Fish Introduction to Jaguars (*Panthera onca*): Response of Zoo Visitors and Jaguars

A Thesis
Presented to
The Academic Faculty

by

Erin McDole

In Partial Fulfillment
of the Requirements for the Degree
Masters of Science in Psychology

Georgia Institute of Technology
May 2007

Fish Introduction to Jaguars (*Panthera onca*): Response of Zoo Visitors and Jaguars

Approved by:

Dr. Terry L. Maple, Advisor
School of Psychology
Georgia Institute of Technology

Dr. Mollie Bloomsmith
School of Psychology
Georgia Institute of Technology

Dr. M. Jackson Marr
School of Psychology
Georgia Institute of Technology

Date Approved: April 5, 2007

ACKNOWLEDGEMENTS

I would like to thank my husband for his support and help with this project! Thank you to my committee for your insightful comments. To the folks of Palm Beach Zoo, Keith Lovett, Amanda Haug, Dave Quavillon, and Jenn Loveless, thank you for making this project possible. Thank you Karen, Rachel, and Stephanie for the many hours you volunteered!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF SYMBOLS AND ABBREVIATIONS

EZ	Edinburgh Zoo
IV	In View
OV	Out of View
PBZ	Palm Beach Zoo
ZA	Zoo Atlanta

SUMMARY

In this study, zoo visitor response to live prey feeding and jaguar response to dead fish feeding were analyzed. Four hundred visitors at Zoo Atlanta and four hundred visitors at Palm Beach Zoo were asked about their attitudes toward feeding live prey to zoo carnivores. Agreement rates were found to be high. Agreement rates at Zoo Atlanta and Palm Beach Zoo were both significantly higher for feeding live fish to penguins than at Edinburgh Zoo as reported in Ings et al. (1997). Zoo Atlanta also had a higher agreement rate for feeding live rabbits to cheetahs in view than Edinburgh Zoo. Both Zoo Atlanta and Palm Beach Zoo had lower agreement rates for feeding live insects to lizards out of view than Edinburgh Zoo.

Agreement rates for visitors at Palm Beach Zoo that saw a dead fish to jaguar introduction did not differ significantly from visitors that had not seen the introduction. However, at both US Zoos, agreement rate was higher for visitors that had seen a live prey introduction at a zoo or aquarium in the past. Agreement rate was significantly greater for feeding live fish to jaguars, mice to hawks, and rabbits to cheetahs in view. For Palm Beach Zoo agreement rate was also higher for feeding live rabbits to cheetahs out of view.

Stay time did not differ significantly between visitors at Palm Beach Zoo that saw and did not see a dead fish to jaguar introduction. Jaguar activity level, behavioral diversity, fecal corticoids, visibility, and percent time spent in water did not significantly differ between fish introduction and baseline.

INTRODUCTION

Maintenance of populations of endangered species in captivity has become an important conservation tool, as evidenced by the reintroduction of California condors and black-footed ferrets, in which captive born individuals are being used to re-establish formerly extinct populations (Seal, 1991). As the average species extinction rate is estimated to be 6% per year, a rate that is approximately 1,000 to 10,000 times the "normal" background extinction rate, the need for maintaining captive populations for reintroduction is only increasing (Wilson, 1992). In 1987, the World Conservation Union (IUCN) issued policies stating that captive propagation programs for species at risk need to be established and maintained for bolstering and restoring wild populations (IUCN, 1987a; IUCN, 1987b), and in the US, the Association of Zoological Parks and Aquaria (AZA) has implemented captive breeding programs for a large number of endangered species.

While maintaining genetic diversity has been the first concern in these programs, there is growing acknowledgement that preservation of natural behavior repertoires in captivity is necessary (IUCN, 1995; May, 1991; Miller, Biggins, Hanebury, and Vargas, 1994; Rabin, 2003; Shepherdson, 1994). With an effective breeding program and an adequate number of individuals, genetic diversity can be maintained for generations. Behavioral repertoires, however, can not be maintained in the same fashion and they degrade much more quickly (May, 1991). One option is to wait until a species requires reintroduction and then work intensively on re-establishing any needed behaviors. However, at the point where reintroduction is absolutely necessary, time is often short and the number of individuals available few (Seal, 1991). Those conditions are not ideal for implementing a new program to re-establish behaviors or to do research to determine what type of program would be effective. The solution is to start maintaining and re-establishing behaviors now. It is not an objective that will be realized quickly or without much creative thinking and redesigning, but if the stated goal is to conserve endangered species in captivity as a safety net against extinction then it is a necessary step (Markowitz, 1997).

When choosing what behaviors to focus initial effort on, the amount of time it will take to re-establish a behavior should be considered; if a behavior takes very little time to restore then a program dedicated to it could be initiated just prior to reintroduction, if however, a behavior takes generations then a program needs to initiated as soon as possible. Of the many types of behaviors, socially transmitted behaviors may require the most time as well as the most creativity and research. This is due to the unique role a skilled conspecific plays in learning these behaviors; for naïve individuals to learn the behavior it is necessary for a skilled conspecific to demonstrate it, and as behaviors degrade quickly in captivity compatible skilled conspecifics may be difficult to find (Box and Gibson, 1999; May, 1991). If a compatible skilled conspecific is not available then applicable stimuli, context, and contingencies may be successful in encouraging an approximation of the behavior that that individual could then demonstrate for other conspecifics and offspring (Griffin and Evans, 2003; Griffin, Evans, and Blumstein, 2001). Depending on the complexity of the behavior involved it may take generations of increasingly close approximations to restore a behavior to full functionality.

In addressing how we develop programs to re-establish behaviors in captivity, the field of environmental enrichment is a good starting point. Environmental enrichment has been used extensively to enhance the lives of captive animals, and in many cases has resulted in maintaining behavioral repertoires as well (Mellen and MacPhee, 2001). However, for this objective the aim of environmental enrichment is too broad, including apparatuses that are non-natural and are presented outside of the applicable biological context (Rabin, 2003). For the aims of behavioral maintenance, the stimuli need to be as close to that which would be encountered in nature as possible and the stimuli also need to be presented in the appropriate context. For example, hanging meat from swinging poles is an environmental enrichment strategy that successfully elicits elements of hunting behavior (Law, 1991). It would not, however, be successful in maintaining the behavioral repertoire of hunting as it is completely removed from any sort of natural context; the animal knows no more about how to dispatch prey or what prey looks and acts like than it did before the encounter. Therefore it is important to delineate what type of environmental enrichment is being used; the term natural behavioral management (NBM) does this. NBM is a sub-area of environmental enrichment which is limited to species applicable stimuli that is presented in the appropriate context in order to elicit and maintain a behavior (Rabin, 2003).

