How many trees does it take to cover an elephant?

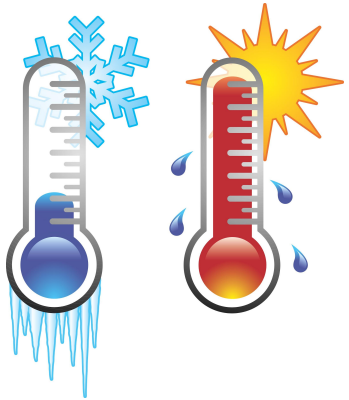
Analyzed variables affecting shade availability for and utilization by elephants at the NC Zoo

Why is shade important?

- Shade availability is an important consideration for **animal welfare.**
  - Chatkept et al. (1999) in Thailand - working elephants
  - Smit et al. (2007) in Kruger Nat'l Park - migration patterns

- To ensure the highest standards of animal care, North Carolina Zoo wanted to assess *how* and *why* elephants use shade

Hypotheses



- **Shade Availability:** NC Zoo's elephant exhibits provide enough shade for the facility's collection.

- **Shade Utilization:** Variation in shade utilization will occur based on disparity in temperature, weather condition, number of elephants present, hour of day, and month of the year.

Methods: Shade Availability

- SketchUp©
  - Aerial photograph of exhibits
  - Created **scenes** for each hour of each month of the study = **time period**
- Used the original aerial photo to determine real tree density, location, and size, then used these values to add 3D model trees onto the 2D photo surface

- SketchUp then conducted **internal shade calculations** based on the photo's geographic & temporal attributes
- Tracing tool to measure shade
- Counted the number of continuous, elephant-sized **shade zones** in each scene
    - **Elephant-sized** = 4' x 12' = at least 48 ft^2 for each shade zone
    - Need ≥ 5 zones
        - 1 for each elephant

Methods: Shade Utilization

- Scan samples
  - Every 2 mins, 60-minute sessions
- Behavior, location, & **shade use** recorded
- Shade use
  - Not in the shade = “No”
  - <50% of body shaded = “Partial”
  - >50% of body shaded = “Yes”

$$\frac{\text{\# of times individual was observed in the shade}}{\text{Total \# of observations}}$$

Proportion * 100

Results: Shade Availability

Time periods when less than five elephant-sized shade zones are available		
Month	**North Exhibit**	**South Exhibit**
January	**09:00**	**09:00**
February	**-**	**-**
March	**-**	**-**
April	**-**	**-**
May	**-**	**-**
June	**09:00**	**-**
July	**-**	**-**
August	**-**	**-**
September	**-**	**-**
October	**-**	**-**
November	**-**	**-**
December	**09:00**	**-**

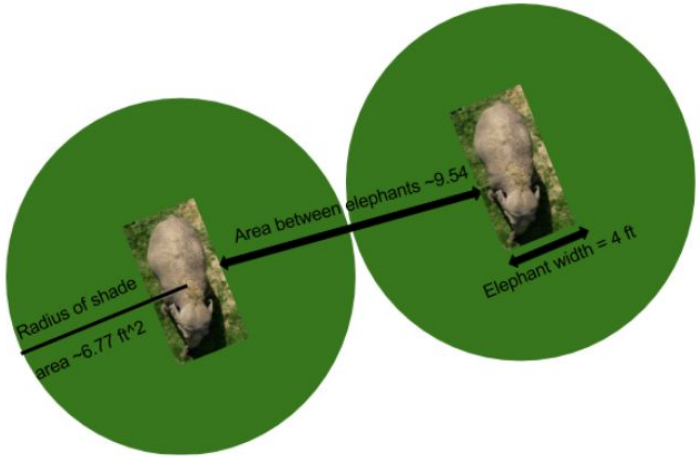
Issue with this calculation?

- Shade zone = minimum 48ft^2

- However, during the early morning and late afternoon hours, shade zones could be extremely large and cover almost 1,000 square feet, and could **possibly have the capacity to hold more than one elephant at a time.**

New Calculation: Shade Patches

- Calculation: total surface area of shade available in the exhibits was divided by the area of this new elephant-sized shade patch (**240 sqft**)



- Allows elephants to stand **>9 ft. away** from other individuals & ample **room to move** around

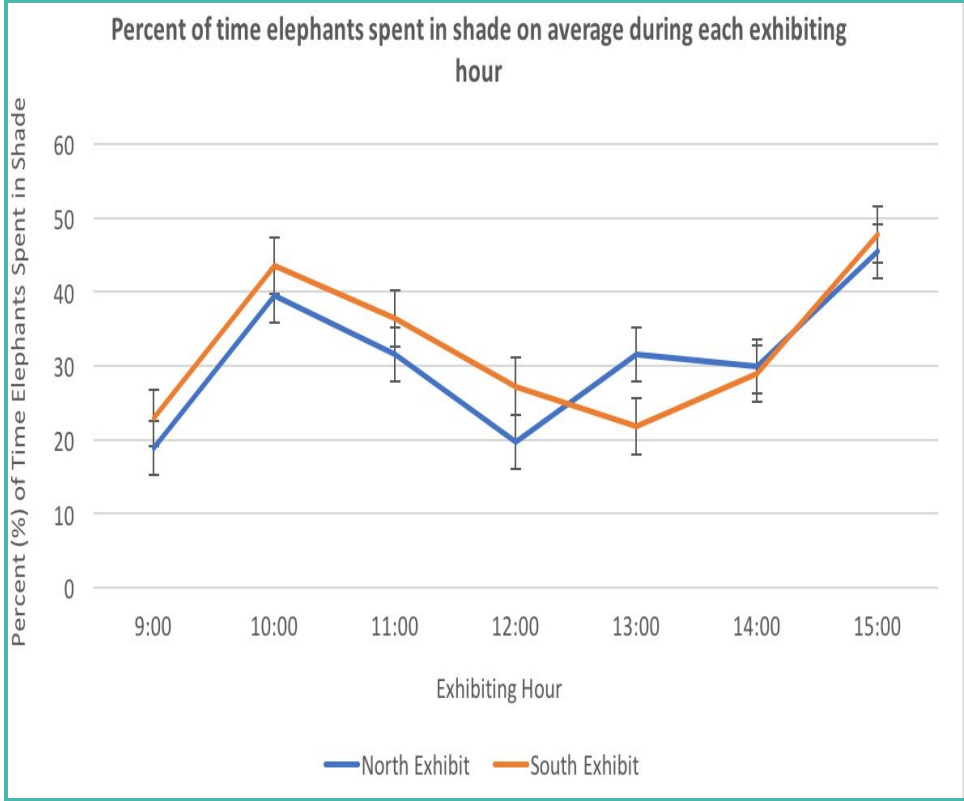
Number of elephant-sized shade patches available within exhibits during time periods previously deemed to not possess adequate shade availability				
Time Period	**Exhibit**	**Original number of shade patches**	**Area of shade available (square feet)**	**Number of elephant-sized shade areas available***
January 09:00	North	2	8477	**58**
January 09:00	South	4	10824	**75**
June 09:00	North	4	12355	**85**
December 09:00	North	4	10412	**72**

- At least five shade areas needed, however, every time period had more than fifty shade patches available for elephants
- Therefore, through this new calculation, adequate shade could be determined to be present in both exhibits for all time periods.

Results: Shade Utilization

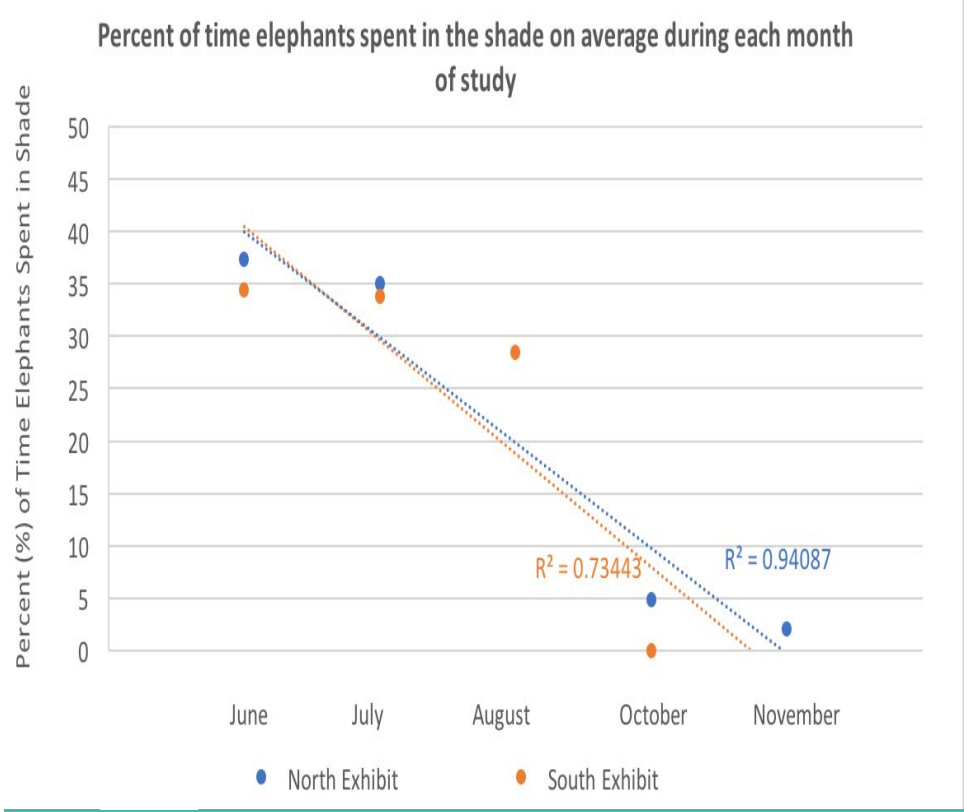
Hour of Day

- Shade use peaks at 10am and then again at 3pm
  - 3pm - high heat of the day (NOAA)
  - 10am - may be correlated with food source location ?

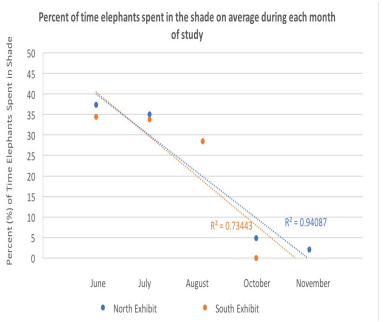


Month of Year

- Overall, ⬇ shade use June - November in both exhibits
- Coefficients of determination (R^2)
  - ➢ R^2 = 0.9409 north, 0.7344 south → fairly high correlation
- Again, correlation could be due to decreasing temperatures



Month of Year (Cont'd)

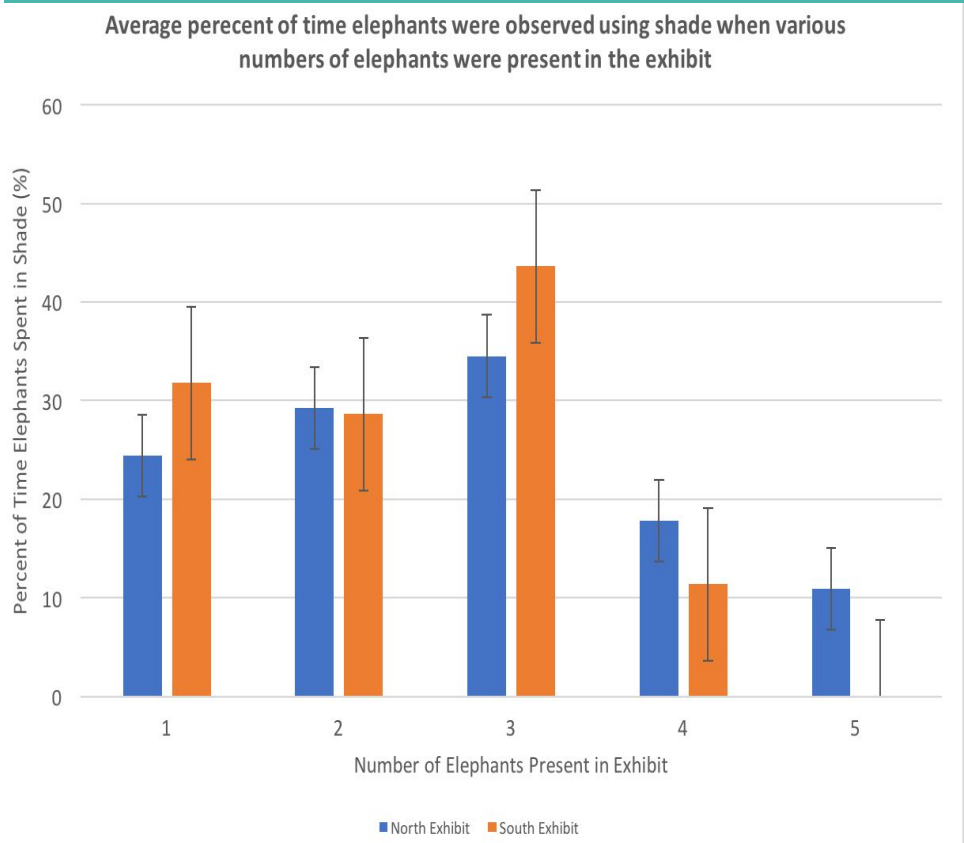


- Average temperatures (Weather Underground) in 2016
  - **June = 76°F, July = 80°F,** August = 79°F, September = 74°F, October = 62°F, and November = 51°F
- **Increase temp from June to July even though decrease shade use???**
  - Interns **learning curve** ?
  - **Weather differences**: July = ~10% more clear, ~25% less cloudy days than June

Month	Cloudy	Partly Cloudy	Rain	Sunny
June	34.4%	21.1%	1.9%	42.6%
July	9.61%	37.4%	0%	52.9%

Number of Elephants in Exhibit

- Anywhere from 1 - 5 elephants could be present within an exhibit at one time
- No significant difference of shade use between exhibits
- Significantly **less shade use when 4-5 elephants present vs when 1-3 elephants were present.**



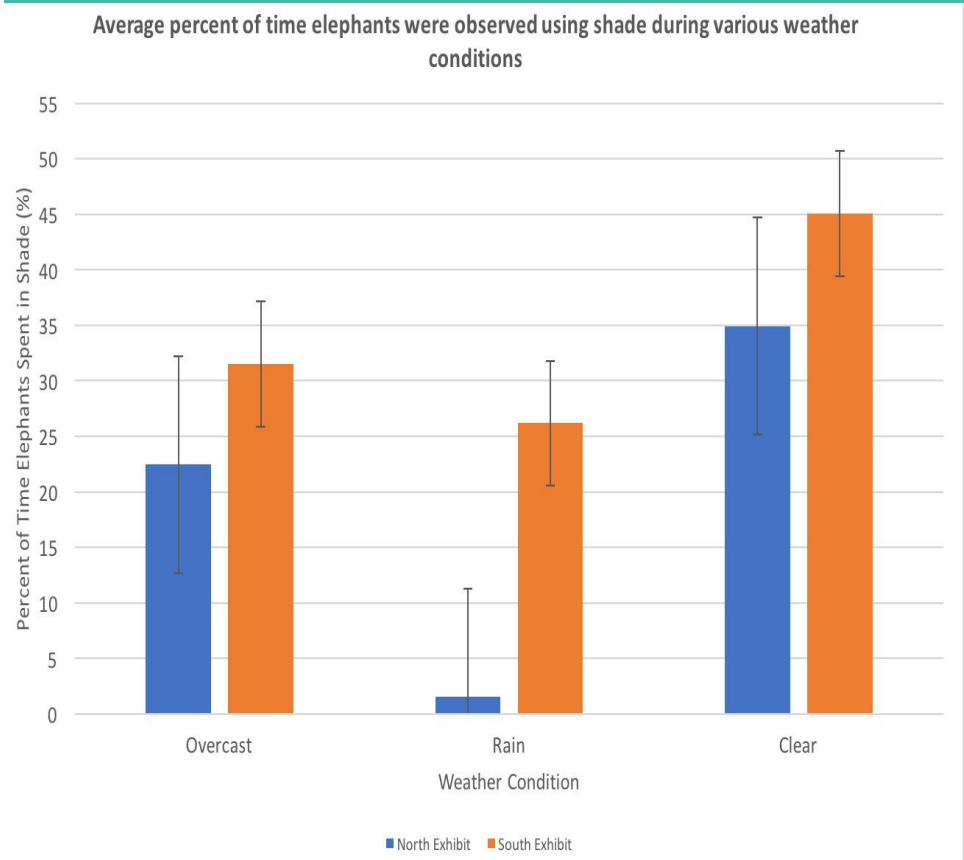
Why might shade use decrease as concentration of elephants increases?

