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Assessment of Potential Measures at Admit of Harbor Seal Pup Rehabilitation Success

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ASSESSMENT OF POTENTIAL MEASURES AT ADMIT OF HARBOR SEAL PUP REHABILITATION SUCCESS

by

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ABSTRACT

Harbor seals frequently strand along the northeast coast of the United States due to injury, illness, disease, and human interaction. In Maine, a non-profit organization, Marine Mammals of Maine (MMoME), is federally authorized to respond to these stranded animals and provide short- and long-term rehabilitation, with the ultimate aim to release the seals back into the wild. I investigated the role of multiple potential measures of marine mammal health that are evaluated at admit in determining rehabilitation success of dependent and weaned harbor seal pups from 2016 to 2019. The variables assessed were the day of the year the patients were first observed in the field, the amount of time they were observed in the field before collection, findings of human interaction, age class, weight:length ratio, and 43 blood parameters. This analysis found that pups have a greater likelihood of being released if they strand later in the year ($p<0.05$). The longer an individual is in rehabilitation, the less likely they are to be released ($p<0.0001$). Pups that were transferred from MMoME to another rehabilitation facility had a greater likelihood of being released ($p<0.05$). Harbor seals that stranded when they were dependent pups were more likely to be released than weaned pups ($p<0.05$). Pups with a lower lymphocyte concentration at admit ($p<0.001$) and a higher total protein concentration ($p<0.05$) were more likely to be released. These findings may help rehabilitation organizations determine which harbor seal pups will be good candidates for a successful rehabilitation early on in the process.

ACKNOWLEDGMENTS

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INTRODUCTION

Marine mammals, and pinnipeds in particular, can be important indicators of coastal ecosystem health. Marine mammals live in coastal waters, are exposed to environmental stressors, and eat similar food to humans (Bossart, 2010). Climate change, pollution, and other factors that affect marine mammals may therefore also impact humans. For example, microplastic fragments and fibers have been found in many marine mammal species and humans, with the primary route of exposure being through ingestion (Meaza et al. 2021). Learning about the problems coastal species, including humans, are facing, gives us the power to lessen the impact.

In Maine, where threats to coastal ecosystem health are mainly caused by increased warming trends (Morrison et al. 2012), the most common pinniped species is the harbor seal. These warming waters may lead to shifts in species' habitat ranges and the introduction of mid-Atlantic species to the Gulf of Maine (Kleisner et al. 2017). Increased competition for resources is expected to be seen for many species, including harbor seals.

Harbor seals are small phocids that are found on both coasts of the United States, Europe, and Asia (Harbor Seal, NOAA Fisheries). On the east coast of the US their habitat spans from the Arctic to New York. In the Gulf of Maine, pups are usually born from late April through June (Harbor Seal, NOAA Fisheries). The average time of weaning is about a month after birth (Cottrel et al. 2006), and then pups are responsible for foraging on their own.

Following historical depletion, harbor seal populations in Maine increased rapidly from the 1970s through the late 1990s as a result of the Marine Mammal Protection Act (MMPA), federal legislation that prohibits the taking of any marine mammal (Gilbert et al. 2005). Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" (United States, National Oceanic and Atmospheric Administration, 2005). Since 2001, the population growth rate of harbor seals in this region has declined or potentially reversed (Waring et al. 2015). This could be a result of competition with the more recently increasing gray seal population, or an indicator that this harbor seal population has reached carrying capacity (Johnston et al. 2015).

In 1992, an amendment was made to the MMPA that instituted the Marine Mammal Health and Stranding Response Program. A national network of stranding organizations provides one of the primary ways we collect information about the health of marine mammal populations, and thus about our coastal ecosystem health. There are currently two stranding organizations in Maine, Marine Mammals of Maine (MMoME) and Allied Whale (AW). MMoME responds to stranded marine mammals in the southern half of Maine, while AW is responsible for the northeastern half. Beachgoers and members of the community call a state hotline to report a stranded animal. Volunteers or staff will then go respond to the stranded animal and assess what further care will be needed.

Beyond stranding response, MMoME also has the capacity to provide both short-term and long-term rehabilitation care to stranded pinnipeds with the ultimate goal of releasing healthy animals back into the wild. Short-term patients can be housed at

MMoME for up to four days and then transferred to another rehabilitation facility. Long-term patients can spend weeks to months in rehabilitation at MMoME. Rehabilitation is important because it can help steady or increase the population of threatened or endangered species, improve the livelihood and lifespan of sick and injured animals, and provide valuable data that can be used to study a population (Moore et al. 2007). However, rehabilitation is costly, and any information that can help rehab organizations predict which animals are most likely to be successful throughout the rehab process is helpful in effectively determining how to spend critical resources. In regions that provide rehab care to multiple types of marine animals, it has been shown that phocids are more likely to be released than cetaceans and sea turtles (Gallini et al. 2021).

Previous studies have evaluated the probability of harbor seal rehabilitation success against variables that changed throughout rehabilitation, for example bloodwork and mass (Morgan et al. 2009, Salazar-Casals et al. 2020). Others have compared bloodwork of seals in rehabilitation to healthy, wild seals, attempting to create reference values (Lander at al. 2003, Trumble and Castellini, 2006). In this analysis, I plan to investigate if the probability of rehabilitation success can be determined at admit. My analysis will focus on harbor seal pups, which are the most commonly stranded type of pinniped in Maine, and the most vulnerable age class (Ashley et al. 2020).

For all seals that are rehabilitated at MMoME, data are collected at admit and throughout rehabilitation to determine health status and a treatment plan. Before a seal is admitted to rehabilitation, data such as date, location, age class, sex, body condition, behavior, signs of human interaction, injury, illness, and other observational notes are collected at the stranding site. Data such as weight, length, blood chemistry and hematology, body condition, behavior, medication, and feeding are taken at admit and throughout rehabilitation. This study will analyze how the day of the year a pup is first observed stranded, time spent in the field before collection, findings of human interaction, age class, weight:length ratio at admit, blood chemistry and hematology at admit, whether or not an individual was transferred from MMoME, and the time spent in rehabilitation is related to rehabilitation outcome.

METHODS

Stranding Data

I analyzed data from dependent (N=72) and weaned (N=10) harbor seal pups that stranded in Maine and were originally admitted to rehabilitation at Marine Mammals of Maine (MMoME) from 2016 to 2019. The majority of pups in Maine strand during the late spring and summer. Because a previous study found that bloodwork differs between seasons due to changes in foraging (Trumble et al. 2006), for this study, only pups that stranded between May and September were included.

For each seal, the initial observation date, findings of human interaction, date admitted to rehabilitation, straight length at admit, weight at admit, transfer facility, rehabilitation outcome, date died, and date released were extracted from the US Marine Mammal Health and Stranding Response Program's National Stranding Database. Blood chemistry and hematology data, as well as data on age class (dependent vs weaned pup), were further provided by MMoME. Because a previous study reported that the difference in bloodwork between male and female pups was not significantly related to survival (Witte et al. 2014), I did not consider sex in this study.