To return to the above example, hunting has been shown to be socially transmitted behavior in a number of different species, including felids, killer whales, and black-footed ferrets (Kitchener, 1999; Rendell and Whitehead, 2001; Vargas and Anderson, 1998). The only definitive way to maintain the socially transmitted behavior of hunting would be to allow predators to interact with live prey; by doing so, unskilled animals will be able to learn how to catch and kill prey, and skilled animals will be able to maintain their behaviors and demonstrate for their offspring or other compatible conspecifics. Zoos, however, are first a business, and as such are dependent on their visitors for support. This necessitates that the visitors' opinions be asked, and wherever possible information be provided to them on the importance of maintaining behavioral repertoires. It is this researcher's belief that such efforts will increase visitor understanding and appreciation for the animals kept within a zoo.

Zoo Visitor Response

Zoo visitor opinion of live feeding has been surveyed in the Edinburgh Zoo in the United Kingdom, but not in the US (Ings, Waran, and Young, 1997). Ironically, it is illegal in the UK to feed live prey to carnivores, yet the research has been carried out and agreement was fairly high. The researchers asked about three specific examples using the format, "Do you agree with live X being fed to Y in public view or out of public view?" The pairs used and the agreement rates found are: live insects to lizards, with a 96% agreement rate for in public view and a 100% agreement rate for out of public view: live fish to penguins, with a 72% agreement rate for in public view and a 84.5% agreement rate for out of public view: and live rabbits to cheetahs, with a 32% agreement rate for in public view and a 62.5% agreement rate for out of public view.

The US does not have a law against live prey introduction, and as part of enrichment research live fish has been given to fishing cats, Asian small-clawed river otters, and tigers (Bashaw, Bloomsmith, Marr, and Maple, 2003; Foster-Turley and

Markowitz, 1982; Shepherdson, Carlstead, Mellen, and Seidensticker, 1993). In this paper, we gave a modified version of Ings et al.'s (1997) survey to zoo visitors at two US zoos, Zoo Atlanta and Palm Beach Zoo, in order to compare agreement rates in the US with those in the UK (See Appendix G). It is hypothesized that visitor agreement rates with live prey introduction in the US will be higher than those in the UK due to greater general acceptance reflected in current law.

In Ings et al (1997) the questions are all compound sentences (i.e. "…in public view or out of public view?"). To facilitate understanding, I broke each question into two questions, "…in public view. How about out of public view?". I added a fourth and fifth prey-predator pair, feeding fish to jaguars and feeding mice to hawks, and changed the dichotomous answer options to a six point Likert scale.

An additional variable of interest is whether the zoo visitors have seen a prey-predator interaction before. It is hypothesized that as this becomes more common, people will become used to it, and agreement rates will go up. This will be tested in two ways; by adding a question that directly assesses whether the visitor has seen a live prey introduction before and also by surveying zoo visitors after they have seen a live prey introduction. The question added will be, "Prior to today, have you ever seen a predator hunt and eat a prey animal, such as on TV or in a zoo?" and a follow up question will ask, "If yes, where?". The complete survey, including these two last questions, will then be giving to visitors are Palm Beach Zoo who have seen a fish introduction to the jaguars there. As it is possible that the visitors might stop at the exhibit while the fish are being introduced and not notice what is going on, an eleventh question will be added, "Did you see the jaguars interacting with the fish today?". Only those visitors who answer yes to this question will be included in the statistical analysis. To directly assess the visitor's opinion of the fish introduction two more questions were added, "If yes, is this something you would like to see again? If no, would you like to see it?" and "Why?". For a complete copy of this survey please see Appendix H.

Another measurement will assess whether visitor interest in the jaguar exhibit increases when the jaguars are interacting with the fish. This will be done by recording the length of time a visitor stays at the exhibit (stay time) for visitors that are present during a fish introduction and comparing those times to the stay times for visitors that are present at the exhibit when no fish is given. Based on research which found increased visitor interest when large felids were active compared to when they were inactive (Margulis, Hoyos, and Anderson, 2003), I hypothesize that average stay time will be longer for visitors that are present for the fish introduction compared to visitors that are present in the no fish condition.

Jaguar Response

Only two peer-reviewed studies with live fish introduction to non-domestic felines have been conducted, one with one subject and the other with two subjects (Bashaw et al., 2003; Shepherdson et al., 1993). In this experiment, we were hoping to use live fish, but due to the difficulty of finding parasite-free fish, we substituted dead fish that were placed in a moving stream to simulate the movement of live fish. As in Shepherdson et al. (1993), behavioral diversity and activity level were calculated to compare behaviors in the no fish condition (baseline) and the fish introduction condition (experimental). In addition, the percentage of time the jaguars spend visible to the public was calculated. I hypothesize that activity level, behavioral diversity, as measured by the Shannon Diversity Index, and percentage of time spent visible will be greater in the experimental condition than in the baseline condition.

Fish introduction may have additional beneficial effects on jaguars that are not measurable using behavioral observation only; therefore a physiological measure of stress will be measured as well using the fecal corticoids, cortisol and corticosterone (Broom and Johnson, 1993; Stoskopf and Gibbons, 1994). Corticoids are stress hormones which have been measured in number of different captive felid species using feces, serum, and urine (Brown, Wasser, Wildt, and Graham, 1994; Graham and Brown, 1996); results of corticoid analysis have not been published for jaguars, and the presence of a corticoid metabolite will be validated by the Endocrinology lab of the St. Louis Zoo. Of the possible biological samples which could be tested to ascertain corticoid levels, fecal matter is optimal as the majority of corticoids in felids is excreted in it (Graham and Brown, 1996). Additionally, fecal matter is also more easily attained and less invasive, and the results of fecal corticoid analysis can be more clearly interpreted as corticoid levels in feces are less affected by circadian rhythms (Graham and Brown, 1996).

Increased corticoids have been found in felids exposed to stressful husbandry practices (Carlstead, Brown, and Seidensticker, 1993) and translocation as short as 30 minutes (Dembiec, Snider, and Zanella, 2004), while decreased corticoids have been found in felids after their environment was enriched with branches (Carlstead et al., 1993). To this researcher's knowledge, urine or serum corticoid levels have not been directly compared to fecal corticoid levels in felids; they have, however, in brown capuchins where the researchers found a significantly decrease in both serum and fecal corticoid levels when capuchins were provided with two plastic toys or a foraging box (Boinski, Swing, Gross, and Davis, 1999). As fish introduction has been found to be enriching for felids (Bashaw et al., 2003; Shepherdon et al, 1993), I hypothesize that expressing this natural behavior will result in a decrease in fecal corticoid levels for experimental versus baseline conditions.

METHODS AND MATERIALS

Zoo visitors

Participants

Four hundred visitors at Zoo Atlanta and 408 visitors at the jaguar exhibit at the Palm Beach Zoo were surveyed. Of the surveyed participants at Palm Beach Zoo, 400 did not see the fish introduction and 8 did. No more than one person per group was sampled to maintain independence of the sample. Only people 18 years or older were surveyed. Stay times were recorded for 855 visitors to the jaguar exhibit at Palm Beach Zoo: 9 of these were between the hours of 9 and 10am and saw a fish to jaguar introduction, 181 of these were between 9 and 10am and did not see a fish to jaguar introduction, and 665 were between 10 and 11am and did not see a fish to jaguar introduction.

