided. However, the histogram (Fig.4) shows that individual #2 had the highest average time interval when interacting with a piece of enrichment. It is possible that this average is skewed because individual #2 tended to swim and hold enrichment simultaneously. Although, holding an item of enrichment while doing another activity is not unique as individual #1 also swam while holding enrichment and individuals #3 and #4 tended to hold items while remaining stationary in the cubby. Adult otters have been seen playing with naturally occurring “enrichment devices” in their native habitat in the forms of rocks, birds (alive or dead), and other small objects that they can find. For example, in 2015 an otter was seen carrying a deceased Common Murre, a species sea bird from the area the otter was sighted in, and diving with it numerous times (Allen, 2019).

4.2 Differences in Behaviors Within Each Individuals

The percentage of time spent on each behavior was broken down for all subjects, this is the cumulative amount of time instead of the duration of each interval. Individual #1, the two sub adult otters, spent the majority of their time swimming at 66% (Fig.5) which corresponds with the data discussed above regarding the differences between individual otters. They spent the smallest amount of their time in the cubby when compared to the three other otters. These two animals were also the only ones to display the "Barrel Roll" behavior post the initial observation period, which could be a play behavior but that was unclear from viewing the web cam whether it was play or simply transportation. "Barrel Roll" behavior was classified as an animal swimming over another otter to cause them to roll over, it was a fleeting action, and it is probable that it could have been missed in the other otters or classified as the "Together" behavior if an otter was next to another when the behavior occurred. In hindsight, the "Barrel Roll" behavior is likely a play behavior derivative of "Wrestling" and was most often seen in the younger otters during initial observation periods. Play behavior in sea otters is most often researched in relation to juveniles that wrestle with other juveniles in groups containing other mothers and pups. Male juvenile otters have been noted to wrestle in a playing manner, but adult males do not tend to instigate these episodes (Scoles, 2012).

Individual #2, the younger of the two adult males, also spent most of his time swimming but at a smaller portion of time (about 51.771%). Notably, they spent the largest section of all the otters on "Wrestling" behavior (4.38%)(Fig.6). Wrestling behavior will be discussed further below, but this high number is probably due to the fact that this male was often removed from the enclosure and replaced with another otter, which also happened frequently with #3, and this replacement possibly skewed their daily behavior distribution since they had the same number of wrestling instances as #1 (Fig.9). On that note, #3 showed a similar percentage of time spent on “Swimming”, “Together”, and “Cubby” behavior (Fig.7) as #2 did. If this experiment were to be repeated the best course of action would be to have an observable population with a consistent individual attendance, preferably with all individuals in the habitat at the same time so that “Offscreen” would count only for when the animal legitimately hid from the camera and not for when the animal was removed by human interference. There remains a possibility that individuals #2 and #3 could have been mistaken for each other, but unlike the sub adults their grizzle pattern was more distinct. The issue was that the enclosure lighting occasionally made their fur appear lighter in color than it normally would in natural light. Any cases of mistaken identity usually occurred if both animals were offscreen at the same time and reappeared in a similar fashion, although this was remediated by watching the screen recording an additional time and tracing certain sightings back to any time stamps that required clarification.

Individual #4 was the oldest male. His average amount of time swimming significantly shorter compared to the other three individuals (30.725% of his time spent). Furthermore, the amount of time spent in the cubby was far longer than the others at 29.705% (Fig.8). These percentages correlate with the high average duration of “Cubby” behavior and the low average associated with “Swimming” behavior when all four individuals were compared. This subject was one of the most common otters seen, it is doubtful that these results are due to a limited sample size since he appeared in most of the observation periods.

Overall, the otters’ percentages do not match those found in the wild. A study performed on a population of wild southern sea otters found that they spent approximately 62% of their day resting and only 28% of their day swimming and actively foraging (Shimek, 1977). Another study showed that Northern Sea Otters in Alaska (*Enhydra lutris kenyoni*) spent an average of 42.38% of their time resting while they had an average foraging time of 43.55% (The data used to calculate those averages was that for adult males and females and juvenile males and females, but this study also studied mothers and pups) (Gelatt, 2002). It is possible this difference between the captive living southern sea otters and the wild dwelling ones is due to the steady and reliable supply of food that the captive dwelling individuals have access to and therefore do not need to reserve the energy for foraging, caring for young, or running away from predators.