- Possible that elephants decrease time in close proximity when the number of elephants present in the exhibit increases
  - **Avoidance** of other elephants may cause elephants to use shade less - Specifically, males were in less likely to be in close proximity to other elephants than females

Number of Elephants Present	Times Elephants were in Close Proximity	Total # Observations	**% of observations with elephants in close proximity**
1	0	440	0%
2	217	969	**22.394%**
3	1438	6385	**22.522%**
4	58	301	**19.269%**
5	146	913	**15.991%**

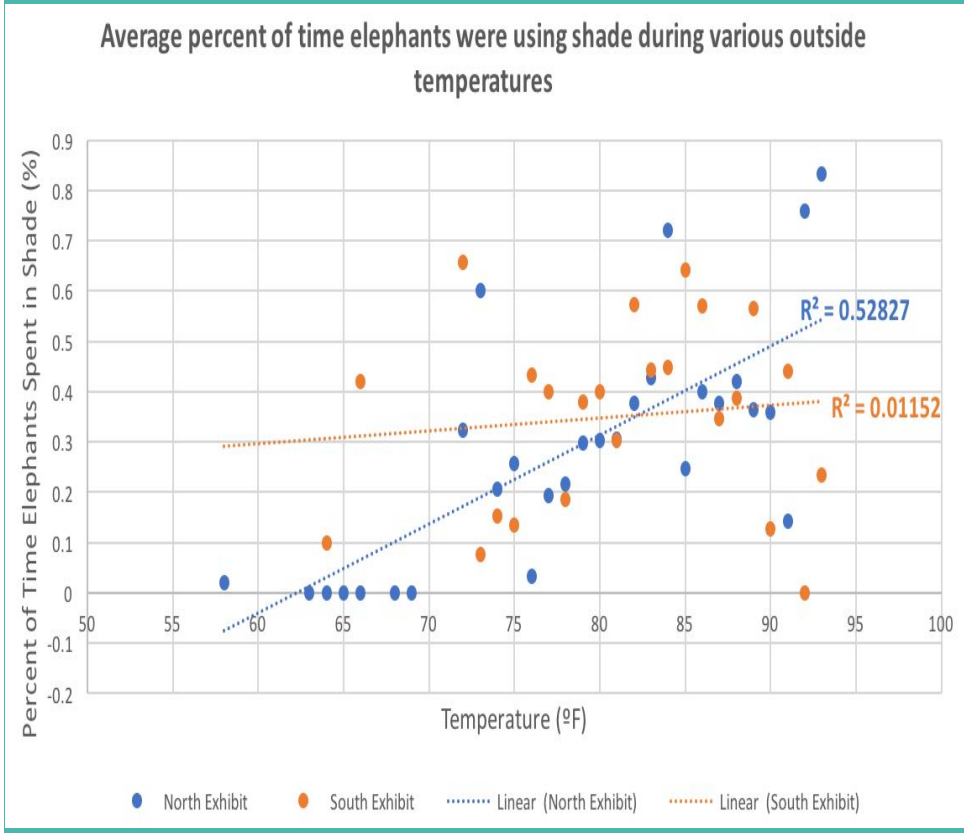
Weather

- Overall, shade use decreases clear → overcast → precipitation
- Difference in shade use between exhibits during rainy conditions
  - **Observation technique** by interns: shade use when raining ?
  - Differences in **precipitation rate**: when elephants may use trees as cover



Temperature

- Positive correlation between shade use and temperature
- R^2 = 0.5283 north exhibit, BUT R^2 = 0.0115 south exhibit 😱
  - Much **less data collected** for south exhibit
  - More elephants were likely to be placed in north vs south exhibit: Fewer elephants present = more shade availability overall = more likely to use shade no matter what



Further Research

- Shade availability
  - Further analysis: **calculations need more support:** shade zones need to provide **proper dimensions** (12'x4' vs 48 x1')
    - Also, since proximity may be affected by # of elephants present, we may want to re-evaluate the 9 ft. distance for elephant-sized shade patches
  - **If more animals are added to the collection, shade availability will need to be re-evaluated**

- Shade use
  - Conduct an **ANOVA to compare the variables** : what has greatest impact on shade use?

We believe zoos can use this data for **exhibit design**, and conservation biologists can use this information to better understand how the shade needs of elephants change with environmental variation, and, therefore, how future populations will be affected by things like **climate change.**

Questions?

EFFECTS OF NOVEL ANIMAL SCENTS & FOOD ENRICHMENT ON SAND CAT WELFARE AT THE NORTH CAROLINA ZOO

MARIAH CHAPMAN

What is a Sand Cat?

- Small, nocturnal cat living in the deserts of Africa & Asia
- Only 35 in zoos in North America

Pacing and Welfare

- **Animal Welfare:** an animal's collective physical, mental, and emotional states (Animal Welfare Council).

- **Abnormal repetitive behavior**
  - Implications for welfare (Garner 2005).
  - Enrichment

Objectives

- **Olfactory Study:**
  - Scents can reduce stereotypies in felids (Guilherme et al. 2015)
- **Food Study:**
  - Repetitive behaviors before feeding (Weller and Bennett 2001)
  - Cosmo is very food-motivated
- Visitor Density (Vidal et al. 2016)
- Novelty (Abou-Ismail and Mendl 2016)
- Light?

Methods – Olfactory Study

- CyberTracker© software
- Scents:
  - Giraffe
  - Arctic Fox
  - Porcupine
  - Ocelot
  - Unscented = Control
- Prediction: All scents will reduce pacing; arctic fox scent will reduce pacing the least

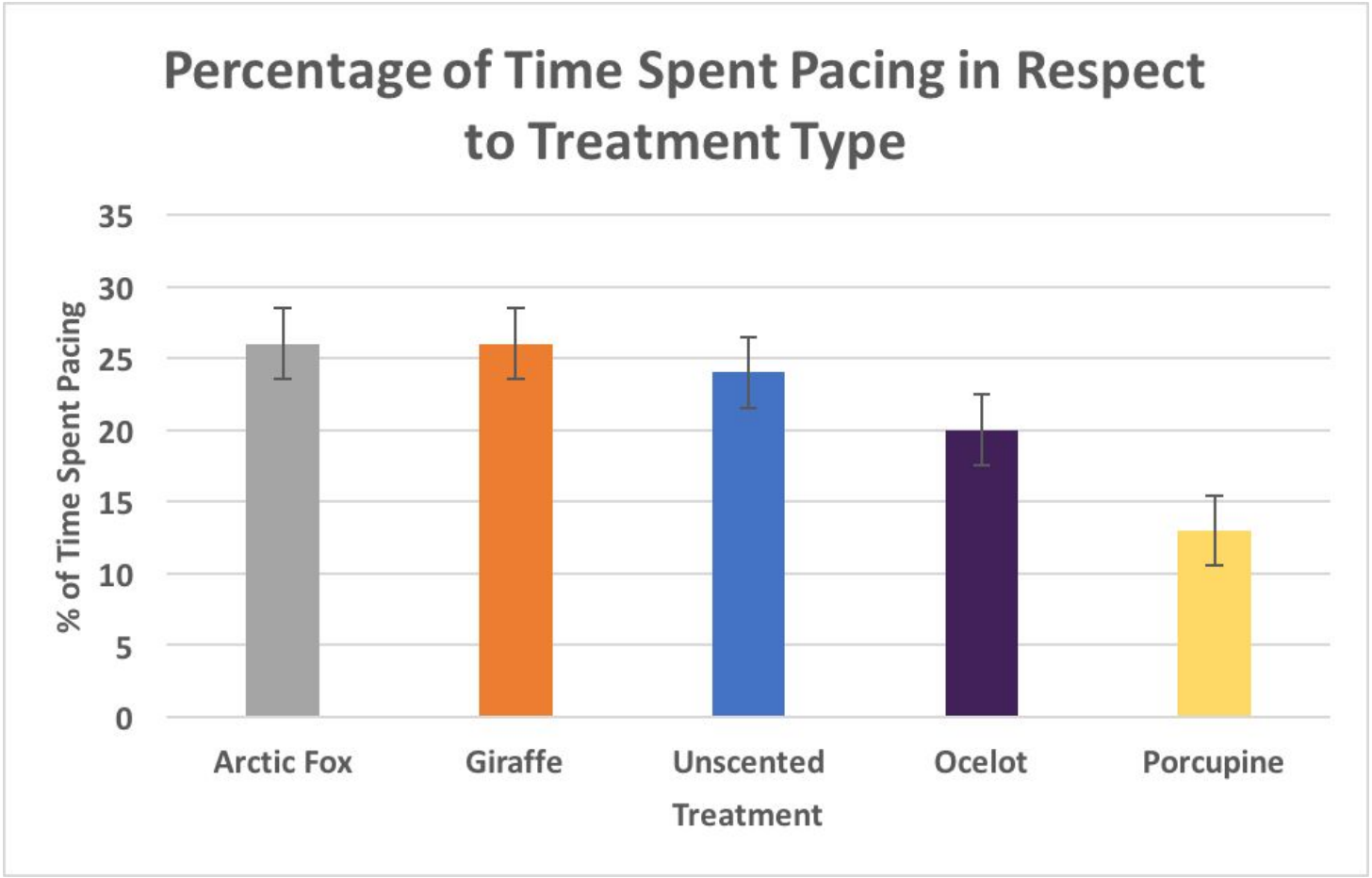
Methods – Food Study

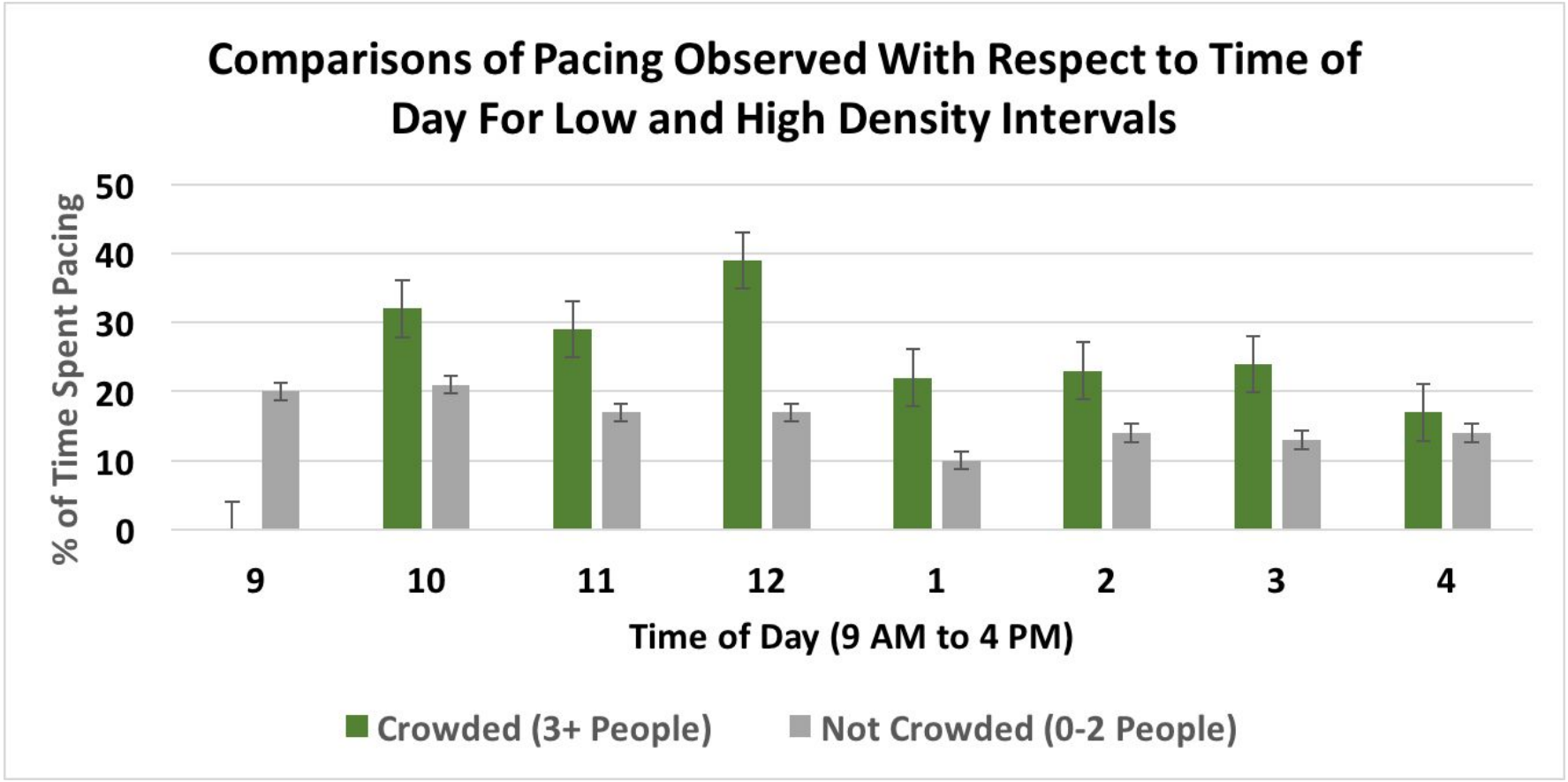
- Enrichment:
  - Frozen Mice
  - Sand-Buried Mice
  - Straw-Buried Mice
  - Puzzle Feeder
  - No Food Enrichment = Control
- Each meal ~33 grams of mice
- 3 meals fed haphazard
- Predictions: Frozen mice will be the most successful to reduce pacing

Analysis

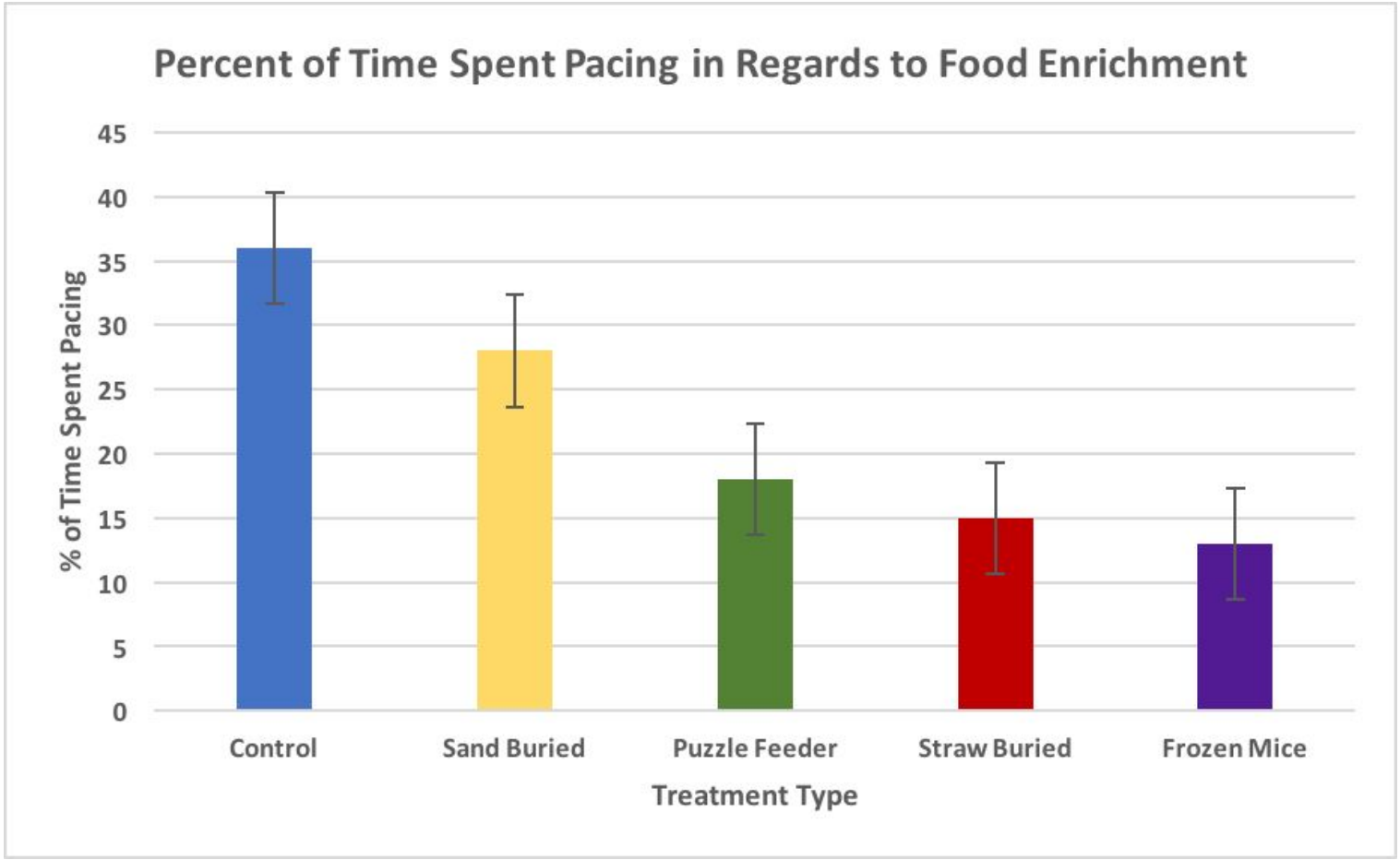
- Only one subject
- Statistical tests not ideal for comparing results
  - Use graphical representations & average %
- The purpose of this study: improve welfare!