Apparatus and Materials

A clipboard and data sheets were used for survey and stay time data collection. A watch was used to measure stay times.

Procedure

Three versions of the surveys were piloted tested at Zoo Atlanta using a total of 90 participants. The first two surveys differed in wording and were given verbally. The piloting process was used to determine which wording was most easily understood. As participants did not differentiate between the two wordings, one was chosen to test in written format (See Appendix G). The three survey versions were equivocal in their results, so the data was pooled and used as part of the 400 person sample for Zoo Atlanta.

At Palm Beach zoo, two dependent variables were recorded for zoo visitors; answers to the selected survey and length of stay at the exhibit (stay time). Unlike at the Zoo Atlanta location, at the Palm Beach Zoo an independent variable was manipulated; the introduction of fish into the jaguar's pool. Both dependent variables, survey answers and stay time, were be measured in a no fish condition (the baseline phase) and in the fish condition (the experimental phase) with time of day controlled. Exhibit exit and entrance points used to determine stay time were standardized across participants (See Figure 2.1), and surveys were only given to visitors after they exited the exhibit to avoid biasing stay time.

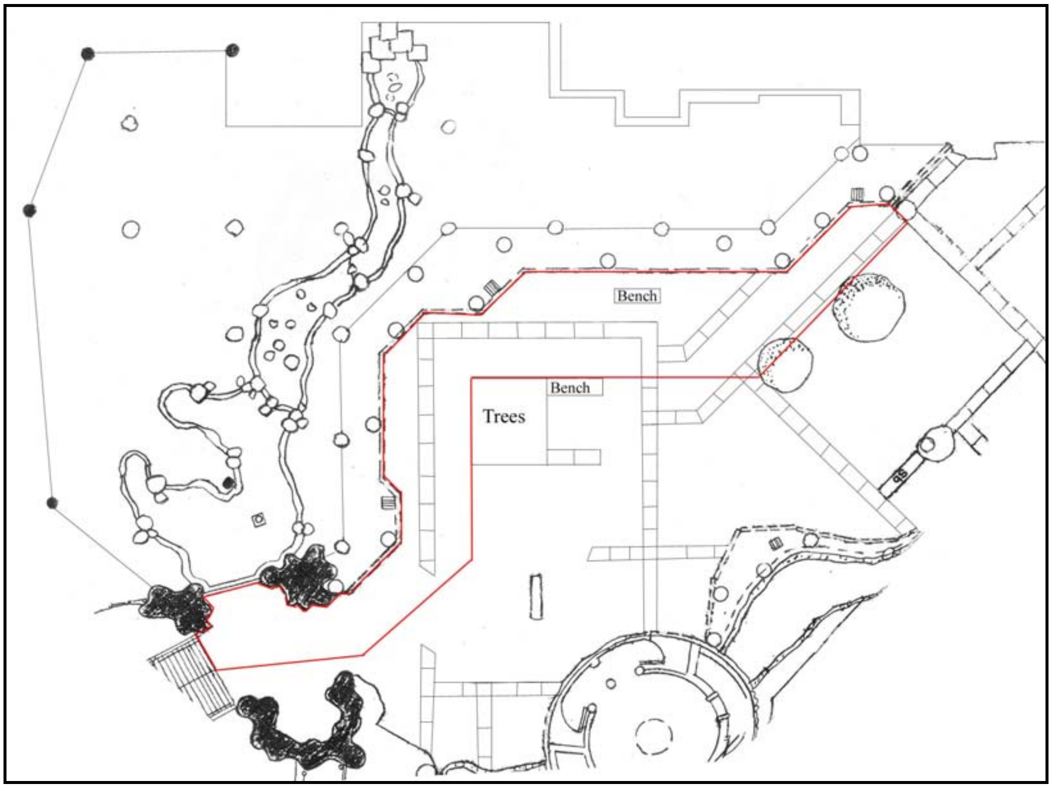

Figure 2.1: Diagram of the jaguar exhibit and surrounding area. The space enclosed by the red lines is the area defined as "at the exhibit".

In each of the two conditions, the surveys and stay times were collected for zoo visitors between the hours of 9:00 and 11:00. Stay times were recorded in minutes and seconds and started when the zoo visitor entered the exhibit and stopped when he or she left the exhibit. When a person exited the exhibit he or she was approached and asked if he or she had time to answer a short survey. If it was a group of people, they were asked who would like to answer the survey. This was partially to dissuade multiple people from trying to answer the questions, and also because no more than one person from a group was surveyed to maintain independence of the survey data. The survey was given verbally. For the experimental phase, the procedure was the same for stay time and survey, except that three questions were be added to the basic survey, "Did you see the jaguars interacting with the fish today?", "If so, would you like to see it again? If not, would you like to see it?" and "Why?" (See Appendix H). For statistical analysis, only those visitors which answered "yes" to seeing the jaguars interact with the fish were included in the sample of visitors that had seen the fish introduction.

At Palm Beach Zoo, the two rabbits to cheetahs questions were removed from the survey after 228 people were sampled. This was due to concern over publicity that the study had received. All visitors that were surveyed after seeing a fish introduction were surveyed after the elimination of the rabbits to cheetahs questions.

Data Analysis

Differences in agreement rate for the surveys were tested statistically using binary logistic regression. Differences in agreement rates between the Edinburgh Zoo (UK), Zoo Atlanta (US) and Palm Beach Zoo (US) were calculated by entering agreement and disagreement rate for each question as a dependent variable and zoo as a covariate. This was done for each question. Alpha was set at 0.0023 to control for family-wise error.

To address the effect of seeing a prey introduction on visitor agreement rate, two methods were used; asking in the survey whether they had previously seen a prey introduction and where, and surveying visitors after they had seen a fish introduction. For the first method, if visitors answered yes that they had seen a prey introduction before, they then had five options for where they had seen it: on TV, at a zoo or aquarium, in the wild, feeding a pet, and other. I chose to focus on visitors that answered they had seen a prey introduction at a zoo or aquarium as it was the most pertinent to the question of live prey feeding within a zoo. The agreement and disagreement rate for these people and that for people that had not seen a prey introduction in that setting were entered as the dependent variable in a binary logistic regression analysis. Whether they had seen a prey introduction in that setting was entered as the covariate. This was done for each question and both US zoos. Alpha for this analysis was set at 0.005 to control for family-wise error.

To assess whether seeing the fish introduction effected agreement rate, a similar binary logistic regression analysis was run. Agreement and disagreement rate for each group (those that had seen a fish introduction and those that had not) were entered as the dependent variable and whether they had seen the fish introduction was entered as the covariate. This was done for each question and both US zoos. To control for family-wise error the alpha was set at 0.005.