As previously hypothesized, it is possible that the difference between individuals #1 and #4's activity could be due to age. As most organisms age the gene expression that dictates most metabolic, growth, and circadian rhythm processes change over time because of accumulated proteins, mutations, and degradation of the genome in the form of telomere shortening. This often translates into a slower metabolism and decreasing activity in older individuals which could be what is occurring in this situation (Goyns, 2002). However, the effects of old age alone on a sea otter's metabolism and wellbeing has not been well researched. Typically, an otter will perish due to disease, starvation due to a lack of available food or tooth wear making eating difficult, or attack by another species. Instances of an animal dying of without a known cause are common as the bodies that fall into this category are highly decomposed (Gerber, 2004). The theory that advanced age is causing the difference is flawed. Individuals #2 and #3 displayed similar behaviors and spent roughly the same about of time on swimming and sitting in the cubby. While the exact ages of these otters are unknown the grizzle pattern suggests that #3 is older than #2 as female sea otters reach sexual maturity before males. This could explain the higher distribution of blonde fur in the female identified as individual #3 (Jameson, 1993).

Finally, “Wrestling” behavior was analyzed separately as not all otters performed this behavior enough to meet the minimum value recommended for the statistical analysis that was used for the comparison between individuals. Wrestling is likely a play behavior for the juvenile sea otters as play behaviors are displayed by most juvenile mammals. In adults it is less essential, and it is believed to be used as exercise and social interaction. Play is difficult to categorize, if you gave two researchers the same set of animals there is a great likelihood that they would give different definitions but be speaking about the same thing. It is generally agreed upon that play as an activity has been attributed to helping define motor skills, developing predatory tactics in juveniles of carnivorous species, and promotes cohesion in groups (Oliveira, 2008). Fighting as a form of play typically is not accompanied by injuries, as is the case in the southern sea otters observed where there were no injuries. Additionally, play tends to occur with two animals close in age, but since the two juveniles could not be distinguished from one another they were observed one at a time making individual #2 the closest in age to them and the best candidate for a playmate during observation sessions.

4.3 Conclusion

Overall, the average time spent on the behaviors between individuals correlated well with their individual behavior distribution. An important observation from this study is that age is likely a contributing factor in the differences in behaviors observed in these captive sea otters. The significant differences seen in the captive animals’ behaviors would not occur in the wild since their life span is shorter. A larger sample size of other aquarium exhibits and individual ages would be needed to confirm this theory. Finally, wrestling behaviors in captive sea otters occurs at a higher frequency in younger individuals like it would in their natural habitat. This observation demonstrates the importance of play behavior in the development of young sea otters both in captivity and in their natural habitat. To provide the best husbandry for captive sea otters, enrichment devices should be provided to encourage play behaviors that would be seen if they were raised in their natural habitat and should be given access to other individuals similar to them in age. This is something the Georgia Aquarium accomplished by placing the sub-adults with Brighton, the younger male, and providing suitable enrichment.

This experiment could be extended with a larger sample size that will create an even stronger statistical robustness to support the main conclusions. However, this was an initial study that provided a look into the daily activities of captive sea otters. Studying an animal's behavior in captivity can increase understanding into their activities in the wild. Another study performed on either other aquariums or wild populations would provide a helpful comparison to further research by providing a consistent baseline on their interactions with one another beyond mating and maternal care. This information is valuable for conservation efforts when determining which areas need protection. In this way not only can life essential tasks (foraging and mating) are considered but areas should also support natural behaviors which will increase wild sea otter welfare. If these things can be considered, the populations previously devastated by the fur trade can be rebuilt along with those currently being harmed by anthropogenic causes and newly introduced diseases.

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