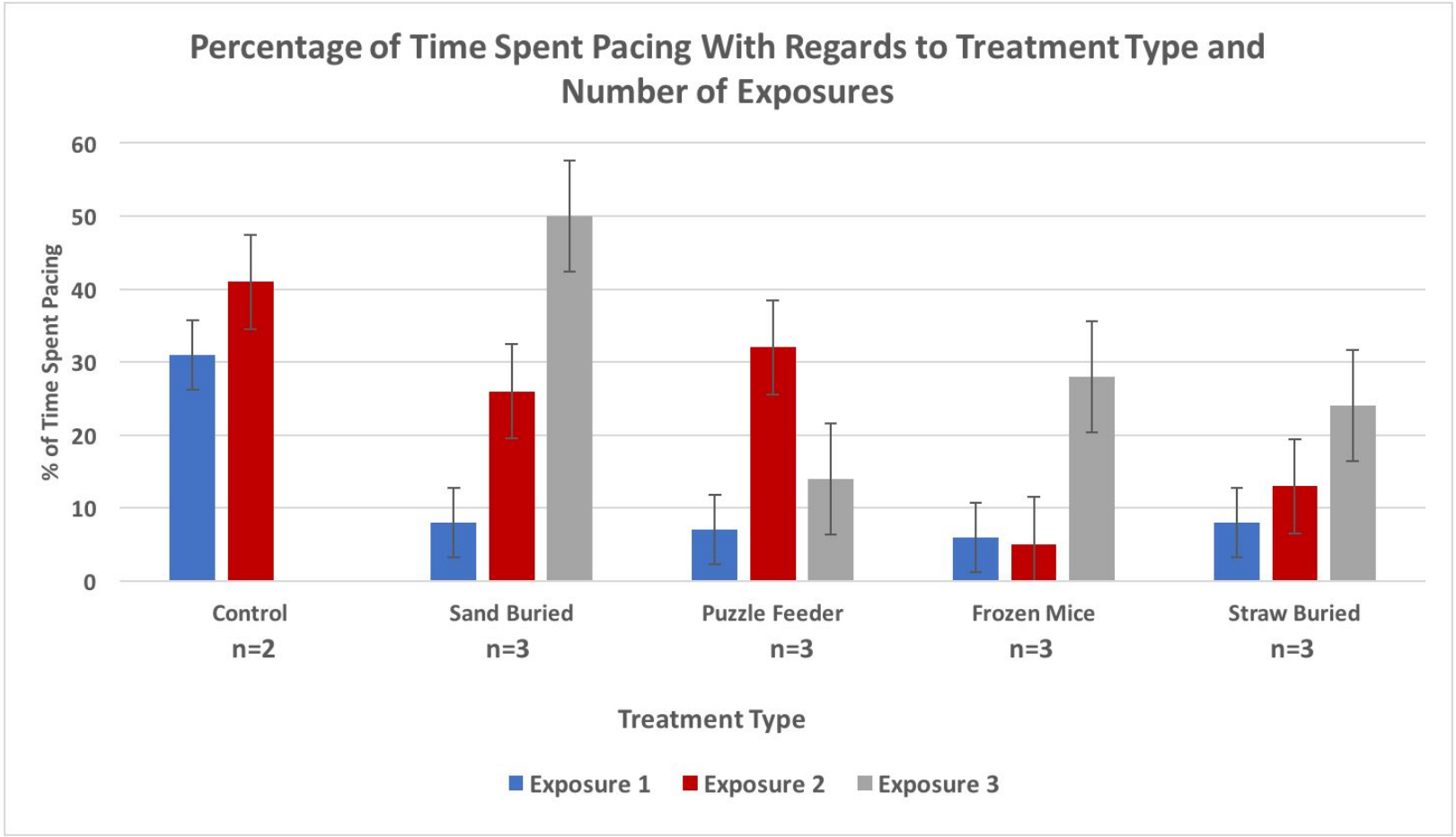
OLFACTORY ENRICHMENT RESULTS…

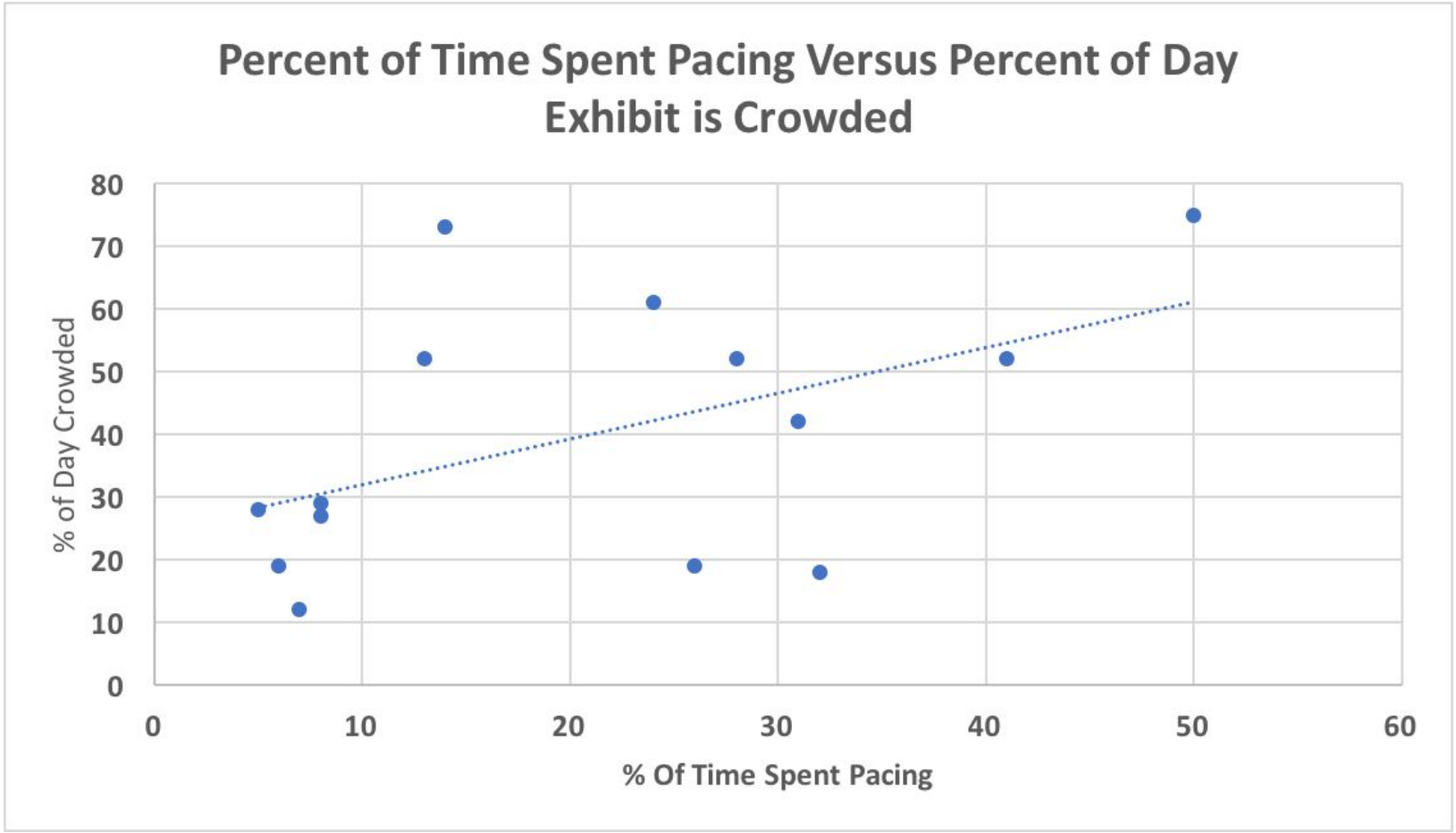

Percentage of Time Spent Pacing in Respect to Treatment Type
% of Time Spent Pacing
35
30
25
20
15
10
5
0
Arctic Fox
Giraffe
Unscented
Ocelot
Porcupine
Treatment


Comparisons of Pacing Observed With Respect to Time of Day For Low and High Density Intervals
% of Time Spent Pacing
50
40
30
20
10
0
9
10
11
12
1
2
3
4
Time of Day (9 AM to 4 PM)
Crowded (3+ People)
Not Crowded (0-2 People)

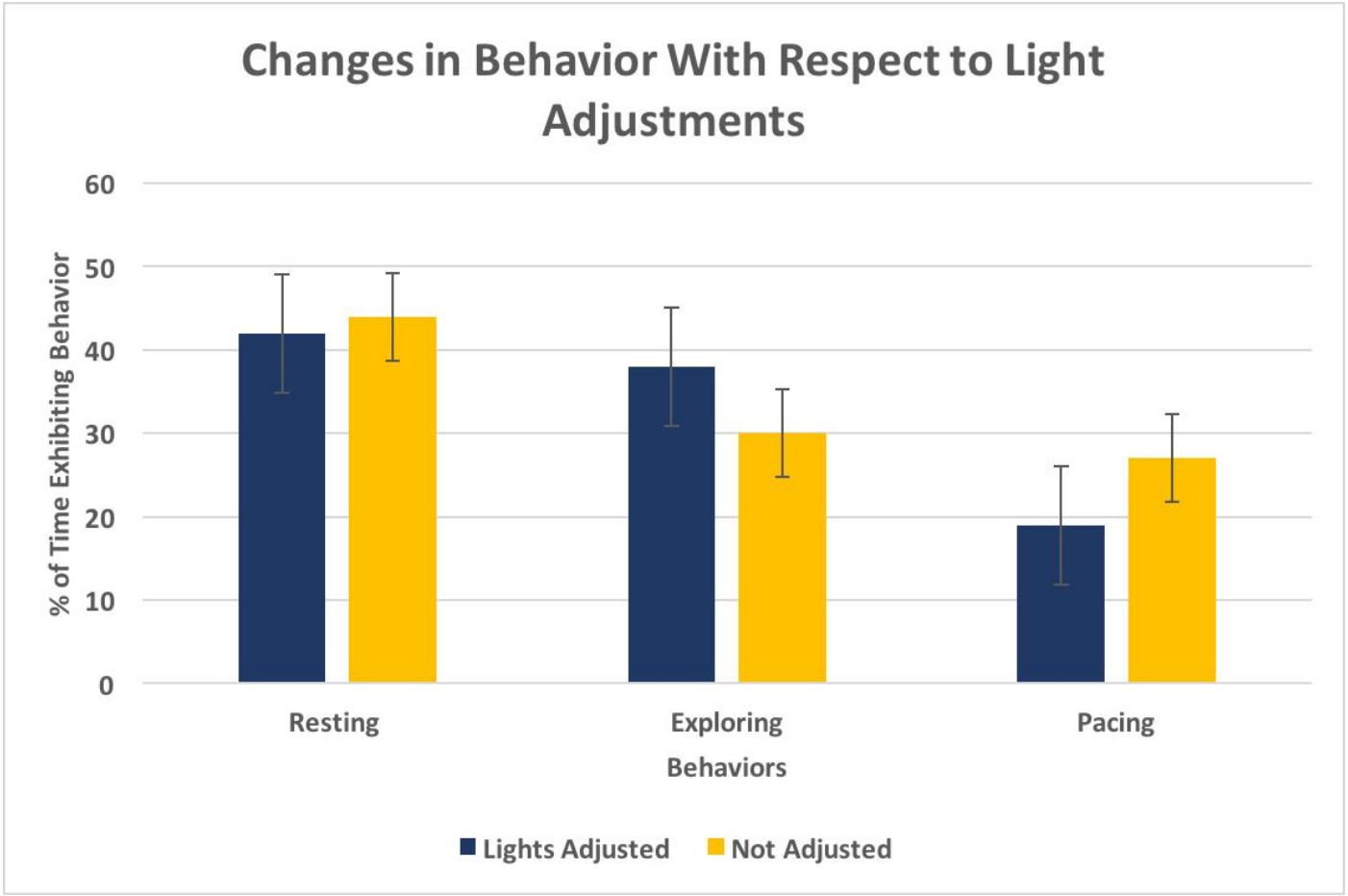
FOOD ENRICHMENT RESULTS…


Percent of Time Spent Pacing in Regards to Food Enrichment
% of Time Spent Pacing
45
40
35
30
25
20
15
10
5
0
Control
Sand Buried
Puzzle Feeder
Straw Buried
Frozen Mice
Treatment Type


Percentage of Time Spent Pacing With Regards to Treatment Type and Number of Exposures
% of Time Spent Pacing
60
50
40
30
20
10
0
Control
n=2
Sand Buried
n=3
Puzzle Feeder
n=3
Frozen Mice
n=3
Straw Buried
n=3
Treatment Type
Exposure 1
Exposure 2
Exposure 3


Percent of Time Spent Pacing Versus Percent of Day Exhibit is Crowded
% of Day Crowded
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
% Of Time Spent Pacing

Both Studies– Data Combined…


Changes in Behavior With Respect to Light Adjustments
60
50
40
30
20
10
0
% of Time Exhibiting Behavior
Resting
Exploring
Pacing
Behaviors
Lights Adjusted
Not Adjusted

Key Points

- Lighting
- Animal scents vs. Food
- Visitor density
- Food enrichment effectiveness seems to vary depending on novelty
  - More times exposed = less efficient?

What I Learned…

- Communication is key
- Importance of confounding variables!
- Quiet areas in zoos?

Acknowledgments

- Dr. Jennifer Campbell
- Dr. Corinne Kendall
- Chris Shupp
- Cosmo’s keepers

NC Zoo - Facebook

Questions?