Differences in the mean stay time between the fish and no fish conditions at Palm Beach Zoo was analyzed statistically using a one-way ANOVA.

Jaguars

Subjects

The subjects are a family group of three jaguars (*Panthera onca*) at the Palm Beach Zoo. The group consists of the mother, Nabalam, and two cubs, Caipora and Izel. At the start of the study Nabalam was 11 years old and the cubs were 7 months old. The study duration was three and a half months.

Apparatus and Materials

A clipboard, watch, and data sheets were used in behavioral data collection. Ziploc bags, a freezer, and dry ice were used for fecal collection, preservation, and shipping. Fish used were thawed sardines approximately six to eight inches in length.

Procedure

Five dependent variables, fecal corticoid levels, activity level, visibility, time spent in water and behavioral diversity were measured for each of the three jaguars. The independent variable manipulated was the introduction of fish into the jaguars' stream. This research procedure followed a modified ABAB repeated measures design; where A is the baseline phase with no fish and B is the experimental phase with fish. This allows for comparison of the dependent variables under baseline and experimental conditions and reversal and replication.

The duration of this experiment was fourteen weeks starting in May and ending in August. The first three weeks were used to gather baseline for the jaguars in order to better interpret the following data. There were six replications of baseline (7 days) followed by fish introduction (1 day) and the post-fish week (6 days). The rationale for a six day post-fish period comes from Shepherdson et al. (1993), which found that behavioral changes from fish introduction tapered off over the following six days.

Four dead sardines were placed in the jaguars' stream on each of the fish introduction days, which were always be a Saturday to control for day of week and to allow the greatest number of zoo visitors to see the introduction. For all fish introductions, a fish scent trail was laid from the shift door to the pond and around the pond. Due to concerns about aggression, Izel, one of the cubs, was excluded from participating in the fish introductions. As she was off-exhibit until the end of the introduction, she served as a quasi-control for the mother and the other cub. Fecal corticosterone levels, behavioral data, and percentage of time spent visible was collected daily for the entire fourteen week period. Although, fecal samples were collected for the entire period, fecal cortisol levels were only determined for the first three and a half weeks (see Fecal corticoids in this section for more details).

Activity Level and Behavioral Diversity

The behavior of each individual was scored using instantaneous scan sampling every minute for 60 minutes in the morning (9:45 to 10:45) and in the afternoon (13:30-14:30). Behaviors scored were climb, groom (self-groom and conspecific groom), hunt, locomote, not visible, other, play (object play, conspecific play, and locomotor play), rest, olfactory investigate, stationary alert, stereotypic pace, and swim (See Appendix I for full ethogram). Activity level was calculated by adding all the non-stereotypic active behaviors together. Behavioral diversity was calculated using a Shannon Diversity Index. The formula is $\Sigma P_i * \text{Log}(1/P_i)$ where P_i is the proportion of time spent engaging in the ith behavior. The Shannon Diversity Index ranges from 0 to 1, with a 0 indicating that the entire period of time was spent engaging in a single behavior and values closer to 1 indicating a wide range of behaviors were expressed during the time period.

Fecal Corticoids

If present, a fecal sample for each individual was collected each morning for the fourteen week period. In order to distinguish between the fecal matter of the three individuals, different color beads were mixed into their food. Each sample, about a teaspoon in size, was placed in a freezer Ziploc bag labeled with the individual's name and collection date. Fecal samples were frozen at 0 ºC until they were shipped overnight with dry ice to the Endocrinology Lab at the Saint Louis Zoo. Fecal cortisol levels were only analyzed for the first three and a half weeks as the levels were so low that they could not be validated. Fecal corticosterone was analyzed for samples from the entire length of the study. Validation and parallelism of the fecal corticosterone analysis were carried out by Dr. Joan Bauman at the Saint Louis Zoo Endocrinology Lab to verify the suitability and accuracy of the test for measuring jaguar fecal corticosterone.

Visibility

During the two hours of daily behavioral data collection, visibility in the exhibit was scored each minute for each individual. The exhibit was divided into areas where the subjects were easily visible and areas where they were not for a person standing on the visitor side of the exhibit (See Figure 2.2).

Figure 2.2: Diagram of the jaguar exhibit and surrounding area. Red indicates regions were jaguar visibility was obscured and green indicate areas were they were easily visible.

Percentage of Time Spent in Water

The percentage of time each individual spent in the water was recorded for each of the two hours of behavioral observation. In the water was defined as at least all four paws in water. Water is defined as the stream and pond.

Data Analysis

A separate time series for fecal cortisol levels, fecal corticosterone levels, behavioral diversity, activity levels, and visibility were plotted for each individual on each day; as behavioral diversity, activity level, and visibility were measured twice a day, there is a graph for morning data and one for afternoon data. In the past ITSE and

ITSACORR statistical methods have been used to test for significance of time-series data like this (Crosbie, 1993). However, in the last three years these statistical methods have suffered from criticism related to their validity in actually testing what they propose to test: changes in slope and intercept (Fisher, Kelley, and Lomas, 2003; Huitema, 2004). Thus, the data in this research was analyzed using the visual method set forth in Fisher, Kelley, and Lomas (2003), which has been shown to control both Type I and Type II error better than previous visual or statistical methods.

RESULTS

Zoo Visitors

Stay Time

Mean stay time of visitors during the fish introduction and non-fish introduction days were not statistically different (F=1.910, df=1, p=0.169). The mean and standard deviation for visitors that saw and did not see a fish introduction was 2:02 minutes and 0:37 minutes, and the mean and standard deviation for visitors that did not see a fish introduction was 3:06 minutes and 2:20 minutes. See Figure 3.1 for a visual representation of the data. Included in this analysis are the stay times for visitors at the jaguar exhibit between 9 and 10am on non-fish introduction days and during the time of the fish introduction (which always started after 9am and ended before 10am) for fish introduction days. There were 182 visitors sampled on non-fish introduction days, and 9 visitors sampled on fish introduction days.

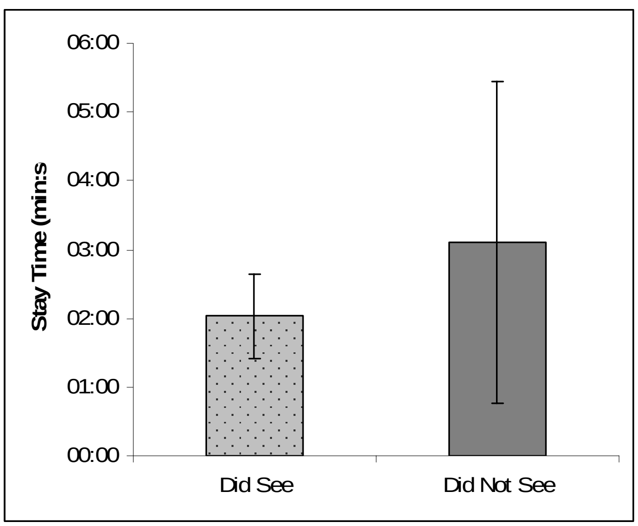

Figure 3.1: Mean and standard deviation for stay time of visitors that did (N=9) and did not see (N=182) a fish introduction to the jaguars at Palm Beach Zoo.