Data Analysis

To assess the role of multiple potential measures of marine mammal health that are evaluated at admit in determining rehabilitation success, I compared variation in the following explanatory variables to rehabilitation outcome using independent logistic regression analyses for continuous variables and contingency analyses for binary variables in the program JMP. Rehabilitation outcome was evaluated as a binary variable;

the "released" outcome was denoted as "1" and the "died" outcome was denoted as "0". Prior to each analysis, I identified outliers in all non-binary independent variables using a box and whisker plot and removed these outliers from the analysis. I also noted how many outliers were identified for each blood parameter and compared the number of outliers between rehab outcome groups.

<u>Explanatory Variables (N, sample size after outliers were removed)</u>

- *Day of year first observed (N = 98).* The date that each seal was first observed in the field was converted to a day of the year (1 through 365) using the formula (month/day/year)-DATE(YEAR(month/day/year),1,1)+1 in Excel. This analysis was done with all individuals and then, to account for the different time spans dependent and weaned pups are present in one season, by age class.
- *Time observed in the field before collection (N = 100).* The observation date was subtracted from the date admitted to rehabilitation to analyze the amount of time they were observed in the field before being collected.
- *Human interaction (N = 85).* Findings of human interaction were denoted as "1" if Yes and "0" if No. "Cannot be determined" cases were excluded. Human interaction is direct or indirect contact from a human to a seal, including boat collision, gunshot, fishery interaction (i.e. entanglement), unauthorized relocation or collection, physical touch, or harassment by humans or dogs.
- *Age class (N = 95).* Dependent pups were denoted as "0" and weaned pups were denoted as "1". Harbor seal pups are nursed by their mothers for 4-6 weeks, after this stage has ended, they are known as weaned pups. At MMoME, both dependent and weaned pups were not with their mothers.

- *Weight:Length ratio (N = 105).* Weight and straight length at admit were used to find the weight:length ratio at admit for each seal. The weight:length ratio is often used throughout the rehabilitation process as a measure of general body condition.
- *Bloodwork*. I analyzed 43 blood parameters (Table 1) that are measured in-house at MMoME using a LaserCycte and CatalystOne. For each blood parameter, outliers were compared by whether they belonged to a seal who was released or one that died. Bloodwork is taken throughout the rehabilitation process to assess health and create a treatment plan for each patient.

Table 1. Blood parameters and sample size.

Parameter	**Sample Size**
Red Blood Cells (RBC)	107
Hematocrit	106
Hemoglobin	101
Mean Corpuscular Volume (MCV)	107
Mean Corpuscular Hemoglobin (MCH)	99
Mean Corpuscular Hemoglobin Concentration (MCHC)	69
Red Cell Distribution Width (RDW)	103
% Reticulocytes	95
Reticulocytes	97
White Blood Cells (WBC)	105
% Neutrophils	105
% Lymphocytes	107
% Monocytes	110
% Eosinophils	105
% Basophils	106
Neutrophils	105
Lymphocytes	103
Monocytes	107
Eosinophils	103
Basophils	106
Platelets	108
Platelet Distribution Width (PDW)	103
Mean Platelet Volume (MPV)	104
Plateletcrit	102
Glucose	100
Creatinine	101
Blood Urea Nitrogen (BUN)	102
Blood Urea Nitrogen:Creatinine Ratio	96
Phosphorus (P)	91
Calcium (Ca)	97
Sodium (Na)	97
Potassium (K)	102
Sodium:Potassium Ratio	102
Chlorine (Cl)	99
Total Protein	102
Albumin	107
Globulin	105
Albumin:Globulin Ratio	106
Alanine Aminotransferase (ALT)	104
Alkaline Phosphatase (ALKP)	106
Gamma-Glutamyl Transpeptidase (GGT)	88
Total Bilirubin	90
Cholesterol	95

- *Transferred to other rehabilitation facility (N = 98).* If the seal was transferred to another facility (Mystic Aquarium or National Marine Life Center) besides MMoME during the rehabilitation process that was denoted as “1”, and if not, that was denoted at “0”. Only seals that survived long enough (4 days) to be considered long-term patients were included in this analysis.
- *Time spent in rehabilitation (N = 72).* I converted the date each seal was admitted to rehabilitation and either the day they died or were released to a day of the year and subtracted the former from the latter to assess the time spent in rehabilitation.

RESULTS

The day of the year an individual was first observed, the time they were observed in the field before collection, and findings of human interaction are all variables that describe what occurred in the field. Of these variables, only the day of the year first observed was significantly correlated with rehabilitation outcome ($p=0.04747$, $R^2=0.0308$), with pups stranding later in the year having a high probability of rehabilitation success (Figure 1). Although not statistically significant, dependent pups had a greater likelihood of being released if they strand later in the year ($p=0.2217$) (Fig. 2). Weaned pups that strand earlier in the year were significantly more likely to be released ($p<0.001$) (Fig. 3). Time observed in the field before collection ($p=0.25$) and findings of human interaction ($p=0.79$) did not significantly affect a pup's likelihood of being released (Appendix A).

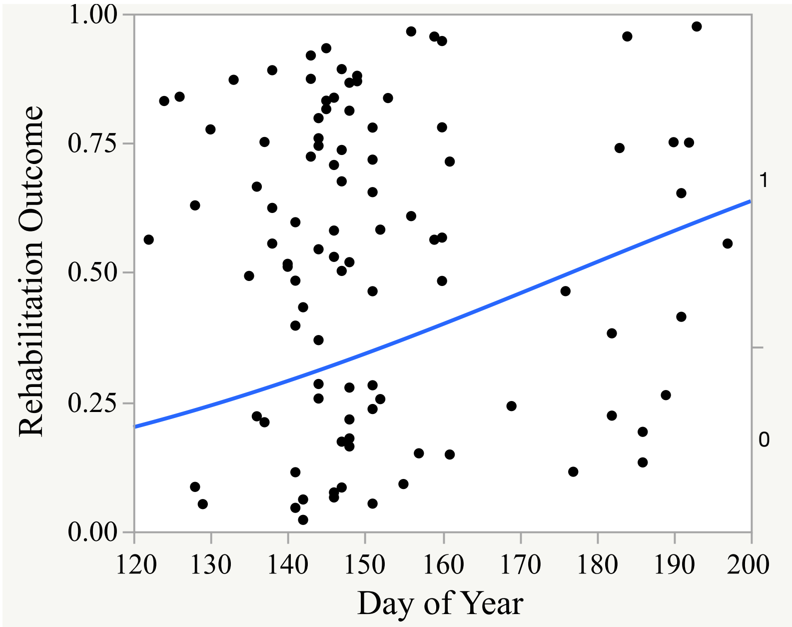

Figure 1. Rehabilitation outcome (0=died, 1=released) as a function of the day of the year all harbor seal pups were first observed stranded. Day 120 is April 30th and day 200 is July 19th. Each point represents the predicted probability of being released if a seal stranded on that day of the year. The blue line represents the logistic curve.