Western Lowland

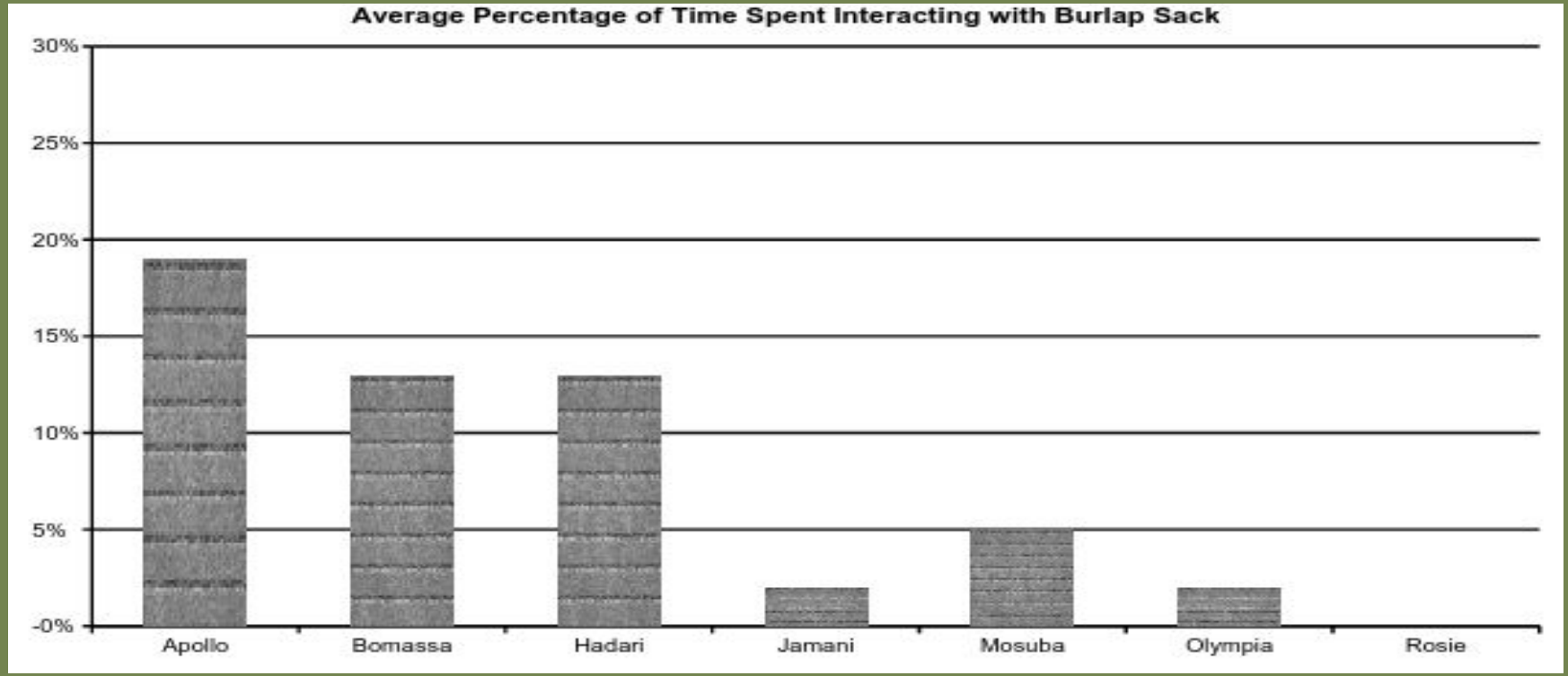
Gorilla Enrichment Options at the North Carolina Zoo – What Works?

Sam Eliades

Gorilla Enrichment Research Thus Far

- Past student research was able to identify enrichment objects that were of particular interest to the gorillas
  - Burlap sacks and gas cans
- A follow up study was designed to investigate the influence of altering time between introductions of their “favorite” objects
  - Not enough replicates to generate statistically significant results

Results from Previous Study



Why Scent as Enrichment?

- Tangible enrichment objects most appealing to juveniles, of little interest to adults
- Non-tactile enrichment may elicit some attention positive or negative, from gorillas

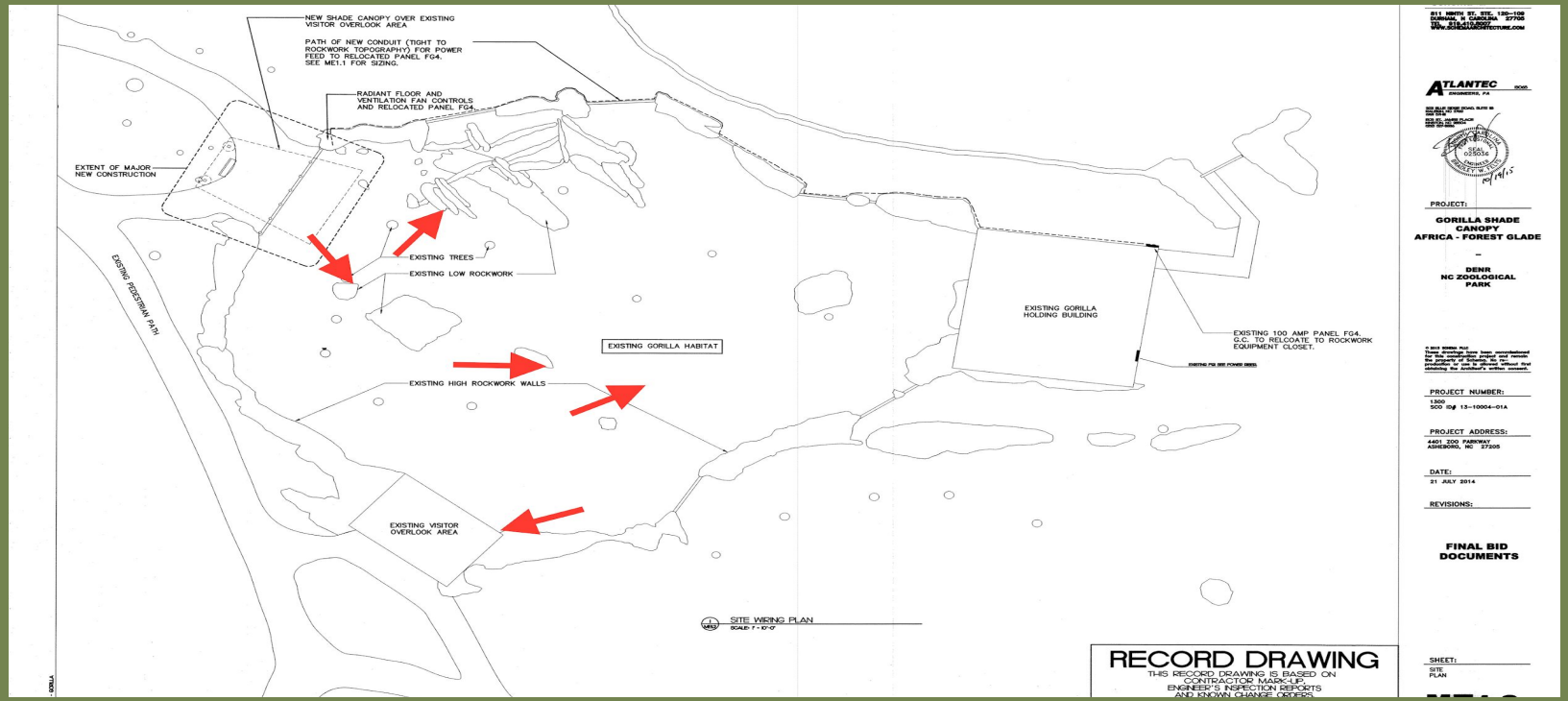
Goal of the Study

- Improve captive welfare of gorilla troop by potentially increasing exploratory behaviors and allowing for a greater array of enrichment options
- Identify possible new ways to reward gorillas during training sessions
- Record where gorillas spend majority of their time within the enclosure through heat maps

Methods

- 3 scents: Lavender, Almond, and Eucalyptus
- 3 replicates for each scent, 4 control days
- Observation period from 9am-12pm
- Recorded behavior at 3 min intervals in ZooMonitor
- Used heat mapping feature to [illegible] gorillas moved throughout the observation period

The Map


NEW SHADE CANOPY OVER EXISTING VISITOR OVERLOOK AREA
PATH OF NEW CONDUIT (TIGHT TO ROCKWORK TOPOGRAPHY) FOR POWER FEED TO RELOCATED PANEL FG4. SEE ME1.1 FOR SIZING.
RADIANT FLOOR AND VENTILATION FAN CONTROLS AND RELOCATED PANEL FG4.
EXTENT OF MAJOR NEW CONSTRUCTION
EXISTING TREES
EXISTING LOW ROCKWORK
EXISTING PEDESTRIAN PATH
EXISTING GORILLA HABITAT
EXISTING GORILLA HOLDING BUILDING
EXISTING 100 AMP PANEL FG4. G.C. TO RELOCATE TO ROCKWORK EQUIPMENT CLOSET.
EXISTING HIGH ROCKWORK WALLS
EXISTING VISITOR OVERLOOK AREA
SITE WIRING PLAN
SCALE: 1" = 10'-0"
RECORD DRAWING
THIS RECORD DRAWING IS BASED ON CONTRACTOR MARK-UP, ENGINEER'S INSPECTION REPORTS AND KNOWN CHANGE ORDERS
ATLANTEC
PROJECT:
GORILLA SHADE CANOPY
AFRICA - FOREST GLADE
DENR
NC ZOOLOGICAL PARK
PROJECT NUMBER:
PROJECT ADDRESS:
4401 ZOO PARKWAY
ASHEBORO, NC 27205
DATE:
21 JULY 2014
REVISIONS:
FINAL BID DOCUMENTS
SHEET:
SITE PLAN

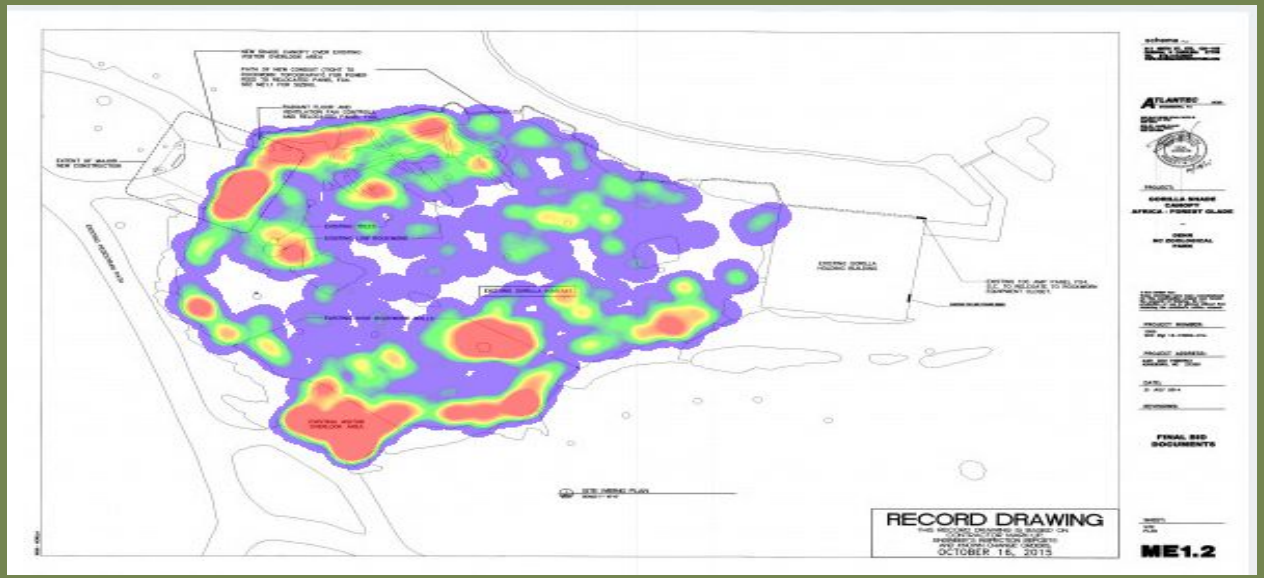
Scent Results

- 3/8/17 at 9:50:41 Apollo sniffed eucalyptus once!
- No other scent interactions were recorded

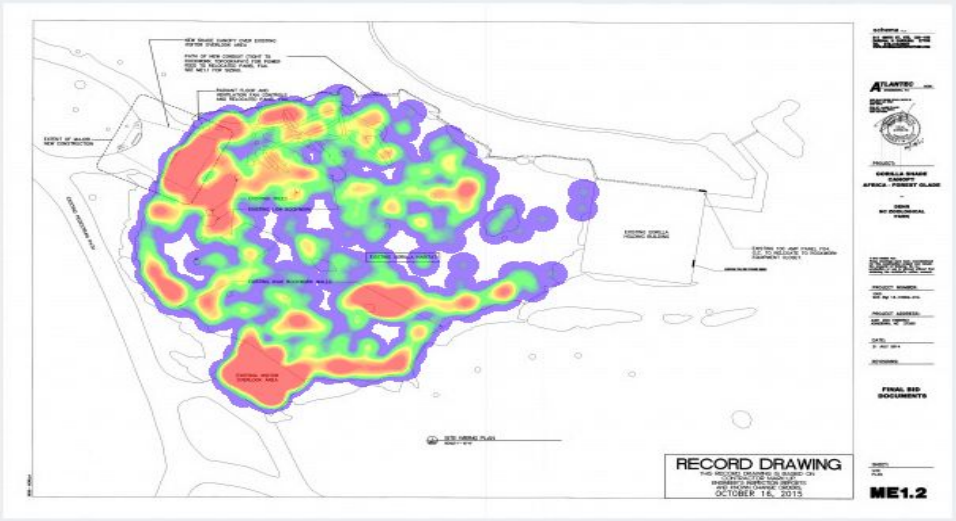
Discussion

- Findings here are similar to Wells et al. (2007), olfactory stimulation has little effect on gorillas
- It is unlikely that scent can be used in eliciting certain beha e reward for training exe