Comparing Agreement across Zoos

Agreement rate for both US Zoos was high (see Table 3.1). Agreement rate decreased as prey exemplars proceeded up the taxonomic hierarchy. The experimenter attempted to keep the percentages of each age and sex constant across zoos (See Tables 3.2, 3.3. and 3.4). In the case of Palm Beach Zoo it was difficult to find participants under 25 years old so it was not possible to get enough of that age class to match the percentage at Edinburgh Zoo. At Zoo Atlanta, the decision was made to match the Palm Beach Zoo age percentages.

Table 3.1: Percentage agreement for each of the three zoos: Palm Beach Zoo, Zoo Atlanta, and Edinburgh Zoo. Percentages of surveyed visitors that had seen a prey introduction in the past and where they had seen it.

	Percent Agreement		
	Palm Beach Zoo N=400	Zoo Atlanta N=400	Edinburgh Zoo N=200
Insects to Lizards (IV)	91.25	96.50	96
Insects to Lizards (OV)	89.00	81.50	100
Fish to Penguins (IV)	88.25	93.00	72
Fish to Penguins (OV)	87.25	80.00	84.5
Fish to Jaguars (IV)	84.75	89.00	
Fish to Jaguars (OV)	86.00	80.25	
Mice to Hawks (IV)	74.25	79.00	
Mice to Hawks (OV)	84.75	78.75	
Rabbits to Cheetahs (IV)	44.30[1]	54.25	32
Rabbits to Cheetahs (OV)	75.44[1]	70.00	62.5
Have seen predator hunt and kill a prey animal	96.25	95.75	
Where?			
Zoo/Aquarium	25.50	32.00	
Feeding a Pet	16.75	22.25	
TV	82.50	90.25	
In the Wild	35.75	33.50	
Other	0.00	0.25	

[1] N=228.

Table 3.2: Percentage of males and females surveyed at Edinburgh Zoo (Ings et al., 1997), Palm Beach Zoo, and Zoo Atlanta.

	Edinburgh Zoo	Palm Beach Zoo	Zoo Atlanta
Female	50 %	50 %	49.75 %
Male	50 %	50 %	50.25 %

Table 3.3: Percentage of each age class surveyed at Palm Beach Zoo and Zoo Atlanta.

	Palm Beach Zoo	Zoo Atlanta
18 to 25	8 %	10.75 %
26 to 38	44.75 %	43.25 %
39 to 50	23.5 %	23.75 %
51 to 65	16.75 %	15.75 %
65+	7 %	6.5 %

Table 3.4: Percentage of each age class surveyed at Edinburgh Zoo (Ings et al., 1997), Palm Beach Zoo, and Zoo Atlanta collapsed on the age classes reported in Ings et al.

	Edinburgh Zoo	Palm Beach Zoo	Zoo Atlanta
12 to 25 [1]	18.5 %	8 %	10.75 %
26 to 50	60 %	68.25 %	67 %
50+	21.5 %	23.75 %	22.25 %

[1] The 12 to 25 age range was reduced to 18 to 25 for Palm Beach Zoo and Zoo Atlanta.

There were no significant differences between the agreement rates of Palm Beach Zoo and Zoo Atlanta (See Table 3.5). Two questions had significantly different agreement rates between Palm Beach Zoo and Edinburgh Zoo: visitors at Edinburgh Zoo had a higher agreement rate with insects to lizards out of view, and visitors at Palm Beach Zoo had a higher agreement rate with fish to penguins in view (See Table 3.6). Three questions had significantly different agreement rates between Zoo Atlanta and Edinburgh Zoo: visitors at Edinburgh Zoo had a higher agreement rate with insects to lizards out of view, and visitors at Zoo Atlanta had a higher agreement with fish to penguins in view and rabbits to cheetahs in view (See Table 3.7).

Table 3.5: There were no significant differences in agreement rates for live prey survey between Palm Beach Zoo and Zoo Atlanta. Alpha was set at 0.0023 to control for family-wise error.

	Wald's Statistic	df	p-value
Insects to Lizards (IV)	8.974	1	0.003
Insects to Lizards (OV)	8.699	1	0.003
Fish to Penguins (IV)	5.204	1	0.023
Fish to Penguins (OV)	7.568	1	0.006
Fish to Jaguars (IV)	3.144	1	0.076
Fish to Jaguars (OV)	4.675	1	0.031
Mice to Hawks (IV)	2.513	1	0.113
Mice to Hawks (OV)	4.789	1	0.029
Rabbits to Cheetahs (IV)	5.729	1	0.017
Rabbits to Cheetahs (OV)	2.124	1	0.145

Table 3.6: Significant differences in agreement rates for live prey survey between Edinburgh Zoo and Palm Beach Zoo. Alpha was set at 0.0023 to control for family-wise error.

	Wald's Statistic	df	p-value	Greater Agreement at:
Insects to Lizards (OV)	10.176	1	0.001	Edinburgh Zoo
Fish to Penguins (IV)	23.489	1	<0.001	Palm Beach Zoo

Table 3.7: Significant differences in agreement rates for live prey survey between Edinburgh Zoo and Zoo Atlanta. Alpha was set at 0.0023 to control for family-wise error.

	Wald's Statistic	df	p-value	Greater Agreement at:
Insects to Lizards (OV)	14.435	1	<0.001	Edinburgh Zoo
Fish to Penguins (IV)	42.670	1	<0.001	Zoo Atlanta
Rabbits to Cheetahs (IV)	25.843	1	<0.001	Zoo Atlanta

The Effect of Seeing a Prey Introduction on Agreement Rate

There was no effect of seeing the fish to jaguar introduction at Palm Beach Zoo on agreement rates on the survey (See Tables 3.8 and 3.9).

Table 3.8: Percentage agreement for visitors at Palm Beach zoo that saw and did not see the fish introduction.

	Percent Agreement	
	Saw Fish Introduction N=8	Did Not See Fish Introduction N=400
Insects to Lizards (IV)	100	91.3
Insects to Lizard (OV)	75	89
Fish to Penguins (IV)	100	88.25
Fish to Penguins (OV)	75	87.25
Fish to Jaguars (IV)	100	84.75
Fish to Jaguars (OV)	75	86
Mice to Hawks (IV)	37.5	74.25
Mice to Hawks (OV)	100	84.75

Table 3.9: Seeing the fish to jaguar introduction did not significantly affect surveyed visitors' agreement with live prey introduction. Alpha was set at 0.005 to control for family-wise error.