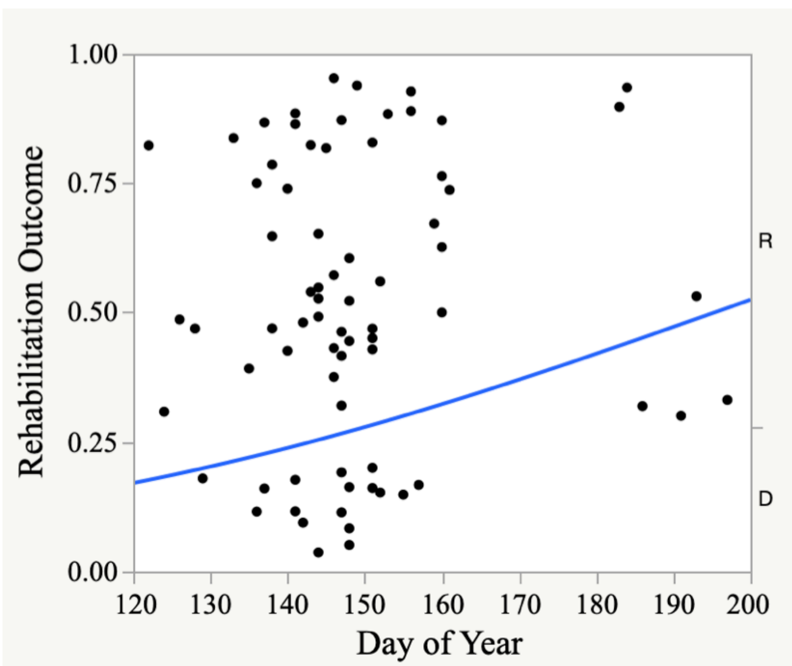

Figure 2. Rehabilitation outcome (0=died, 1=released) as a function of the day of the year only dependent harbor seal pups were first observed stranded. Day 120 is April 30th and day 200 is July 19th. Each point represents the predicted probability of being released if a seal stranded on that day of the year. The blue line represents the logistic curve.

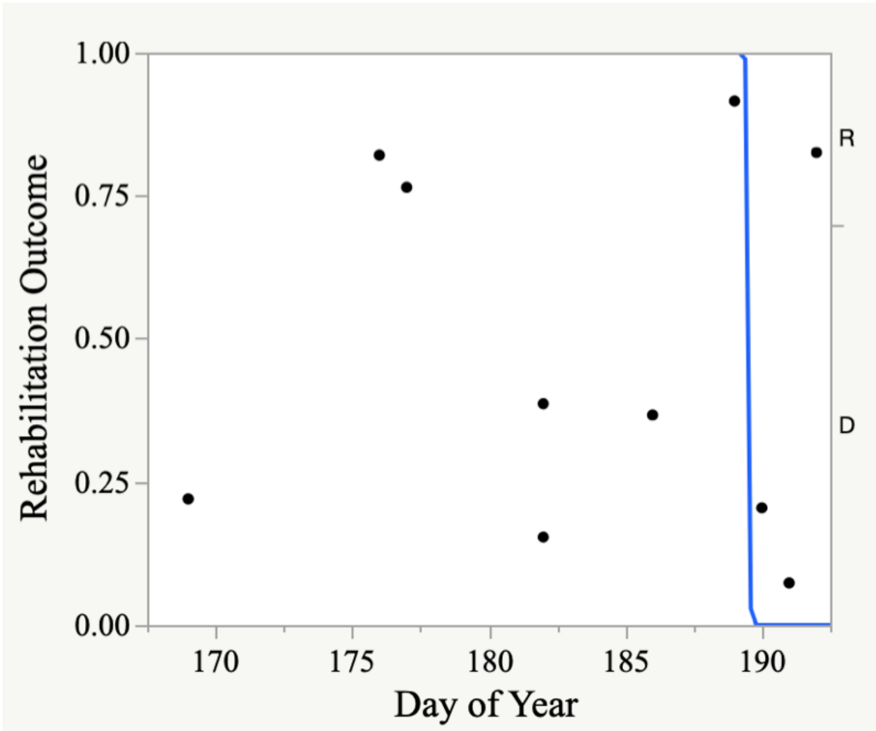

Figure 3. Rehabilitation outcome (0=died, 1=released) as a function of the day of the year only weaned harbor seal pus were first observed stranded. Day 120 is April 30th and day 200 is July 19th. Each point represents the predicted probability of being released if a seal stranded on that day of the year. The blue line represents the logistic curve.

Time spent in rehabilitation and whether or not an individual was transferred from MMoME to another facility are variables that pertain to the rehabilitation process. Both time spent in rehabilitation ($p<0.0001$, $R^2=1$) and whether or not an individual was transferred ($p=0.0355$, $R^2=0.0372$) were found to be significantly correlated with rehabilitation outcome. The longer an individual is in rehabilitation, the less likely they are to be released (Fig. 4). Harbor seal pups that were transferred from MMoME to another rehabilitation facility had a greater likelihood of being released (Fig. 5).

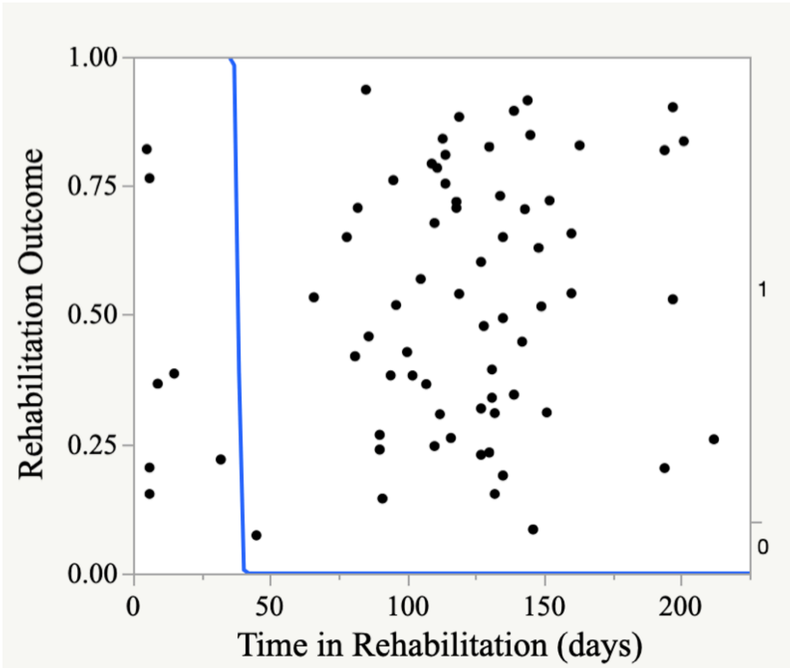

Figure 4. Rehabilitation outcome (0=died, 1=released) as a function of days spent in rehabilitation, from admit to release or death. Each point represents the predicted probability of being released if a pup spent that many days in rehabilitation. The blue line represents the logistic curve.