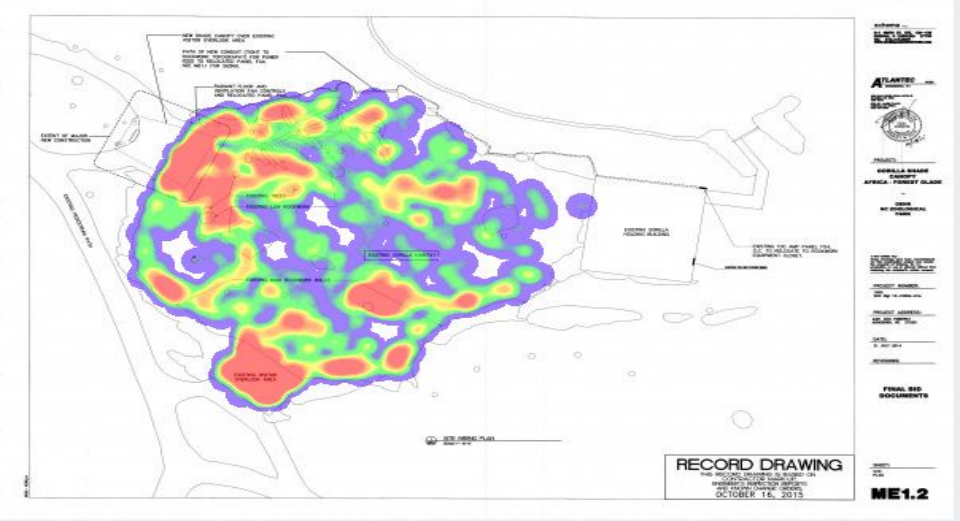
Heat Maps



Foraging Heat Maps

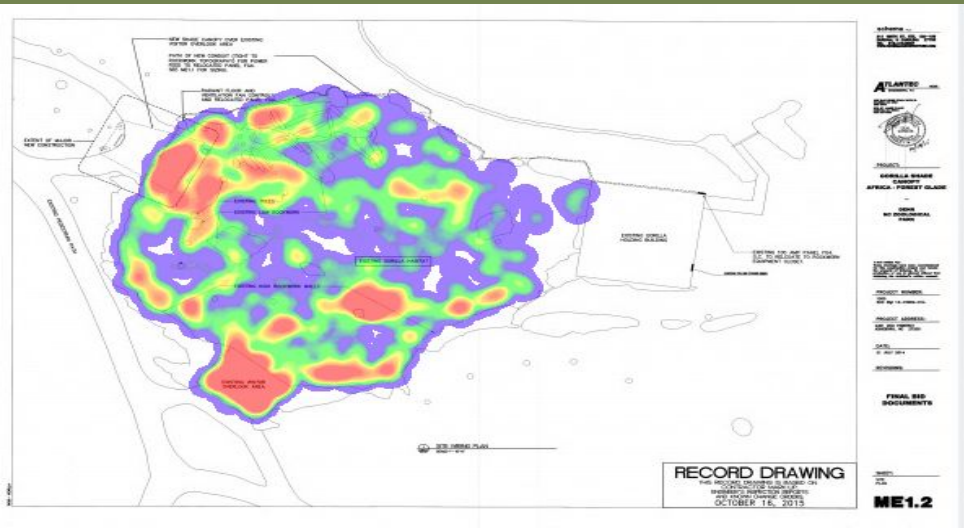


Apollo

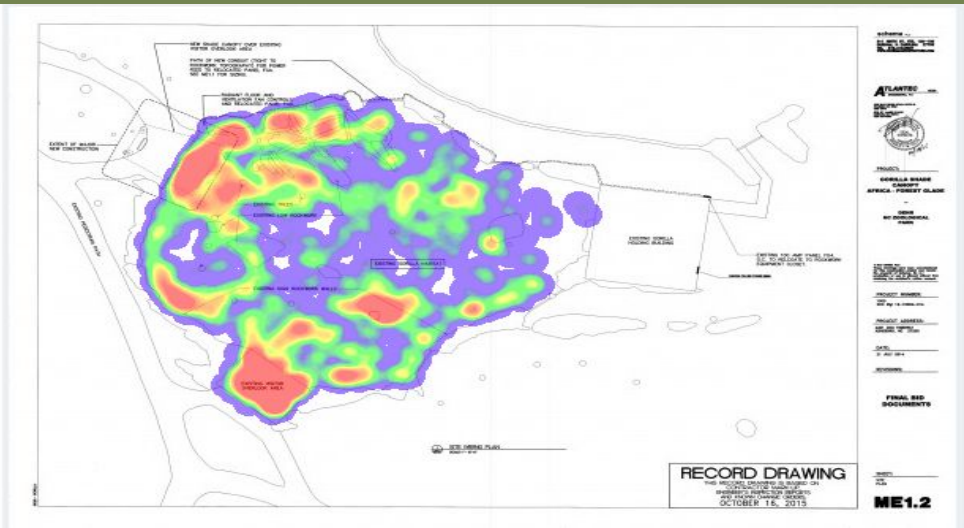


Bomassa

Foraging Heat Maps

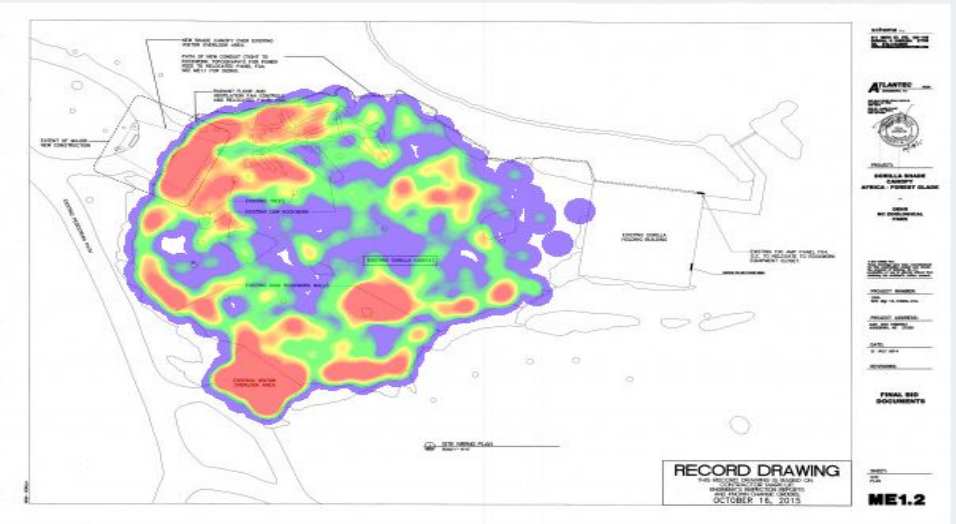


Jamani

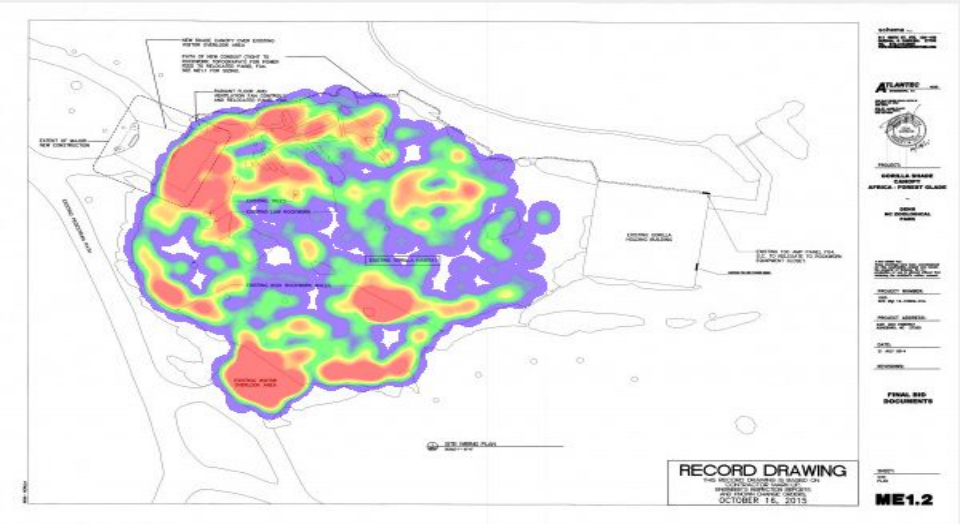


Olympia

Foraging Heat Maps

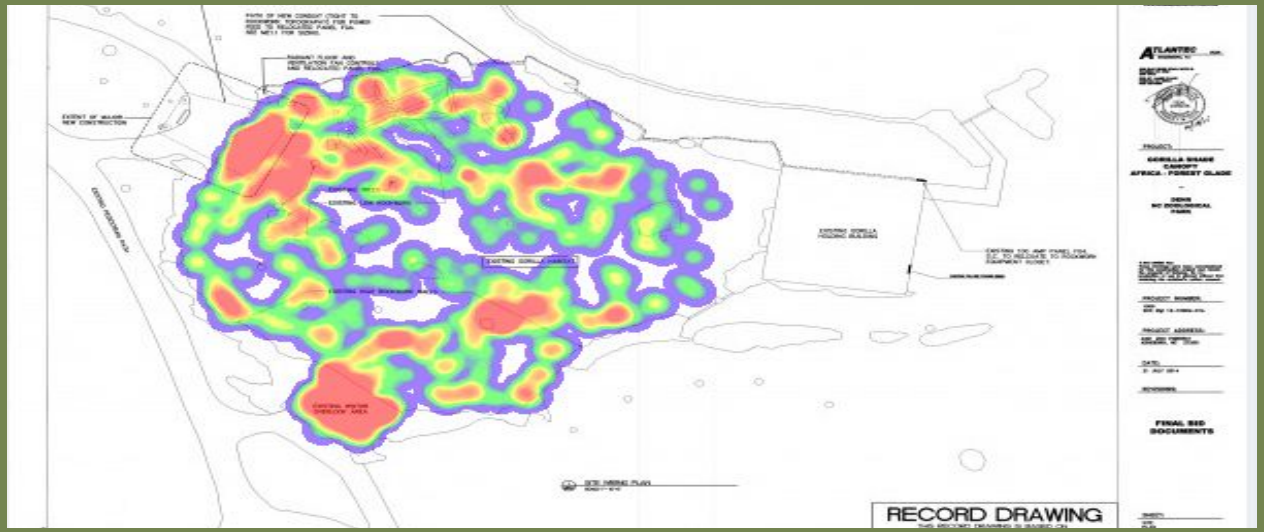


Rosie



Hadari

Foraging Heat Map



Mosuba

Future Study

- From observation, burlap sacks and hay piles are commonly used as sleeping mats by Jamani, Mosuba, and Olympia.

- May be beneficial to identify tangible items that could serve some purpose for the adults
  - ie. firehoses, bamboo mats, etc.

Enrichment Complexity and Stereotypic Behavior in Polar Bears at the NC Zoo

By Aleah Querns

Questions Addressed

- How effective are the zookeeper's observation methods at providing accurate representations of activity budgets?
- What factors relate to levels of stereotypic behavior?
  - Air temperature, time of day
- How does the complexity of enrichment activities affect levels of stereotypies?

Methodology

- One hour observation sessions10AM–4PM
- Observations every 10 minutes
- Initial baseline data collection period
- Later sorted by complex enrichment, simple enrichment, or control days
  - Enrichments provided to Nikita 10:30 AM, 1:15PM, 3PM at randomly assigned locations

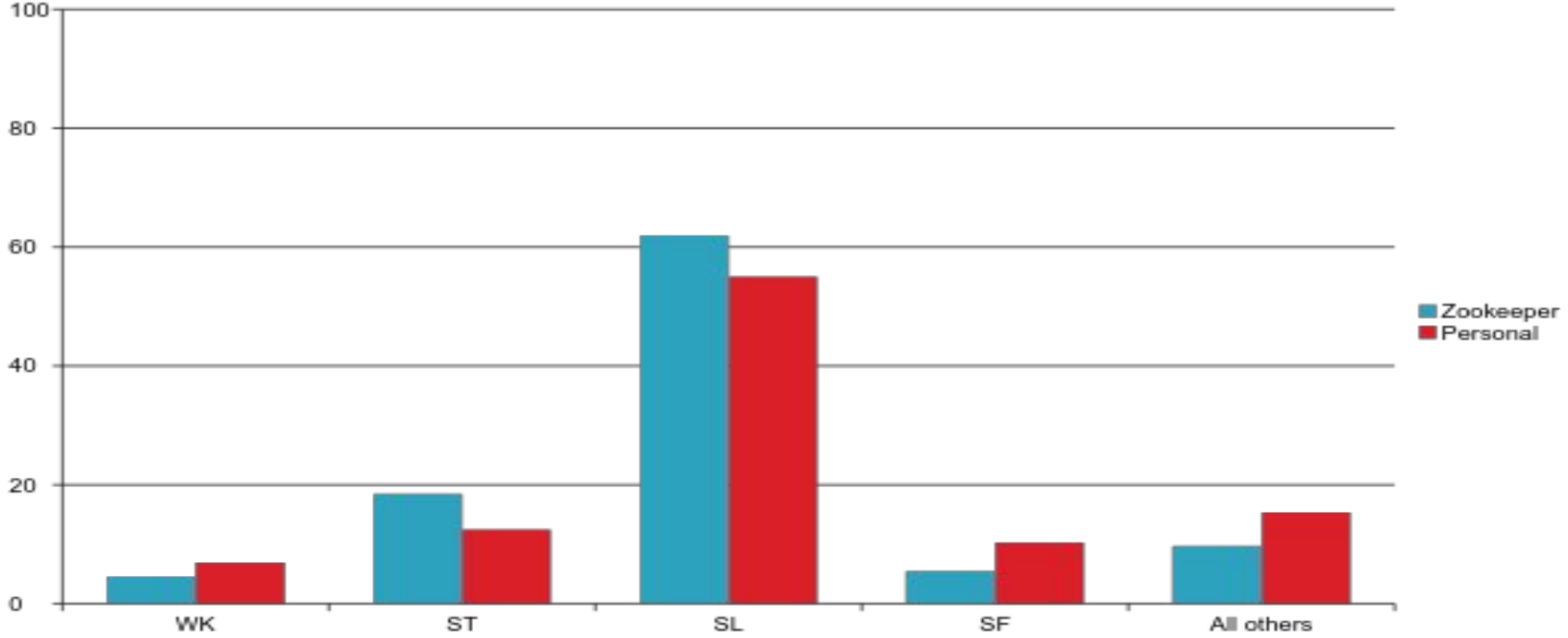
Enrichments Used

- **Simple Enrichments**
- Thesaurus
- Full spool
- Lid
- Plain boomer ball (no holes)
- Lifeguard buoy
- Stair stepper
- Black pallet
- Pickle
- **Complex enrichments**
- Half boomer-balls stacked inside soda crate, tied to mesh using firehose
- Boomer ball under flipped mop-bucket, tucked inside a half-barrel
- Boomer ball inside milk crate, tied with fire hose
- 3 gas cans strung together using firehose
- Bread crate with ferret log inside, tied with fire hose
- Black plastic square bowl with two ferret logs inside
- Broken Easter basket with 2 boomer balls inside, with a half planet ball set on top, facing upside down

Results

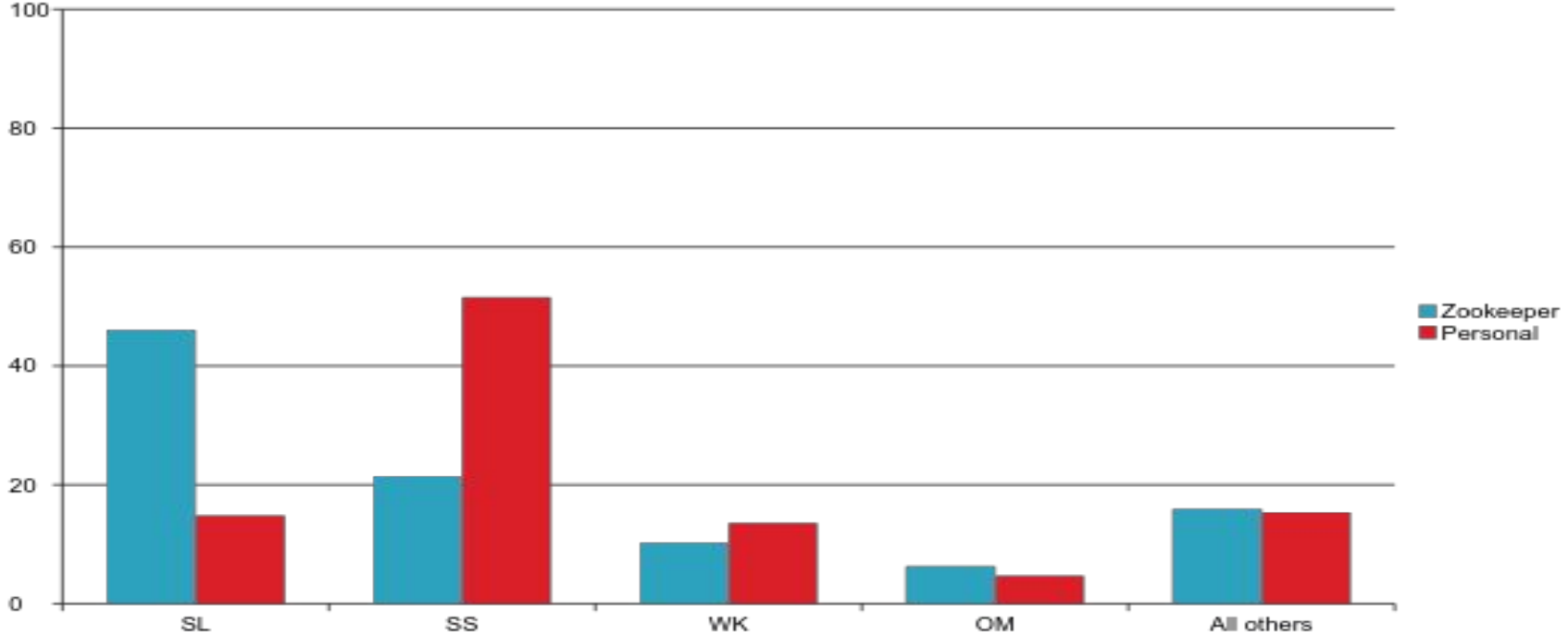
Anana's Activity Budget –

My Data vs. Zookeeper's (All Available Data Oct– Dec)



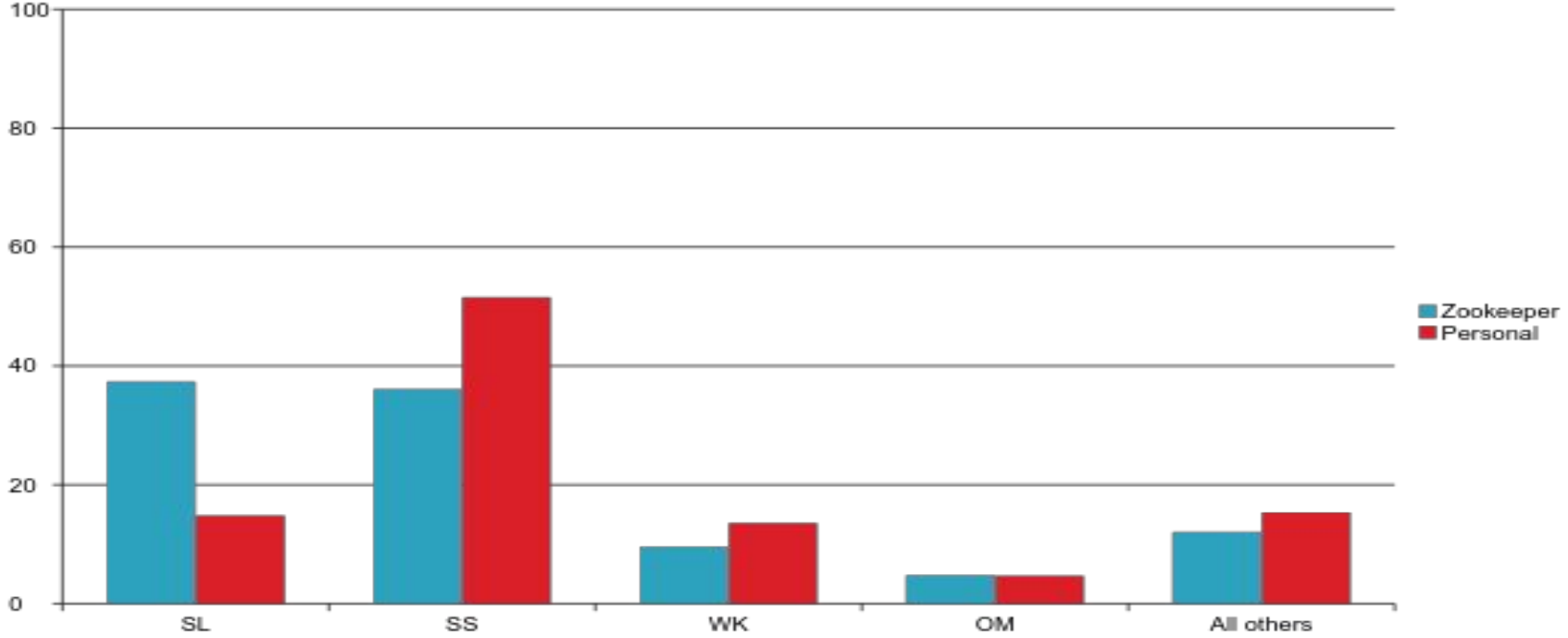
Nikita's Activity Budget–

My Data vs Zookeeper's (All Available Data Oct–Dec)