	Wald's Statistic	df	p-value
Insects to Lizards (IV)	0.021	1	0.886
Insects to Lizards (OV)	1.422	1	0.233
Fish to Penguins (IV)	0.029	1	0.865
Fish to Penguins (OV)	0.987	1	0.321
Fish to Jaguars (IV)	0.234	1	0.628
Fish to Jaguars (OV)	0.747	1	0.387
Mice to Hawks (IV)	4.510	1	0.034
Mice to Hawks (OV)	0.206	1	0.650

Visitors at Zoo Atlanta and Palm Beach Zoo that had seen a prey introduction in the past at a zoo or aquarium had higher agreement rates than visitors that had not seen such an introduction. Visitors at Zoo Atlanta that had seen a prey introduction at a zoo or aquarium had significantly higher agreement rates with feeding live fish to jaguars in view, live mice to hawks in view, and live rabbits to cheetahs in view (See Tables 3.10 and 3.11). Visitors at Palm Beach zoo that had seen a prey introduction at a zoo or aquarium in the past had significantly higher agreement rates with feeding live fish to jaguars in view, live mice to hawks in view, live rabbits to cheetahs in view, and live rabbits to cheetahs out of view (See Tables 3.12 and 3.13).

Table 3.10: Percentage agreement for visitors surveyed at Zoo Atlanta that have and have not seen a live prey introduction at a zoo or aquarium.

	Percent Agreement	
	Saw a Prey Introduction at Zoo or Aquarium N=128	Have Not Seen a Prey Introduction at a Zoo or Aquarium N=272
Insects to Lizards (IV)	100	94.85
Insects to Lizard (OV)	75	84.56
Fish to Penguins (IV)	97.67	90.81
Fish to Penguins (OV)	72.67	83.46
Fish to Jaguars (IV)	96.09	85.66
Fish to Jaguars (OV)	73.44	83.46
Mice to Hawks (IV)	90.63	73.53
Mice to Hawks (OV)	73.44	81.25
Rabbits to Cheetahs (IV)	72.67	45.59
Rabbits to Cheetahs (OV)	70.31	69.85

Table 3.11: Significantly higher agreement for surveyed visitors at Zoo Atlanta that had seen a live prey introduction in the past at a zoo or aquarium. Alpha was set at 0.005 to control for family-wise error.

	Wald's Statistic	df	p-value
Fish to Jaguars (IV)	8.410	1	0.004
Mice to Hawks (IV)	14.037	1	<0.001
Rabbits to Cheetahs (IV)	24.624	1	<0.001

Table 3.12: Percentage agreement for visitors at Palm Beach Zoo that have and have not seen a live prey introduction at a zoo or aquarium.

	Percent Agreement	
	Saw a Prey Introduction at Zoo or Aquarium N=102	Have Not Seen a Prey Introduction at a Zoo or Aquarium N=298
Insects to Lizards (IV)	98	88.93
Insects to Lizard (OV)	89.22	88.93
Fish to Penguins (IV)	95.10	85.91
Fish to Penguins (OV)	87.25	87.25
Fish to Jaguars (IV)	94.12	81.54
Fish to Jaguars (OV)	86.27	85.91
Mice to Hawks (IV)	89.22	69.13
Mice to Hawks (OV)	86.27	84.23
Rabbits to Cheetahs (IV)	62.96 [1]	38.51 [2]
Rabbits to Cheetahs (OV)	87.04 [1]	71.84 [2]

[1] N=54. [2] N=174.

Table 3.13: Significantly higher agreement for surveyed visitors at Palm Beach Zoo that had seen a live prey introduction in the past at a zoo or aquarium. Alpha was set at 0.005 to control for family-wise error.

	Wald's Statistic	df	p-value
Fish to Jaguars (IV)	8.312	1	0.004
Mice to Hawks (IV)	14.523	1	<0.001
Rabbits to Cheetahs (IV)	17.735	1	<0.001
Rabbits to Cheetahs (OV)	9.053	1	0.003

Jaguars

Activity Level

None of the experimental weeks for Nabalam, Caipora, or Izel had significantly higher or lower activity levels than the baseline weeks. See Appendix A for a full listing of the visual graphs used to determine significance.

Behavioral Diversity

None of the experimental weeks for Nabalam, Caipora, or Izel had significantly higher or lower behavioral diversity than the baseline weeks. See Appendix B for a full listing of the visual graphs used to determine significance.

Fecal Corticosterone

The majority of experimental corticosterone data for Nabalam, Caipora, and Izel was not significantly different than baseline data. In two cases, corticosterone for the experimental week was significantly less than for the previous baseline week. For Nabalam during the third dead fish introduction, her corticosterone was significantly lower (See Figure 3.x). For Caipora during the fourth dead fish introduction, her corticosterone levels were significantly lower than the previous baseline week (See Figure 3.x). However, since we were not able to replicate this effect in at least three of the introductions for one or more individuals, the conclusion is that the dead fish introduction had no effect on corticosterone levels.

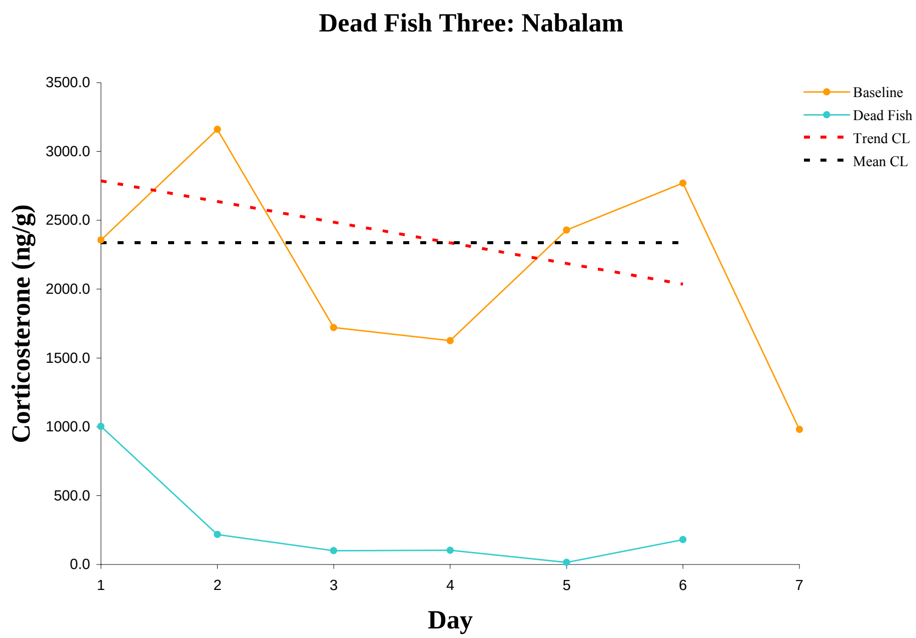

Figure 3.2: Fecal corticosterone levels for Nabalam for dead fish three. The results are significant.