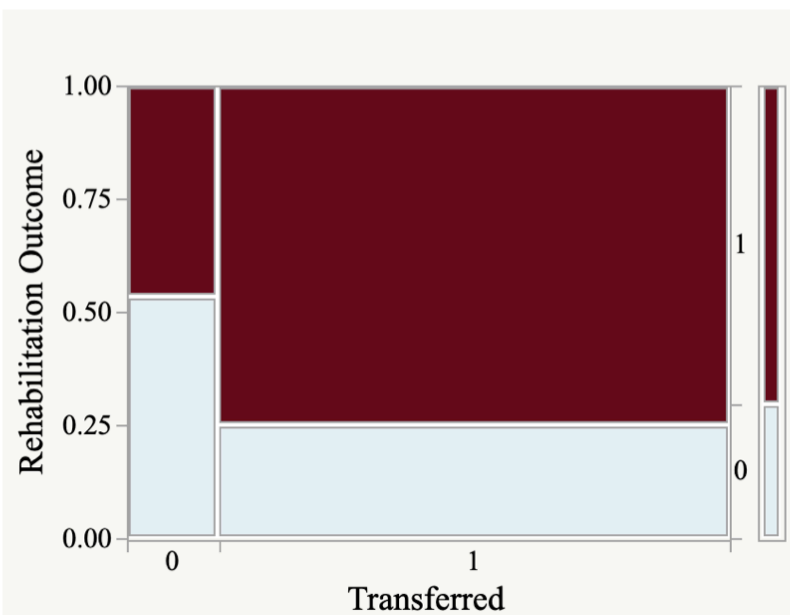

Figure 5. Rehabilitation outcome (0=died, 1=released) as a function of whether or not an individual was transferred (0=not transferred, 1=transferred). The size of each box corresponds to the proportion of individuals in that category.

Age class, weight:length ratio, and bloodwork are variables related to physiological characteristics of the seals in this study. Age class (p=0.0126, R^2=0.0503), lymphocytes ($p<0.001$, $R^2=0.0907$), and total protein ($p<0.0238$, $R^2=0.0379$) were found to be significantly correlated with rehabilitation outcome. Harbor seals that stranded when they were dependent pups were more likely to be released than pups that were weaned when they stranded (Fig. 6). Harbor seal pups were more likely to have a successful rehabilitation if their lymphocyte count at admit was lower (Fig. 7) and their total protein at admit was higher (Fig. 8). Weight:length ratio ($p=0.73$) and other bloodwork parameters were not significant (Appendix A, Appendix B).

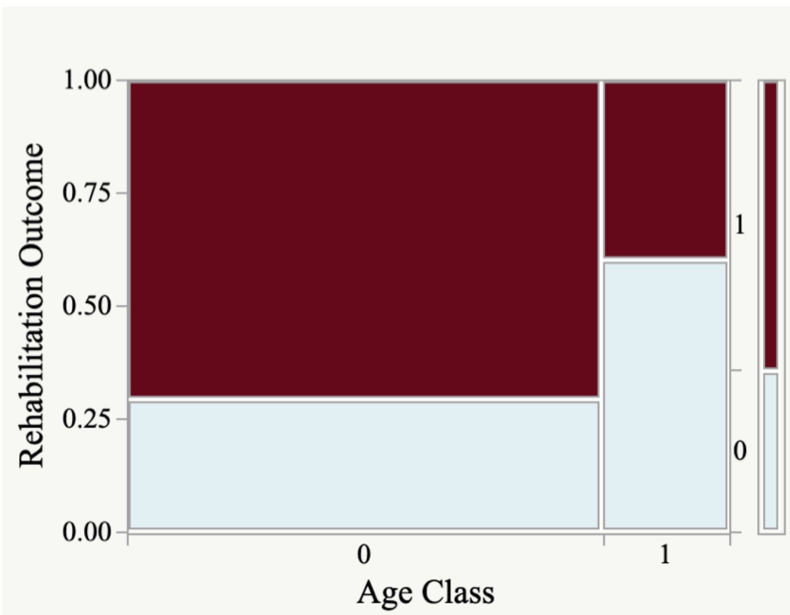

Figure 6. Rehabilitation outcome (0=died, 1=released) as a function of age class (0=dependent pup, 1=weanling). The size of each box corresponds to the proportion of individuals in that category.

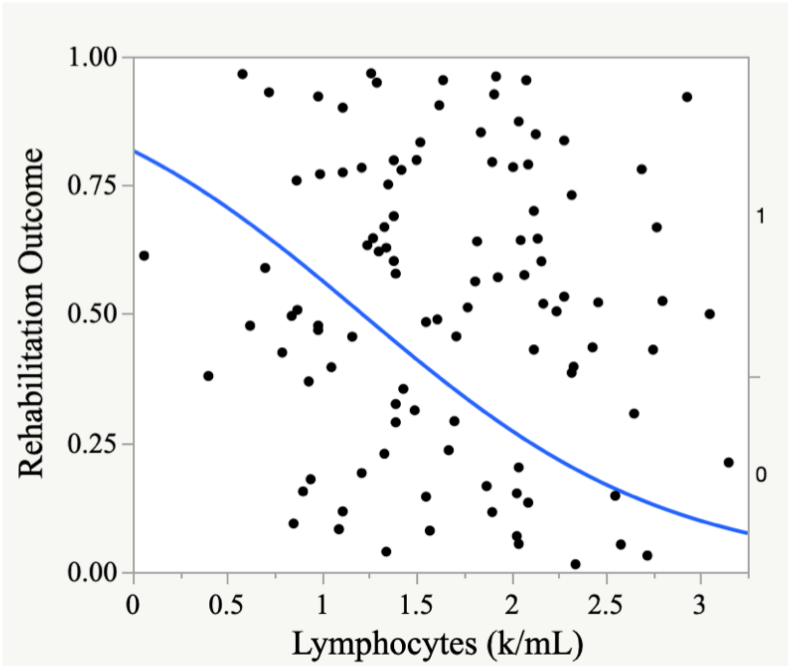

Figure 7. Rehabilitation outcome (0=died, 1=released) as a function of lymphocyte concentration (k/mL). Each point represents the predicted probability of being released if a pup has that concentration of lymphocytes. The blue line represents the logistic curve.