Nikita's Activity Budget–

My Data vs. Zookeeper's (Select Days)

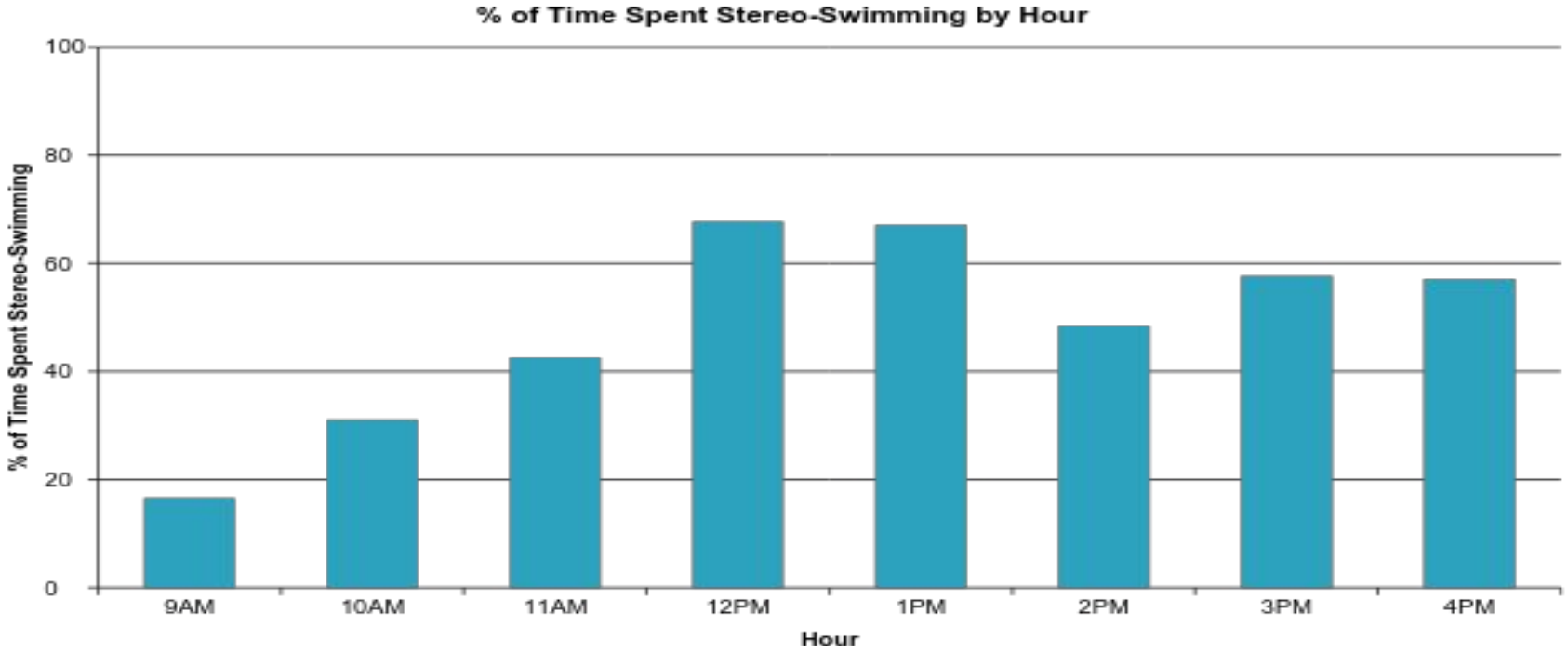


Chi–Square Data

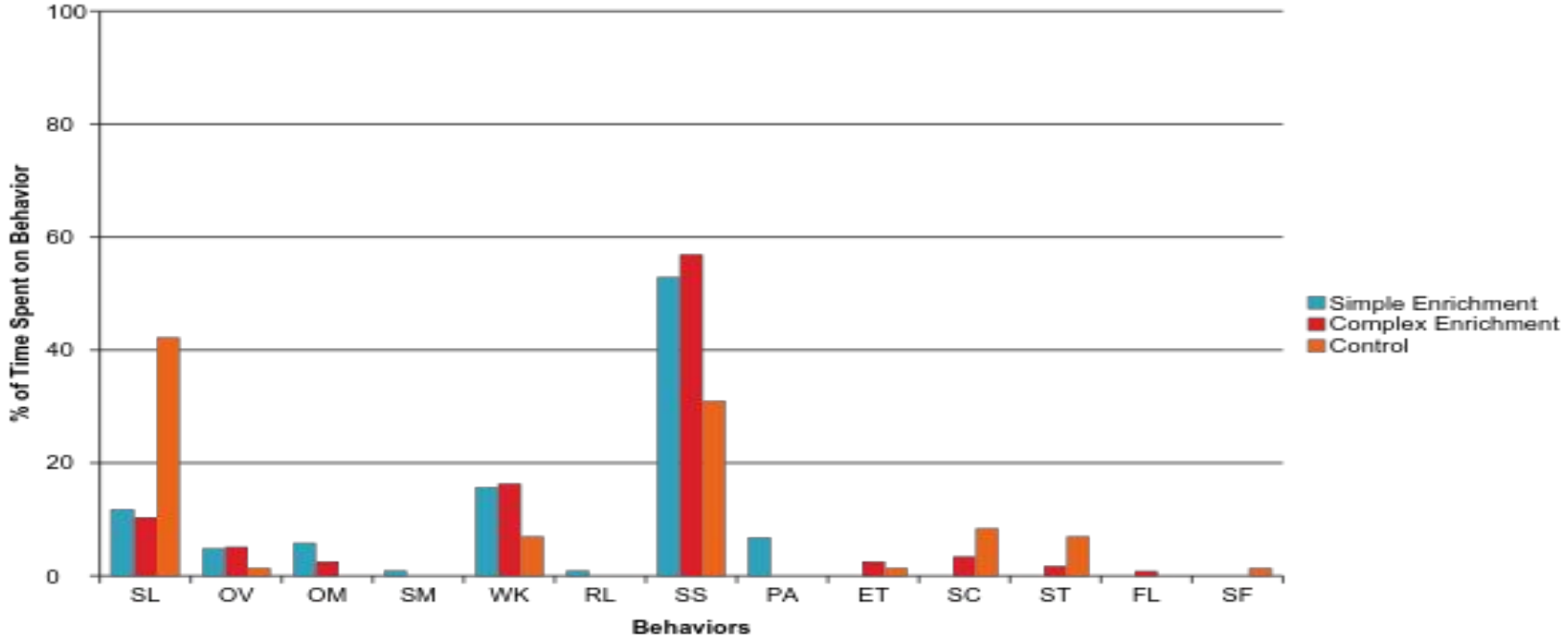
My Data vs. Zookeeper's (all)

- Anana's data did not show any significant differences in most exhibited behaviors
- Nikita's data showed significant differences in top two exhibited behaviors (stereo–swim and sleep/lie)

Nikita


% of Time Spent Stereo-Swimming by Hour
% of Time Spent Stereo-Swimming
100
80
60
40
20
0
9AM
10AM
11AM
12PM
1PM
2PM
3PM
4PM
Hour

Nikita's Activity Budget Dependent on Enrichment Complexity



Findings

- Activity budgets
  - Anana's activity budget was accurate
  - Nikita's was not
  - Influence of enclosures
- Stereo-swim peaks around mid-day
  - Crowds?
  - Zookeepers at lunch?
- No significant relationship between stereo-swimming and temperature
- Enrichment- lack of overall interest

Management Implications

- Daily behavioral observations provide valid representation of overall activity budget
  - But, consider sorting based on what exhibit bear is in
- Importance of exhibit design
- Importance of food in enrichment

Aggressive Behaviors and Swimming Patterns in Pinnipeds at the NC Zoo

By Aleah Querns

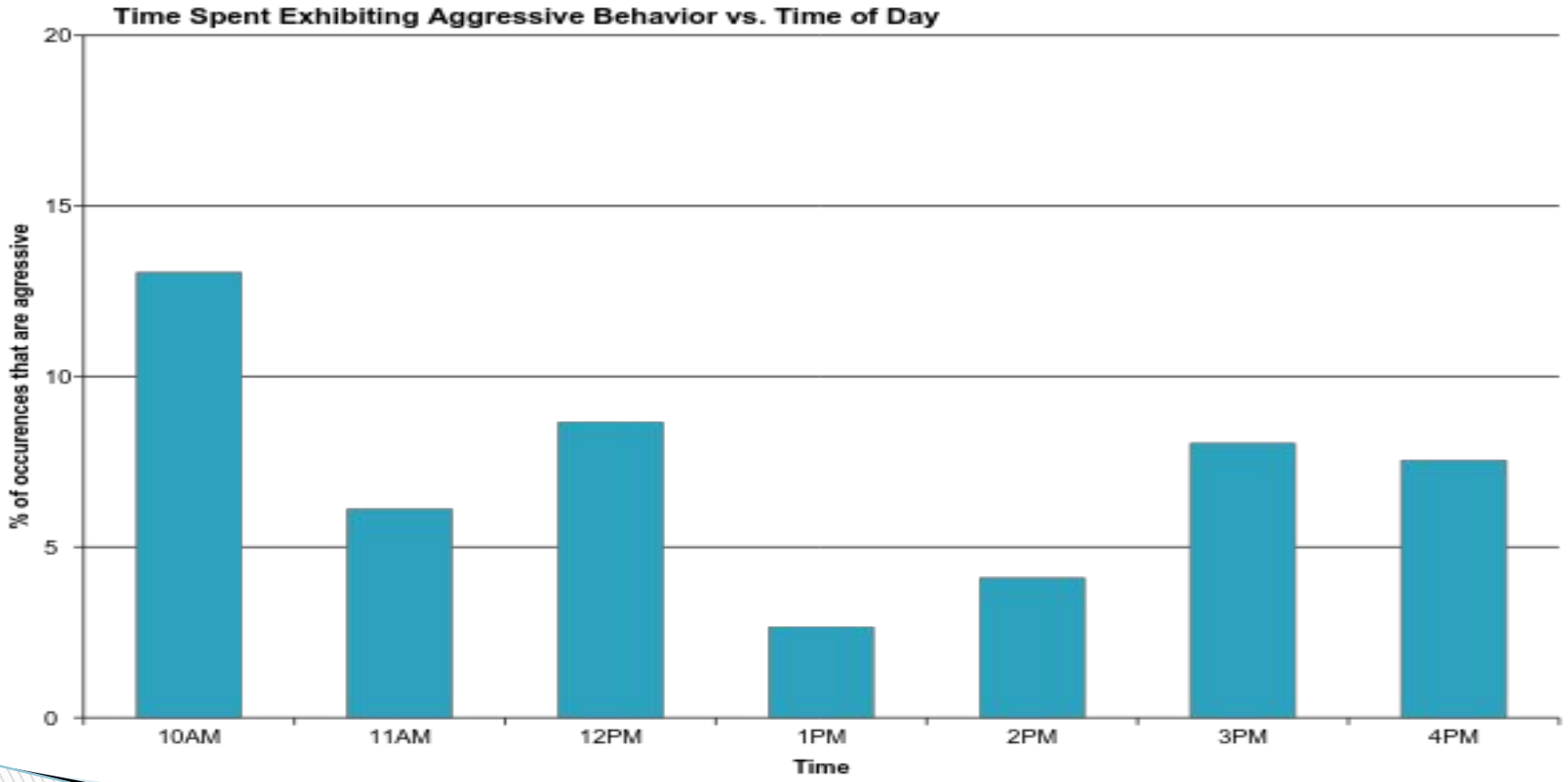
Questions Addressed

- How do weight fluctuations affect dominance/aggressive behaviors in California sea lions?
- Is there a relationship between food and aggression in California sea lions?
- How does air temperature affect aggressive behaviors in California sea lions?
- How do California sea lions and harbor seals interact in captivity?