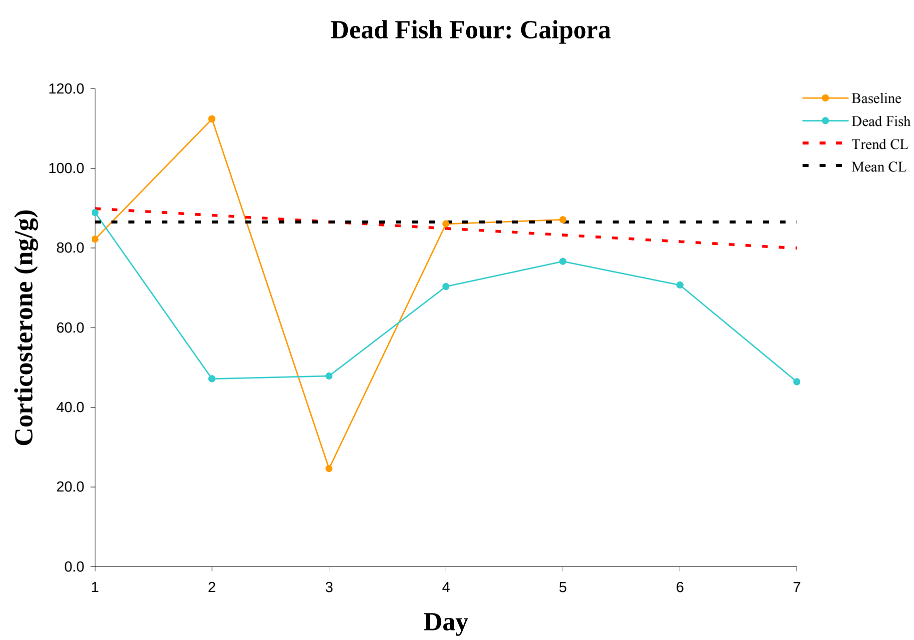

Figure 3.3: Fecal corticosterone levels for Caipora for dead fish four. The results are significant.

Insufficient data exists to analyze the effect of dead fish introduction on corticosterone levels for the second dead fish introduction for Caipora and Izel, the fifth fish introduction for Nabalam, and the sixth introduction for Nabalam, Caipora, and Izel. In these cases, trash was thrown into the exhibit (Styrofoam and a leather strap) and the jaguars were removed from the exhibit and watched. See Appendix C for the graphs used to determine significance.

Fecal Cortisol

Fecal cortisol levels were too low for the test to be validated for accuracy. Therefore it is debatable whether the cortisol levels measured are accurate. There was sufficient data to evaluate cortisol levels for all three individuals for the first dead fish introduction. The results were not significant. There was also enough data to evaluate the second dead fish introduction for Nabalam. The results were not significant. See Appendix D for a full listing of the graphs used to determine significance.

Visibility

None of the experimental weeks for Nabalam, Caipora, or Izel had significantly higher or lower visibility than the baseline weeks. See Appendix E for a full listing of the visual graphs used to determine significance.

Percentage of Time Spent in Water

None of the jaguars spent significantly more or less time in water during fish introduction weeks than baseline weeks. See Appendix F for a full listing of the visual graphs used to determine significance.

DISCUSSION

Zoo Visitors

The overwhelming majority of visitors surveyed at Palm Beach Zoo and Zoo Atlanta agree with feeding live prey to predators at zoos. As predicted, US zoos did have significantly higher agreement rates than the UK zoo, Edinburgh Zoo, for a number of prey predator exemplars. Edinburgh Zoo had higher agreement rates for feeding live insects to lizards out of view. From comments that visitors at Palm Beach Zoo and Zoo Atlanta made, I believe the lower agreement rate is due to visitors either wanting to see the prey predator interaction or not wanting the predator (in this case lizards) to have to wait until it goes off exhibit to eat.

The few visitors at Palm Beach Zoo that saw a dead fish to jaguar introduction did not have a higher rate of agreement than visitors that did not see this introduction. However, this may be partially due to the small sample size of visitors that saw the introduction. With 8 subjects, each person's opinion is equal to 12.5% of the 100% scale. Whereas there were 400 visitors that did not see the fish introduction, so each person's opinion was equal to 0.25%. With equivalent sample sizes, it is possible that the results would be different. The results of the comparison between percent agreement of visitors that had seen a prey introduction in the past at a zoo or aquarium to visitors that had not lends support to this supposition.

Visitors to Palm Beach Zoo and Zoo Atlanta that had seen a prey introduction in the past at a zoo or aquarium had significantly higher agreement rates for a number of predator-prey combinations: fish to jaguars in view, mice to hawks in view, and rabbits to cheetahs in view. In addition, visitors at Palm Beach Zoo had a significantly higher agreement rate than Edinburgh Zoo for feeding rabbits to cheetahs out of view. These two groups of visitors, those that have seen a prey introduction at a zoo or aquarium in the past and those that have not, may have other differences not measured in this study which affected this pattern of results. However, the finding of a similar pattern at both zoos lends support to the conclusion that seeing a prey introduction in the past in a zoo or aquarium affects visitor opinion towards greater agreement with prey introduction.

I also hypothesized that stay time would be greater for visitors seeing a fish to jaguar introduction compared to visitors that were just watching the jaguars. This comparison was not found to be significant. This could be due to a number of reasons. The average stay time for the fish introduction was 2 minutes and 2 seconds compared to 3 minutes and six seconds for those that did not see an introduction. In both instances this is a fairly long stay time, and it may be that seeing a mother jaguar and two cubs interacting already puts the stay time near ceiling. There was also much more variation in the non-introduction stay times, and the sample sizes of the two groups were vastly different: 9 for the fish introduction and 181 for the no fish group. With sample sizes of more similar magnitude, the results might have varied.

Live prey introductions have the potential to improve zoo visitor experience as well as maintain or re-establish the socially transmitted behavior of hunting for carnivores in captivity. However, the opinion of zoo visitors regarding live prey introductions had not been quantified until this study. Depending on the question, 13% to 18.25% and 8 to 10% of surveyed visitors at Zoo Atlanta and Palm Beach Zoo, respectively, agreed with feeding live prey in view and disagreed with feeding live prey out of view. When asked about their response pattern, visitors answered that they would prefer to see this event.

The finding that visitors that have seen a prey introduction in the past at a zoo or aquarium had higher agreement rates, 10 to 25% higher depending on the question, than visitors that had not seen a prey introduction in that setting lends support to the educational value of prey introductions. It also is reassuring for public relations within a zoo; there may be more complaints initially from zoo visitors but as this survey shows, opinions can be positively affected by seeing prey introductions at zoos and aquariums. To help with this, exhibit interpreters could explain to zoo visitors the importance of maintaining behaviors in captivity and how the zoo is making this possible by providing hunting opportunities for zoo predators.