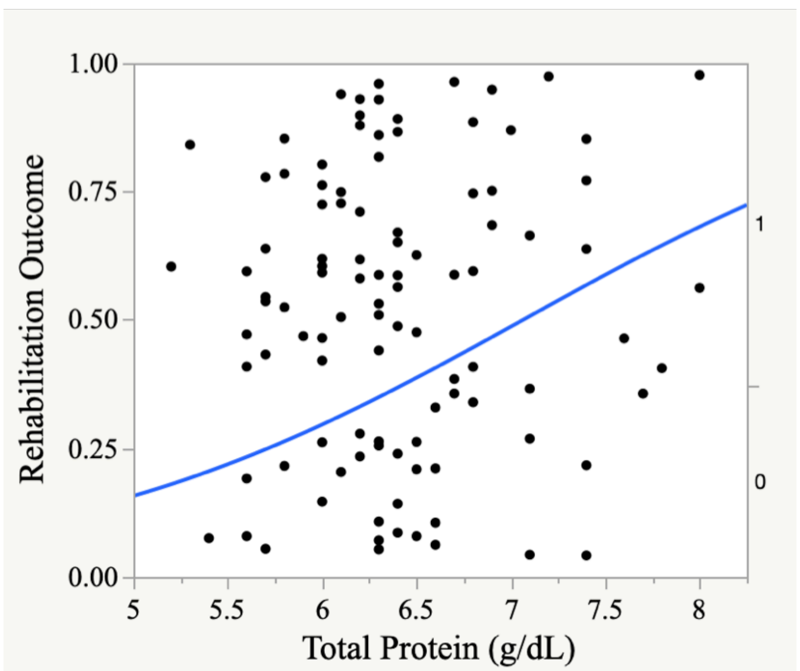

Figure 8. Rehabilitation outcome (0=died, 1=released) as a function of total protein concentration (g/dL). Each point represents the predicted probability of being released if a pup has that concentration of total protein. The blue line represents the logistic curve.

Albumin, the albumin:globulin ratio, % monocytes, and Ca did not have outliers. Blood parameters where extreme values were more often observed in animals that died were % reticulocytes, basophils, hematocrit, MPV, Na/K, neutrophils, platelets, plateletcrit, RBC, reticulocytes, and WBC (Fig. 9). Blood parameters where extreme values were more often observed in animals that were released were % eosinophils, % lymphocytes, % neutrophils, ALT, BUN, cholesterol, Cl, creatinine, GGT, globulin, glucose, hemoglobin, K, lymphocytes, MCH, MCHC, monocytes, Na, P, and total bilirubin (Fig. 9). Blood parameters that had a similar number of outliers that belonged to pups that died and were released were the BUN:creatinine ratio, % basophils, eosinophils, MCV, osmolality, PDW, RDW, and total protein (Fig. 9).

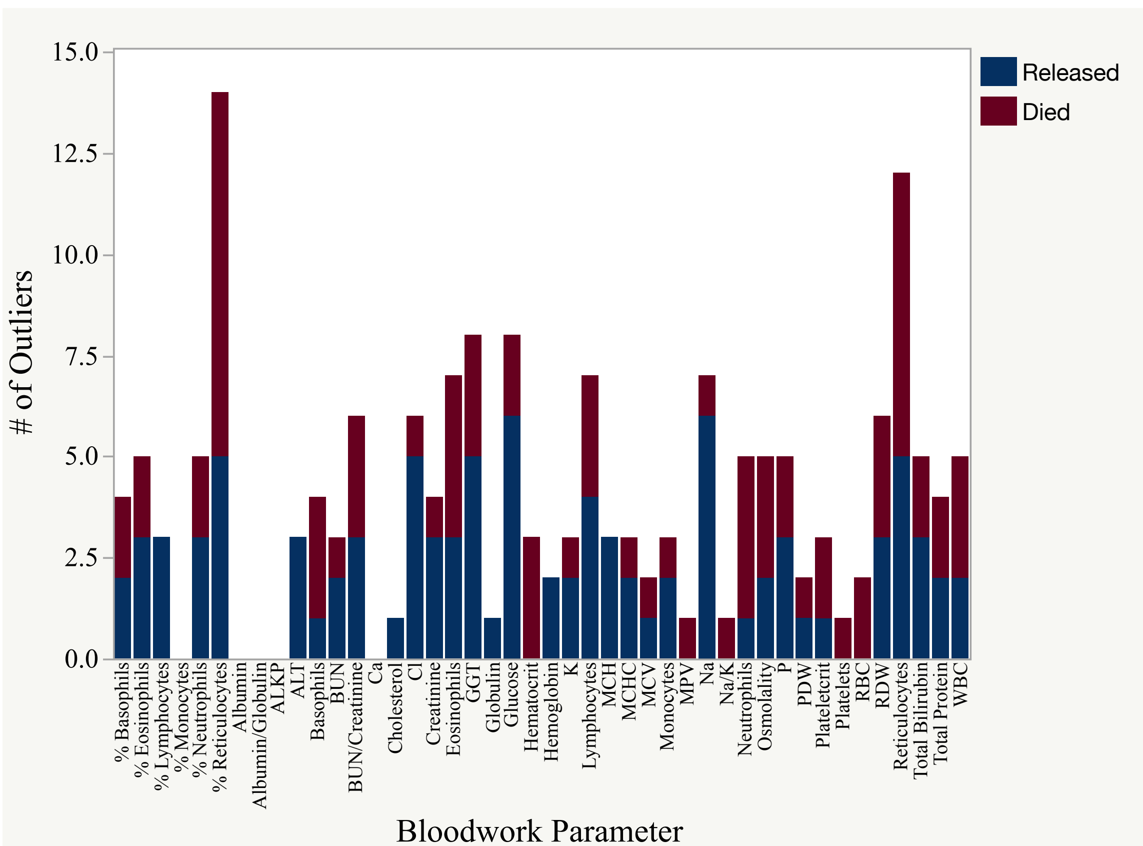

Figure 9. Stacked bar chart comparing the number of outliers between pups that were released and those that died for each blood parameter.

DISCUSSION

The objectives of this study were to compare certain health measures and rehabilitation variables that are taken at admit to determine their relationship with rehabilitation success. The ultimate goal was to determine if rehabilitation outcome can be predicted at admit. The variables that were significantly correlated with rehabilitation outcome were the day of the year first observed, whether or not an individual was transferred from MMoME, time spent in rehabilitation, and age class. Two bloodwork parameters were significantly correlated with rehabilitation success: lymphocytes and total protein. Time observed in the field before collection, findings of human interaction, and weight:length ratio were not significantly correlated with rehabilitation outcome.