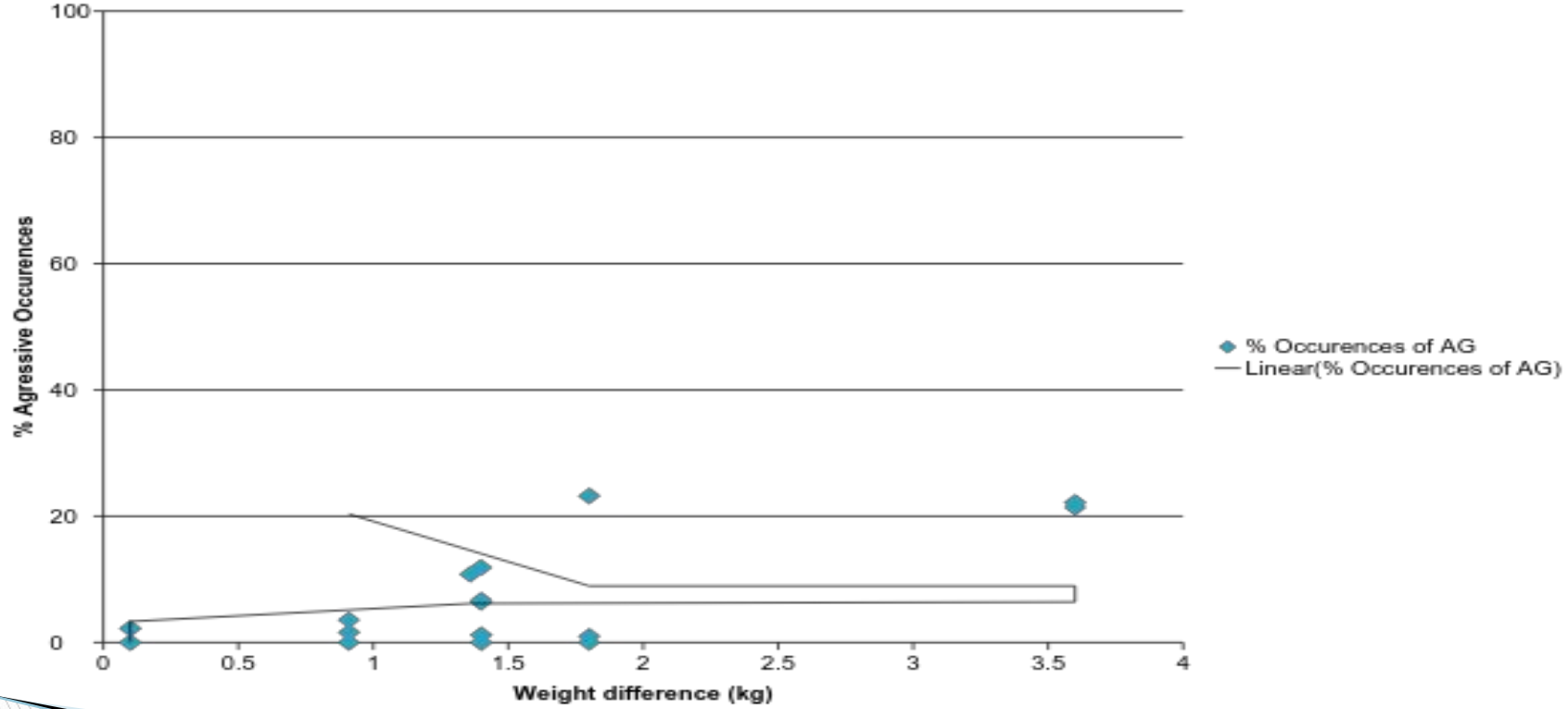
Methodology

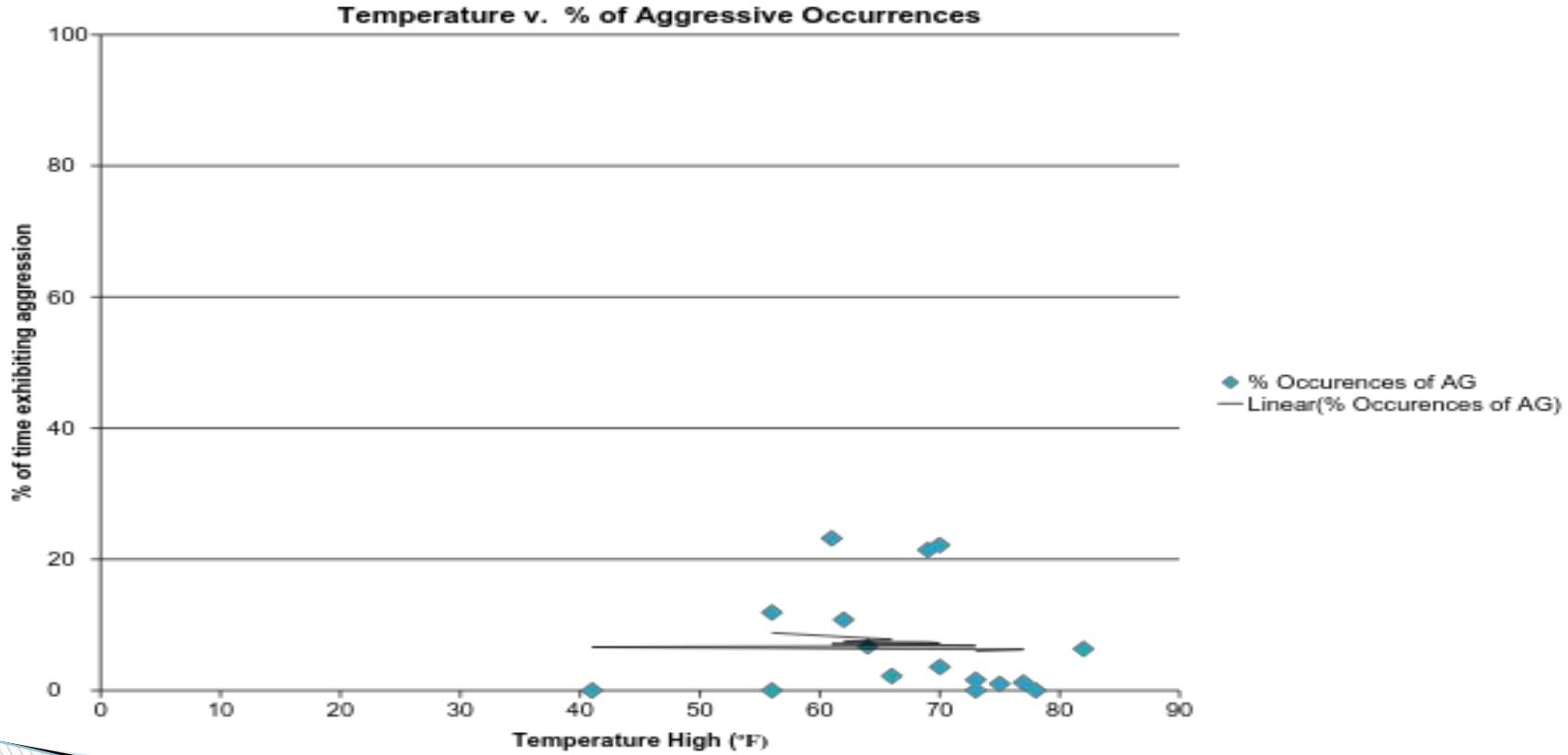
- Observations taken between 9:30–4:30
- 30 minute sessions taken consecutively, observations every 2 minutes.
- Observed 2 at a time
- Record behavior based on ethogram provided by zookeepers
- Aggressive behaviors later compared to weekly weight records from ZIMS
- Swim directions

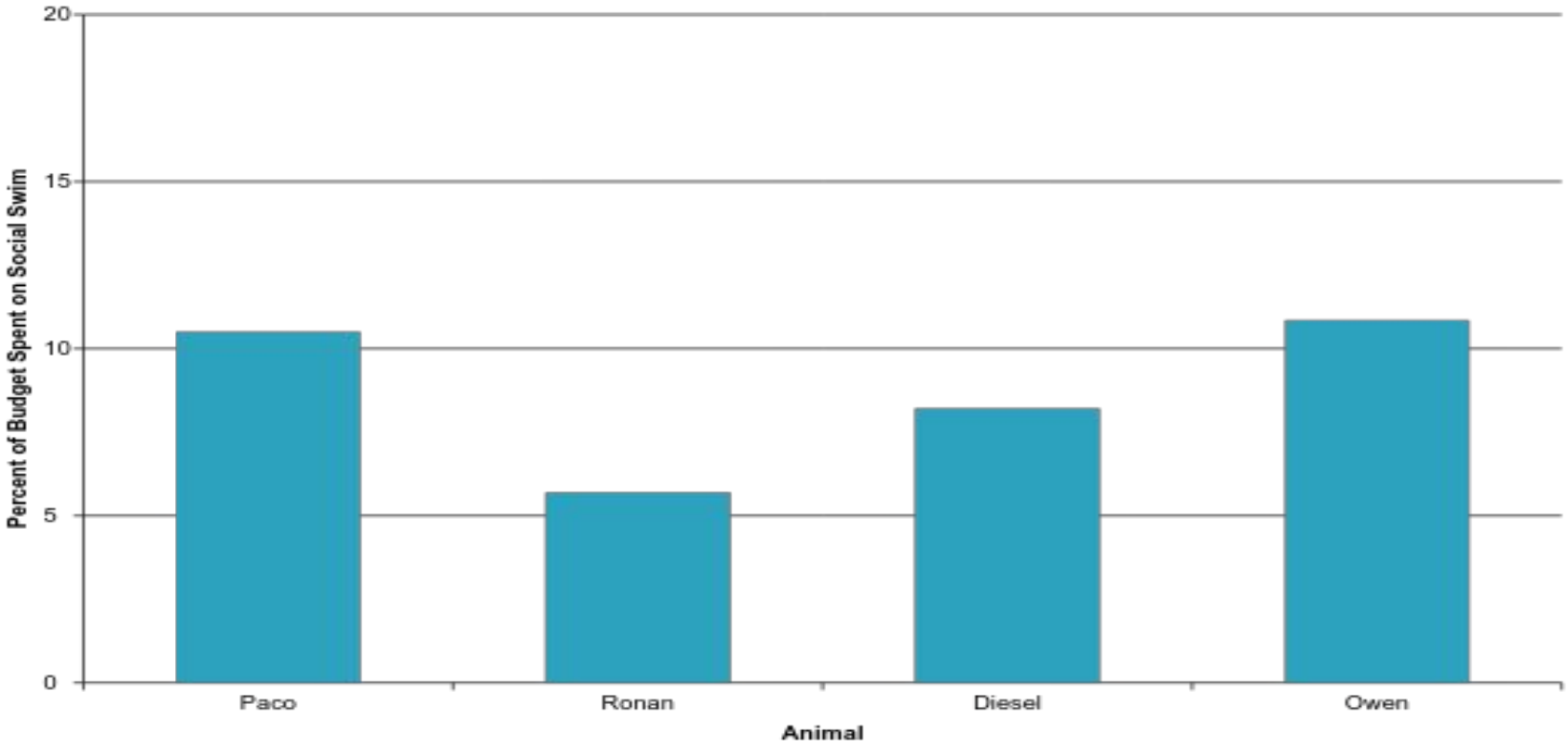
Results

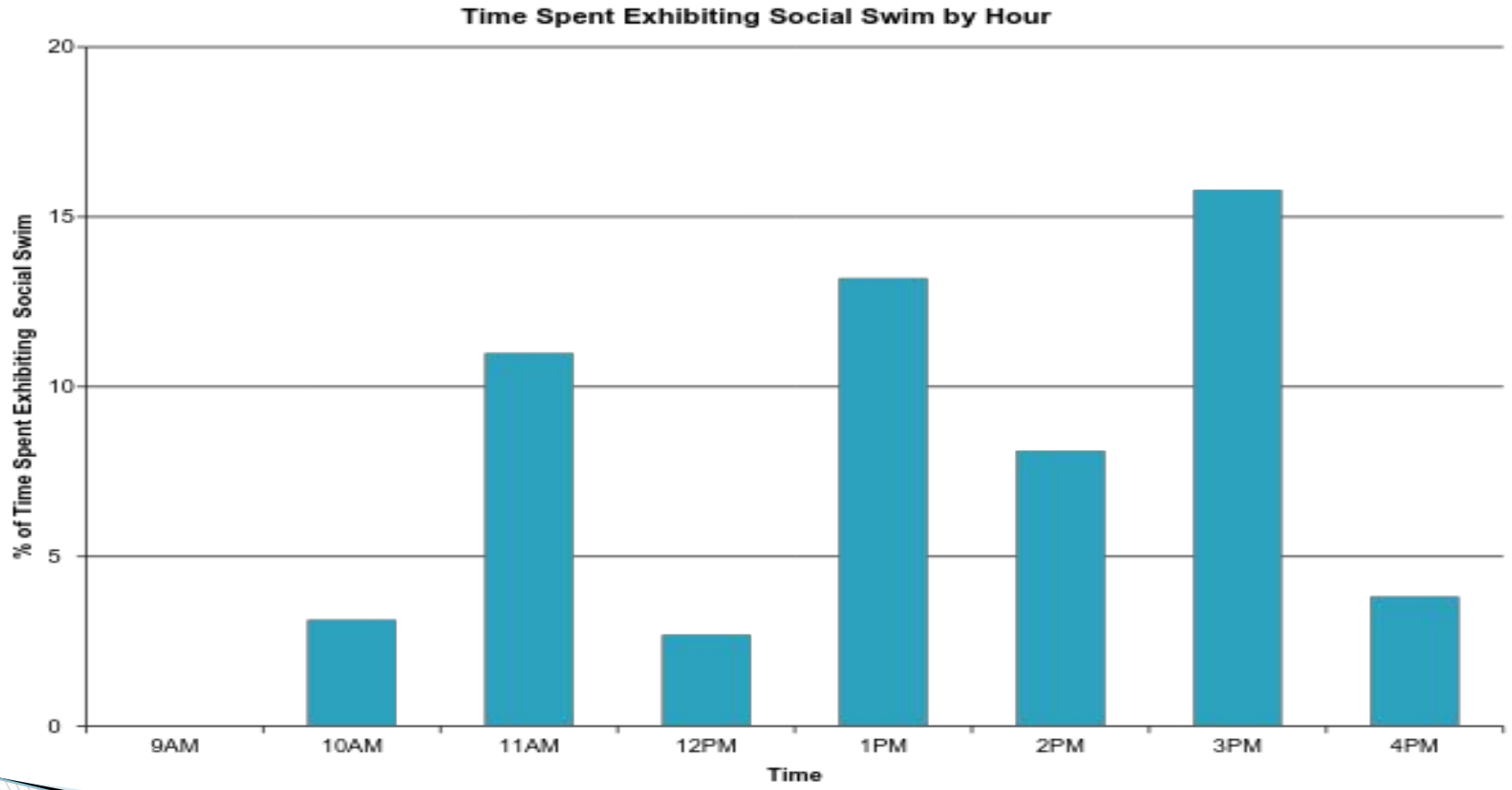

Time Spent Exhibiting Aggressive Behavior vs. Time of Day
20
15
10
5
0
% of occurences that are agressive
10AM
11AM
12PM
1PM
2PM
3PM
4PM
Time

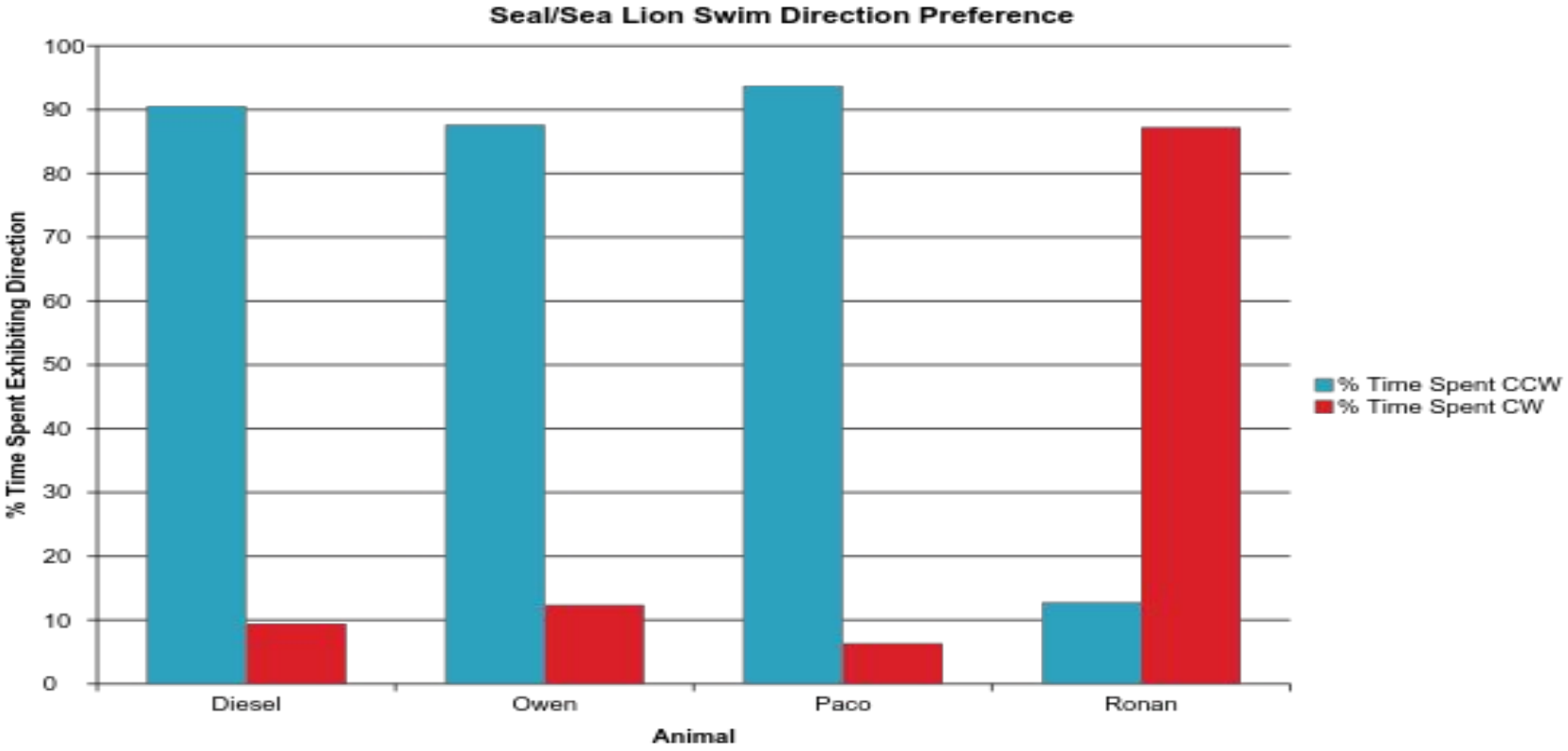
Daily Weight Difference v. % of Time Exhibiting Aggressive Behavior