Pups that were observed stranded later in the summer were found to have an increased probability of rehabilitation success (Fig. 1). The trend in this analysis mainly came from the dependent pups that were included. Dependent pups that stranded later on in the year were more likely to be released (Fig. 2). This is consistent with a study on harbor seal pups in the German North Sea. They found that if a pup was going to die, they were most likely to die within ten to twenty days after their birth (Witte et al. 2014). Pups that strand earlier in the season are usually younger and can even be premature. Weaned pups were significantly more likely to be released if they stranded earlier in the year (Fig. 3), however, the sample size for this analysis was very small, being only 10 individuals. Weaned pups may have been more likely to be released if they stranded earlier in the year because they were still young and had not been in the wild, and exposed to environmental threats, for as long. This explanation is also in agreement with the age class analysis that was done in this study, which suggested that dependent pups had a higher likelihood of rehabilitation success.

I found that dependent pups were more likely to be released than weaned pups. Pups are weaned after an average of 32 days (Cottrel et al. 2006), so pups that strand later on in the season are usually weaned. However, this analysis found that weaned pups have a greater probability of dying in rehabilitation. Studies from San Juan County, WA and the Netherlands found the main cause of death for dependent harbor seal pups was malnutrition and emaciation (Ashley et al. 2020, Osinga et al. 2012). Weaned pups' main cause of death was malnutrition, infection, or trauma (Ashley et al. 2020). The treatment of pups suffering from malnutrition and emaciation may be easier than those with infection and trauma because the former mainly require food and rehydration whereas the latter require more intense medical treatment. Weaned pups may also have been exposed to more environmental threats during their longer lifetimes in the wild, which is why they are more prone to illness and injury.

Similar to many other studies that have reported that bloodwork at admit is not a good predictor of rehabilitation outcome (Frouin et al. 2013, Witte et al. 2014, Greig et al. 2010, Marrie and Gaydos, 2007), I found little to no association between most bloodwork parameters and rehabilitation success. Bloodwork values at admit may instead reflect life history or cause of stranding; for example, Morgan et al. (2009) found that dependent and weaned pups had different bloodwork at admit. The only exceptions in my analysis were lymphocytes and total protein, which had a statistically significant relationship with rehabilitation outcome.

Pups that had a higher total protein concentration were more likely to be released (Fig. 8). The range of total protein from my data (5.2-8 g/dL) was consistent with the reference values established by Greig et al. (2010) (5.2-8.9 g/dL) and Trumble and Castellini (2002) (5.0-8.2 g/dL). Higher than normal total protein is an indicator of dehydration and chronic illness, where lower than normal total protein is an indicator of malnutrition and liver damage (Bossart et al. 2001). A study of rehabilitated harbor seal pups from Vancouver Aquarium found that emaciated pups had lower total protein concentrations than those that were moderately malnourished (Frouin et al. 2013). Pups that are dehydrated may be easier to treat than those that have an extreme nutrition deficiency and/or liver damage.

Pups with a lower lymphocyte concentration were more likely to be released (Fig. 7). A comparison between lymphocyte concentration in this study and previous studies cannot be made because the reference values established for lymphocytes were not in the same units. Lymphocytes are a part of the immune system, involved in antigen response, and will increase due to stress and infection (Latimer, 2011). Pups with a higher lymphocyte concentration may have had a more severe response to stranding, and/or were fighting an infection around the same time. Lymphocyte count has also been found to decrease with age (Latimer, 2011). The animals that did have a lower lymphocyte concentration may have been older and more mature.

The bloodwork outliers analysis had a small sample size, so it is difficult to draw conclusions, however there may be value in considering the trends observed. For sodium, all of the extreme values were higher than the average, and six out of seven of those pups were released. High sodium levels are a sign of dehydration, and early detection of this may increase the probability of a successful rehabilitation (Frouin et al. 2013).

For two of the variables tested in this study, whether or not an individual was transferred from MMoME to another facility and time spent in rehabilitation, there is very little previous research indicating a gap in knowledge. Pups are transferred from MMoME to NMLC or the Mystic Aquarium when MMoME's rehabilitation facility is full. When compared to rehabilitation outcome, pups that were transferred were more likely to be released (Fig. 5). I am not sure how MMoME chooses which seals are transferred, but I would guess that they may select those that are healthier and who they think will survive the trip to another facility. The drive from MMoME to NMLC or Mystic is at least three to four hours, so the seals have to be stable enough to be able to survive the car ride without extra care.

Pups that spent around 45 days or less in rehabilitation were found to be more likely to have a successful rehabilitation resulting in release (Fig. 4). With the average weaning time for harbor seal pups being 32 days (Cottrel et al. 2006), I suspect that the majority of these pups were admitted as dependent pups who were malnourished or dehydrated. These pups would have needed to gain enough weight and mature enough so that they are able to survive in the wild on their own. If there were little to no other illness or injury present, their treatment plan would be relatively simple, and the animals should be able to be released soon after they are weaned. It would make sense that those individuals that enter rehab due to a serious injury or illness would take longer to recover and have lower likelihood of success.

The weight:length ratio at admit was not significantly correlated with rehabilitation outcome. This contradicts previous studies that found a higher weight:length ratio to be a good predictor of rehabilitation success (Witte et al. 2014, Marrie and Gaydos, 2007). My data showed the opposite trend, though not significant (Appendix 1). Other studies have also reported that high body mass at release is important in predicting survival in the wild (Greig et al. 2019, Frouin et al. 2013). The extra body mass may act as an important energy store during the time that rehabilitated pups need to learn how to forage for food in the wild (Greig et al. 2019). In this study, pups that were more likely to be released were dependent pups. One of this group's main causes of stranding is emaciation. If it is true that the dependent pups that were emaciated were more likely to survive, that would explain why the pups with a lower weight:length ratio had a higher likelihood of rehabilitation success. The results of this analysis may also not have been found significant because a majority of the pups in this study were dependent pups and there may have been a small range of weight:length ratios.

Evidence of human interaction was also not found to be a good predictor of rehabilitation success. The types of human interaction included in this study were harassment, touching/picking up, boat collisions, gunshots, or a fishery interaction such as entanglement. All of these behaviors are examples of direct interaction between humans and protected wildlife. It would be interesting to see how indirect human interaction, such as pollution and contamination, affects stranded harbor seals in the northwest Atlantic. A study on Pacific harbor seals found that weaned pups that were admitted to rehabilitation had similar blood contaminant levels to adult harbor seals, and weanlings with higher contaminant levels were less likely to have a successful rehabilitation (Greig, 2011). These high contaminant levels could be another reason why weaned pups had a lower likelihood of release than dependent pups.

There were a few limitations to this study. One being that MMoME's definition of a pup was different from the definition from the US Marine Mammal Health and Stranding Response Program's National Stranding Database. While MMoME separated dependent pups and weanlings, the National Stranding Database grouped them together as one age class. I also noted some inconsistencies in the age class designations, with a few pups listed as dependent despite stranding later in the season when most pups were categorized as weanlings. This made it difficult to determine whether the analyses should have been further separated by age class. In addition to this, not all of the data collected were consistent for all individuals in the sample population, resulting in differing sample sizes between the analyses. If I were to perform this study again, I would like to confirm age class designations with MMoME and perform each analysis by age class, separating dependent and weaned pups.

There were also other research questions I became interested in after examining the results of this study. First, I would like to know how causes of stranding, such as emaciation, illness, and injury affect rehabilitation success. Changes in bloodwork, weight:length ratio, medication, and feeding would also be interesting to assess in relation to outcome. Finally, I would like to research levels of contamination and pollution that harbor seals are exposed to at admit and how that impacts rehabilitation success.

The findings of this study can be useful for rehabilitation organizations to consider when there is limited space or resources for patients. Dependent pups and those that strand earlier in the year are most likely to have a successful rehabilitation. It would be important to verify that pups that are emaciated and malnourished at admit are more likely to be released than those that are admitted with a serious illness or injury so that these results can be used to prioritize certain patients if needed. This study also reenforced the idea that harbor seals of different age classes are physiologically different and that should be taken into account. From an ecological perspective, pups that are admitted to rehabilitation after spending more time in the wild are less likely to be released. This indicates that there is something in the wild that is causing more serious health problems for harbor seals. It is important that we research what is causing these strandings that ultimately lead to death, because what could be harming seals will most likely have negative effects on the rest of the coastal ecosystem.

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APPENDICES

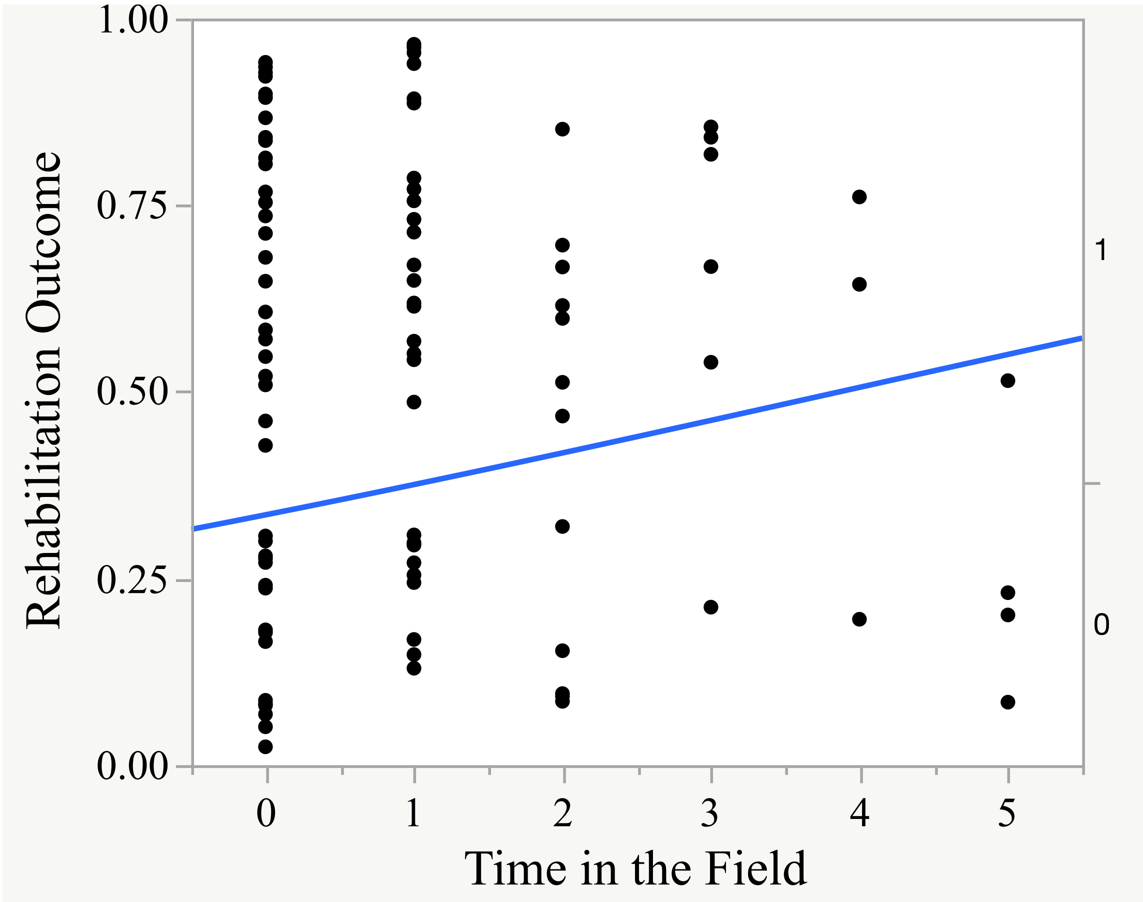

Figure 10. Rehabilitation outcome (0=died, 1=released) as a function of the amount of days monitored in the field before being transported to MMoME. Each point represents the predicted probability of being released if a pup spent that amount of time in the field before collection. The blue line represents the logistic curve.