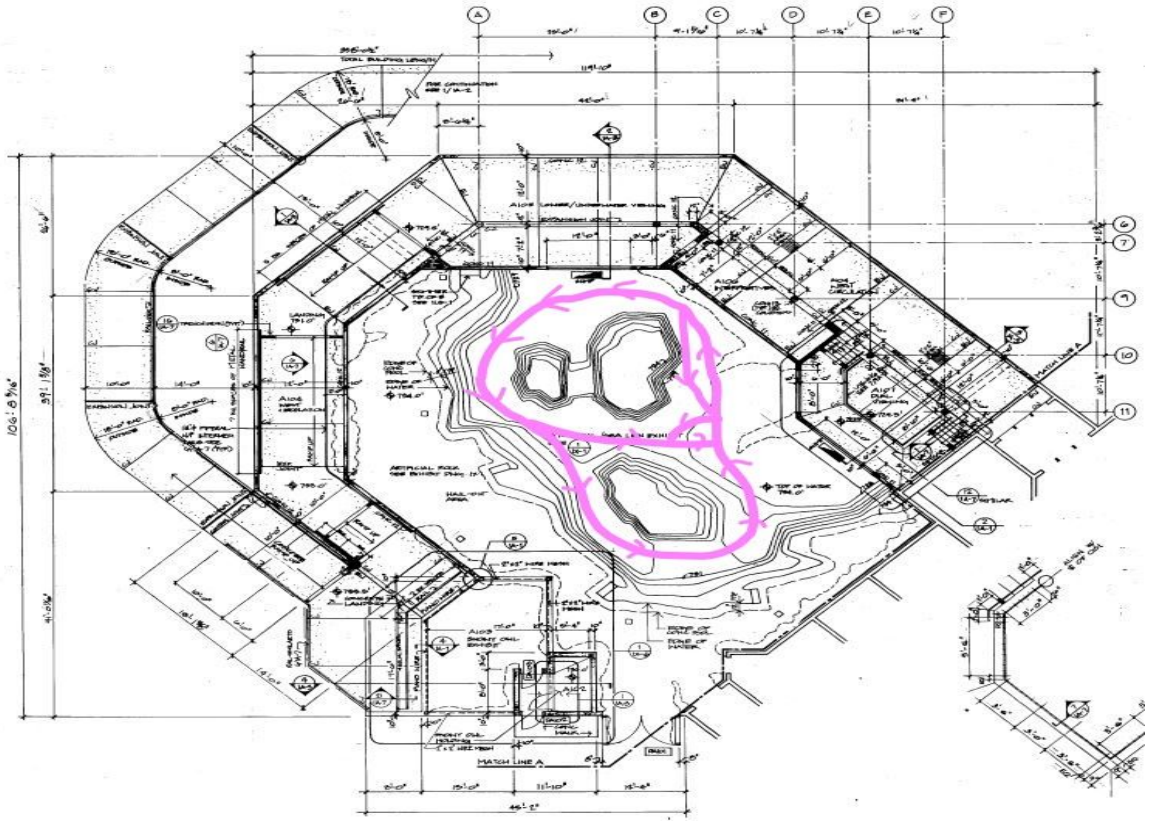

Temperature v. % of Aggressive Occurrences
% of time exhibiting aggression
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
Temperature High (°F)
% Occurences of AG
Linear(% Occurences of AG)


20
15
10
5
0
Percent of Budget Spent on Social Swim
Paco
Ronan
Diesel
Owen
Animal

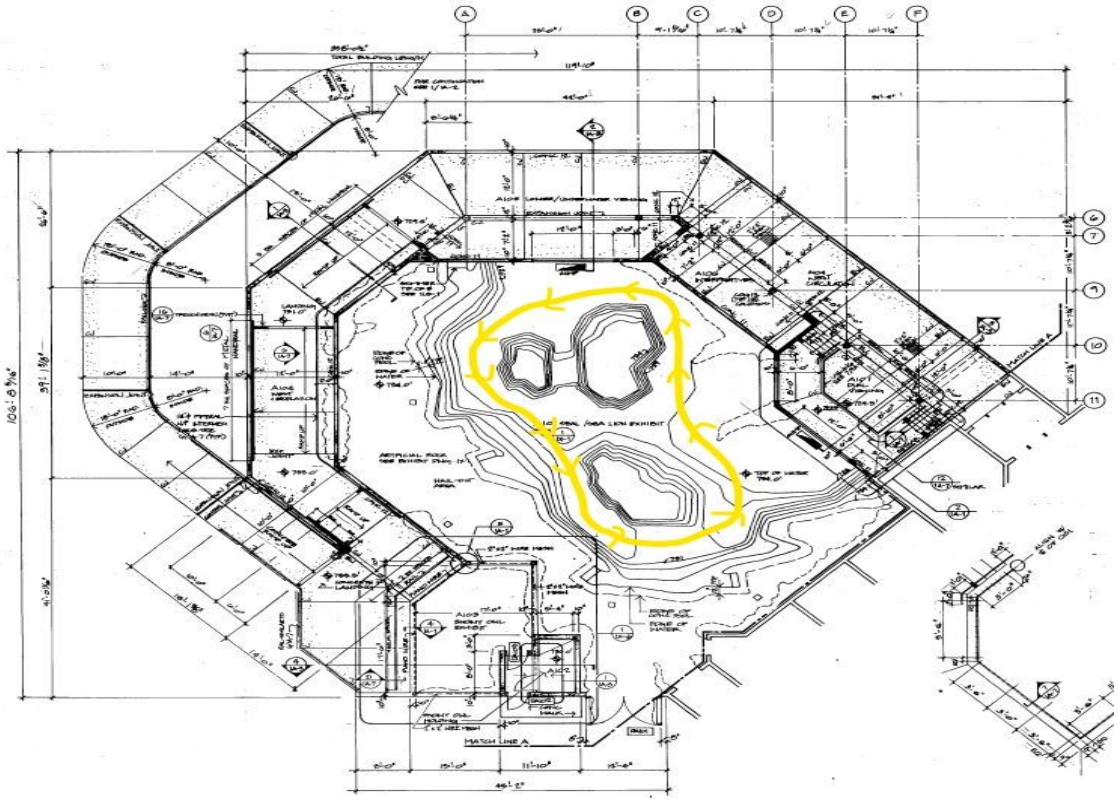

Time Spent Exhibiting Social Swim by Hour
% of Time Spent Exhibiting Social Swim
20
15
10
5
0
9AM
10AM
11AM
12PM
1PM
2PM
3PM
4PM
Time


Seal/Sea Lion Swim Direction Preference
% Time Spent Exhibiting Direction
100
90
80
70
60
50
40
30
20
10
0
Diesel
Owen
Paco
Ronan
Animal
% Time Spent CCW
% Time Spent CW

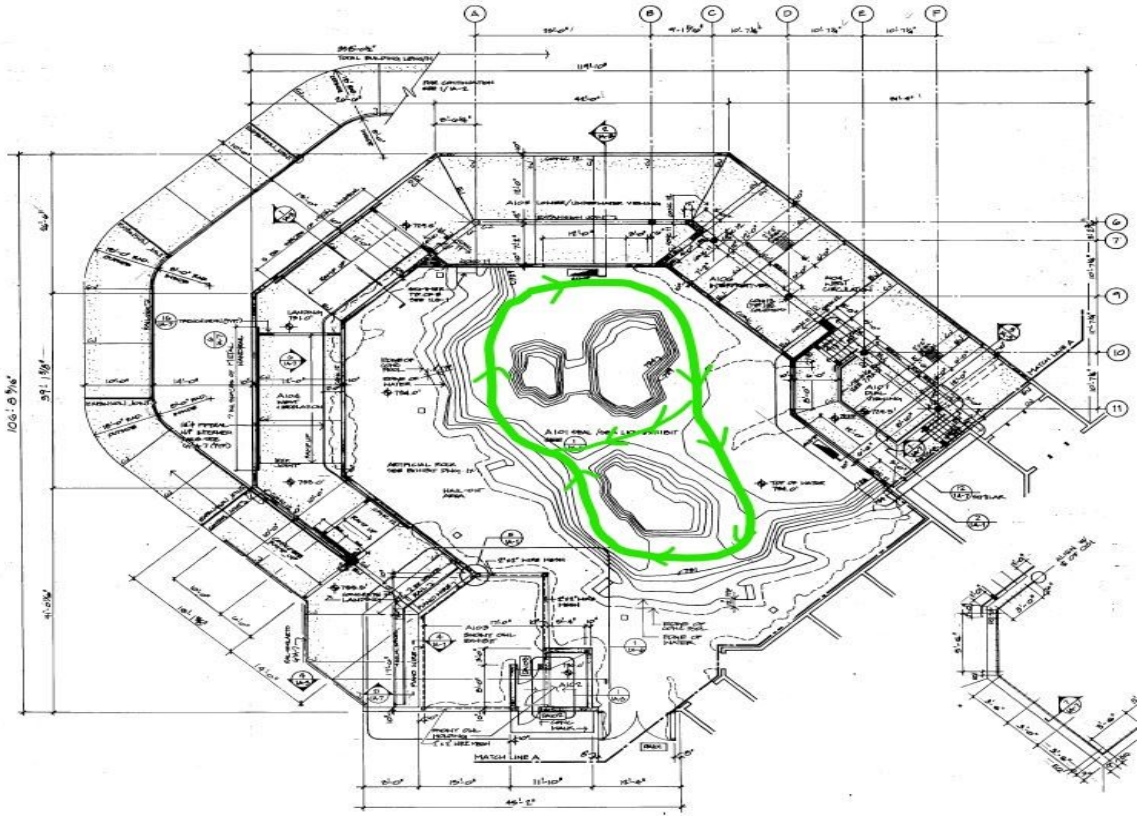
Sea Lion Swimming Pattern



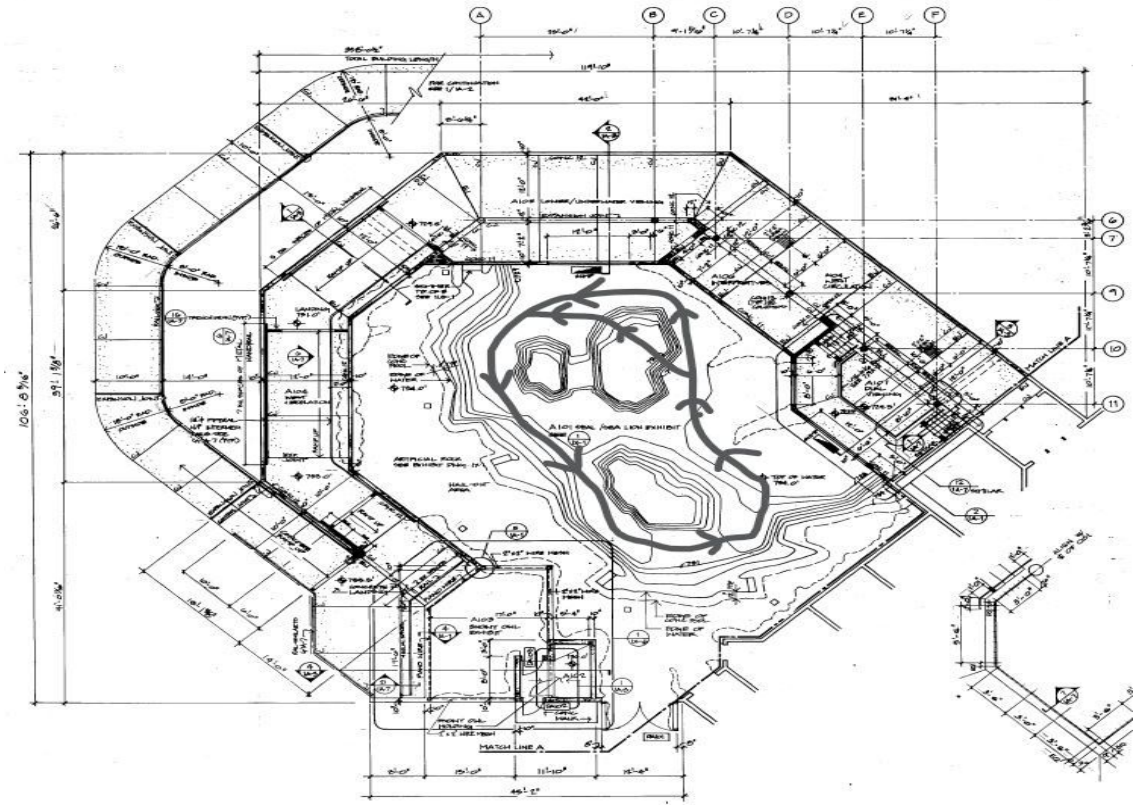
Paco's Swimming Pattern



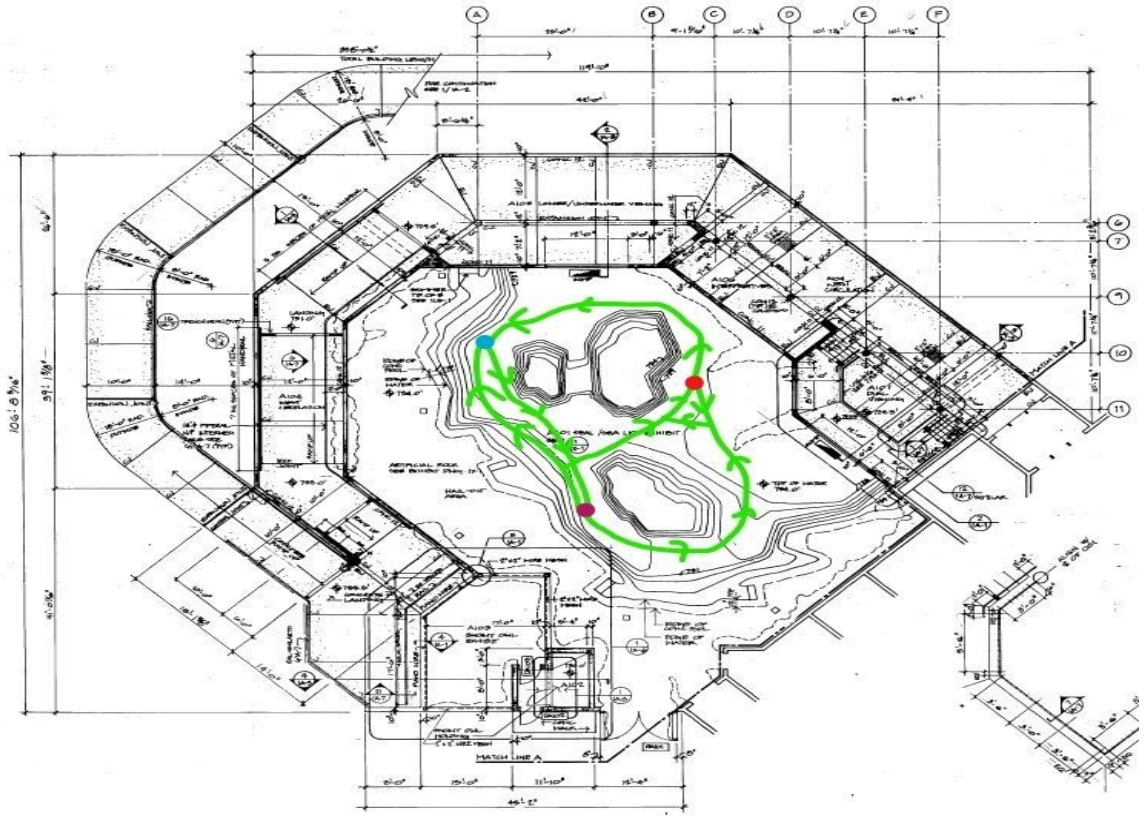
Ronan's Swimming Pattern



Social Swim Pattern (Diesel, Owen, Paco)



Ronan's Social Swim Pattern

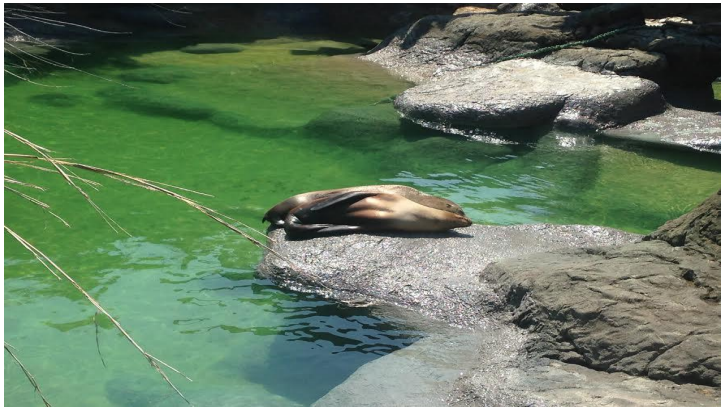


Findings

- Correlation between weight difference and aggression
- Social swim, aggression, and feedings occurred around same time of day
- Paco and the sea lions have similar swim patterns
- Ronan follows different pattern
  - Pattern more similar to others when social swim
  - Changes direction more when social swimming

Management Implications

- Size-related aggression
  - Establishing a hierarchy
- Social swim and aggression
  - Coercion?
- Ronan's unique swim pattern



Thank you for your time!