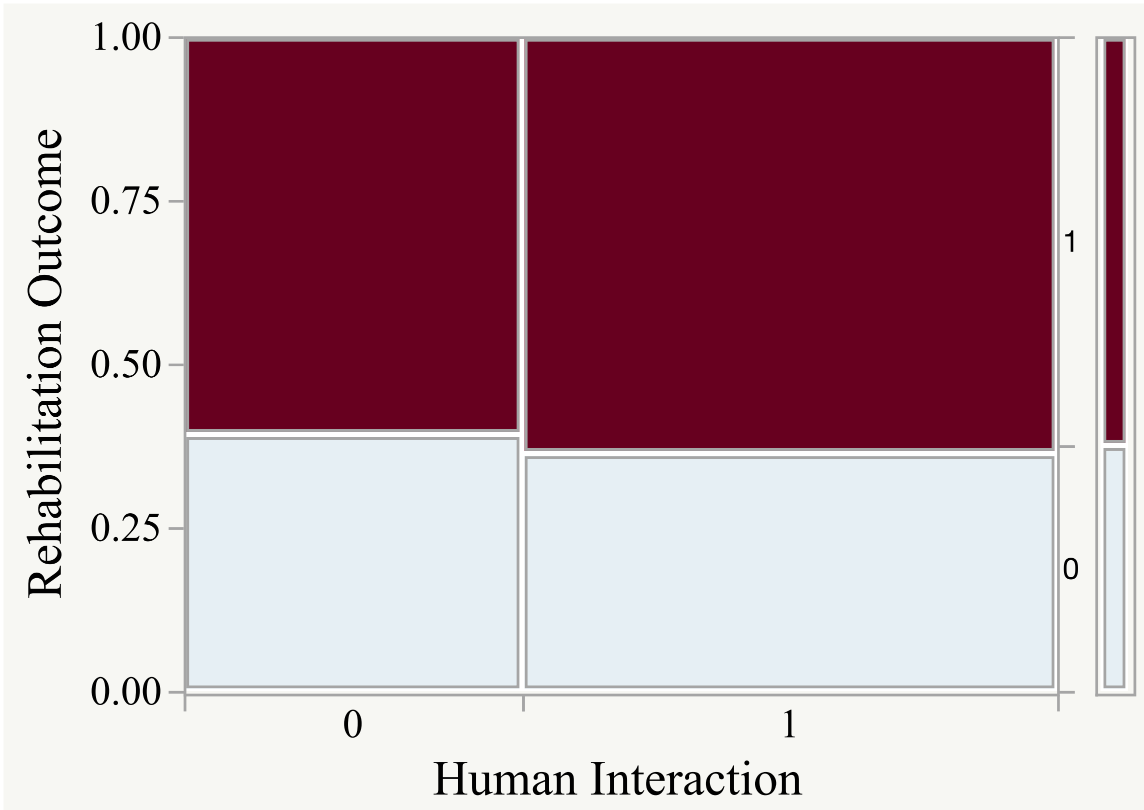

Figure 11. Rehabilitation outcome (0=died, 1=released) as a function of findings of human interaction (0=no, 1=yes). The size of each box corresponds to the proportion of individuals in that category.

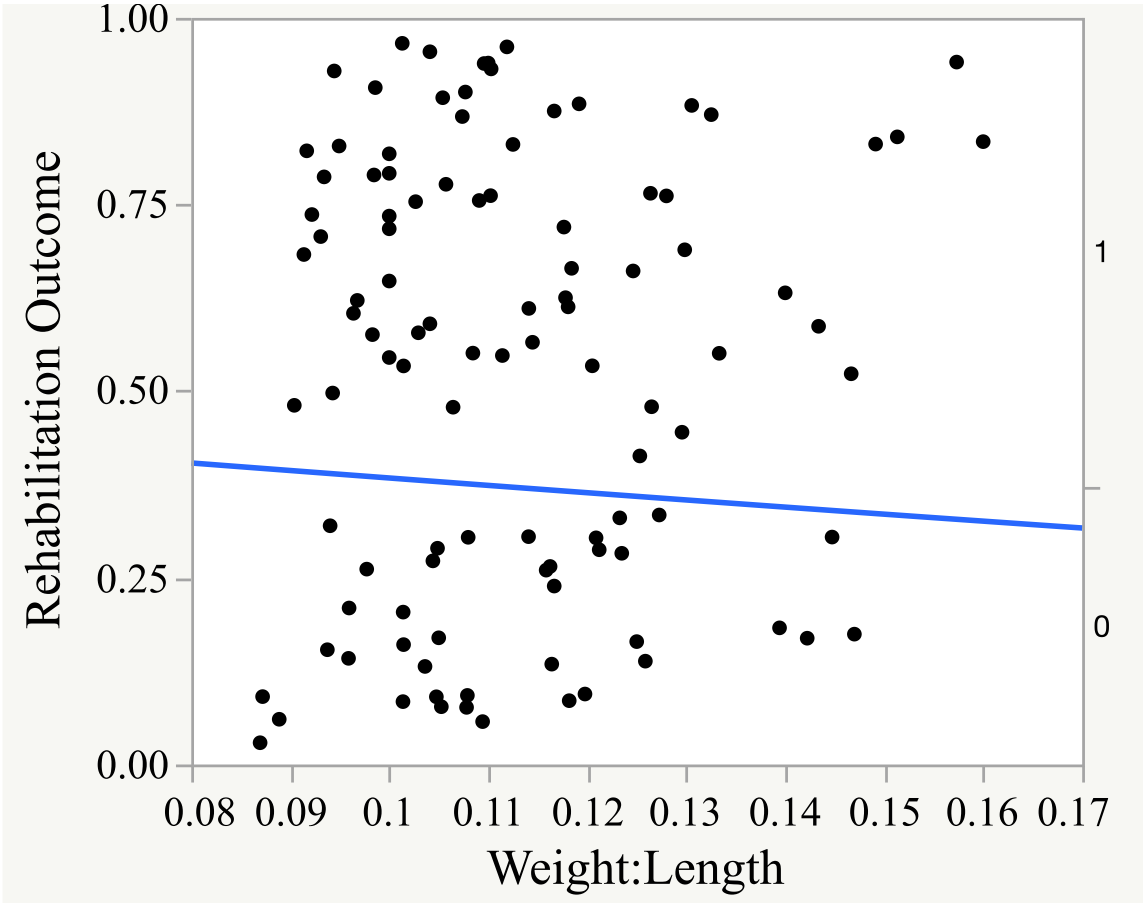

Figure 12. Rehabilitation outcome (0=died, 1=released) as a function of weight:length ratio at admit. Weight was measure in kilograms and straight length was measured in centimeters. Each point represents the predicted probability of being released if a pup had that weight:length ratio at admit. The blue line represents the logistic curve.

APPENDIX B: ADDITIONAL TABLES

Table 2. P-values of logistic regression analyses for each bloodwork parameter compared to rehabilitation outcome.

Parameter	P-Value
RBC	0.4551
Hematocrit	0.3483
Hemoglobin	0.5281
MCV	0.3562
MCH	0.2966
MCHC	0.0949
RDW	0.975
% Reticulocytes	0.8782
Reticulocytes	0.5224
WBC	0.3518
% Neutrophils	0.3456
% Lymphocytes	0.264
% Monocytes	0.4001
% Eosinophils	0.5925
% Basophils	0.2306
Neutrophils	0.4195
Lymphocytes	0.0004
Monocytes	0.3808
Eosinophils	0.5002
Basophils	0.3735
Platelets	0.1296
PDW	0.7964
MPV	0.0599
Plateletcrit	0.4969
Glucose	0.893
Creatinine	0.7208
BUN	0.6419
Blood Urea Nitrogen:Creatinine Ratio	0.7281
Phosphorus	0.994

Table 2. (continued)

Calcium	0.7379
Sodium	0.762
Potassium	0.5689
Sodium:Potassium Ratio	0.5508
Chlorine	0.8917
Total Protein	0.0238
Albumin	0.7002
Globulin	0.1083
Albumin:Globulin Ratio	0.8684
ALT	0.2581
ALKP	0.5669
GGT	0.3987
Total Bilirubin	0.5821
Cholesterol	0.6225
Osmolality	0.7824

AUTHOR'S BIOGRAPHY

Shannon R. Brown was born on August 30, 1999 in Melrose, Massachusetts and graduated from Medford High School in 2017. Shannon is expecting to graduate from the University of Maine in 2021, majoring in marine science with a concentration in marine biology. During her time at UMaine, she was a student research assistant in the Cammen Lab and a member of Dance Club, Hip Hop Club, and UMaine Undergraduate Women in STEMM. In the summer of 2019, Shannon interned at the National Marine Life Center and in the fall of 2020, she was an intern at the New England Aquarium. After graduation, Shannon hopes to pursue a career in marine mammal health and conservation.