Jaguars

None of the measurements taken for the jaguars showed an effect of dead fish introduction. The measurements used were activity level, behavioral diversity, cortisol, corticosterone, visibility, and percentage of time spent in water. It is possible that had live fish introduction been possible the results would have been different. However, it may be difficult to do live fish introduction in warm climates and/or during certain times of year as warm water fish commonly survive with a high parasite load as I found out during the necropsies of fish from several different species and populations. Four populations of tilapia and two populations of goldfish were examined for parasites, and all were found to have intestinal nematodes or nematodes and tapeworms. As the intestinal environment is similar in fish and mammals, these parasites could easily be transmitted to jaguars (Roberts, Janovy, and Schmidt, 2004). Trout, as a cold water fish with low tolerance for parasites, may be a better alternative in climates or exhibits where it is possible to maintain water at 33-78º F (Piper et al., 1982).

This study was designed to measure whether there were any carry over effects of dead fish introduction. Had we measured the behavioral effect during the fish introduction it is quite possible that the results would have been different. The measurements used in this study were based on a study where live fish were given to fishing cats and a significant difference in behavioral diversity and activity level was found for the six days following the fish introduction (Shepherdson et al., 1993). The comparison of that study to this one lends support to the idea that live fish have more of an effect on behavior than dead fish do. For this to be examined fully, dead fish would have to be fed to fishing cats and live fish would have to be fed to jaguars using the same methodology as in Shepherdson et al. (1993) and this study. Live fish have also been shown to be effective enrichment for Asian small-clawed river otters and tigers (Bashaw et al., 2003; Foster-Turley and Markowitz, 1982).

The finding that an enrichment device failed to have carry over effects is not uncommon. For example, Forthman et al. (1992) found that ice blocks containing fish had an effect on the immediate behavior of Kodiak and polar bears, but this effect failed to carry over even five hours later. Schapiro et al. (1996, 1997) also failed to find an overall behavioral effect of the presence or absence of enrichment for 93 rhesus macaques over a period of three years.

Although there were no carry over effects and behavior during the presentation of the enrichment was not part of this study, it is possible to anecdotally describe the jaguars' interest in the dead fish. For all six fish introductions, a similar pattern of behavior was seen; upon exiting the shift door, the jaguars walked to the stream, they visually searched it and the larger pool (even though fish was never placed in the pool) until they found each fish, and they consumed each fish completely. From the point at which the first fish was found to the last fish consumed, the average length of the introductions was 13.5 minutes. Both mother and cub actively searched. If the cub, Caipora, approached while the mother had a fish, the mother would give up the fish. Both consumed fish, and in most cases did so immediately after finding it. The exception is that in the last two introductions, Caipora played with her last fish. She did eat them within a couple minutes after batting them up logs and into the grass.

Based on these observations, fish seem to be an interesting enrichment item for jaguars. Prior to this study, neither jaguar had seen or eaten fish to the knowledge of the keepers or the director of collections. It may be that dead fish are not able to provoke interaction of a sufficient duration to see the carry over effects hypothesized here and seen in Shepherdson et al. (1993) with fishing cats. Ultimately, more research is needed.

As predators will continue to be held in captivity for the foreseeable future it is important that we find ways to provide them with hunting opportunities as the stated goal of captive breeding is to maintain populations of endangered species against the possibility of extinction in the wild and the behavioral repertoires of felids will be just as important as genetic diversity in surviving reintroduction. Additionally, while the importance of genetic diversity has been taught through a wide variety of mediums, including zoos, little emphasis has been placed on educating the public about the importance of behavioral conservation. Hunting, as a species appropriate behavior and one necessary for survival in the wild, is a good example that can be used to teach zoo visitors about the importance of behavior in conservation.

With nearly all 36 species of felids threatened in at least some of their natural range, it seems likely that captive felines will be used to bolster or reestablish wild populations at some point in the future (Nowell & Jackson, 1996). The IUCN Cat Group has recognized this, as well as our lack of knowledge on how to restore hunting behavior and has stated that research into this area needs to be conducted (Nowell & Jackson, 1996). As hunting in felids is a socially transmitted behavior success in restoring this behavior will depend on teaching females how to hunt and then allowing them to teach their offspring (Kitchener, 1999). There is evidence that the most opportune time to teach female felids is when they have cubs as they are more motivated to hunt at that time (Leyhausen, 1979). As the mother will be teaching herself to hunt rather than watching her own mother interact with prey and will be doing so when she is an adult rather than a cub, it is likely that there may be deficits in her abilities. Thus it may take several generations of successively more efficient hunting behaviors to rebuild the efficiency and skill seen in wild counterparts. Meanwhile, live prey introductions can provide feeding enrichment and serve as a medium for zoo visitor education about the behavior of predators. In this way, the net result is positive even if that individual or its offspring are never reintroduced.

APPENDIX A: PERCENTAGE OF TIME SPENT ACTIVE

Dead Fish One: Nabalam Morning

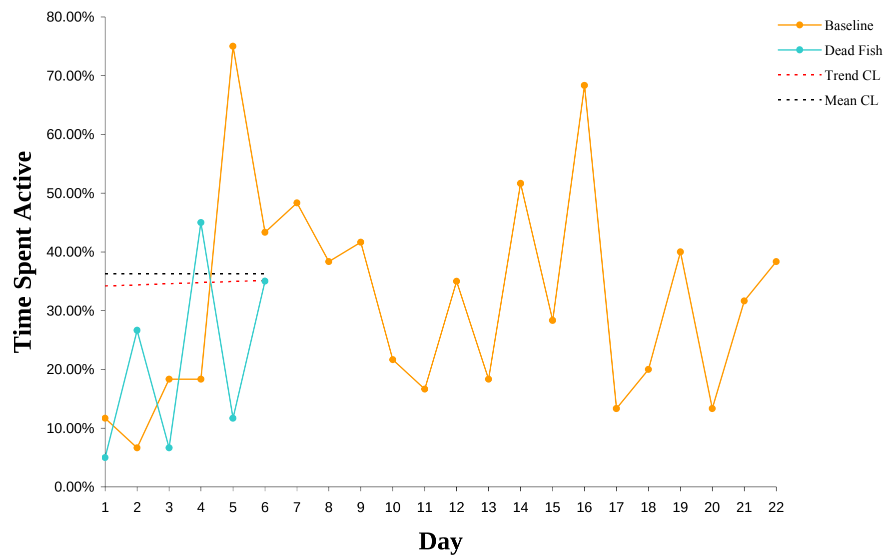

Figure A.1: Percentage of time spent active for Nabalam in the morning of dead fish one. The results are not significant.

Dead Fish One: Nabalam Afternoon

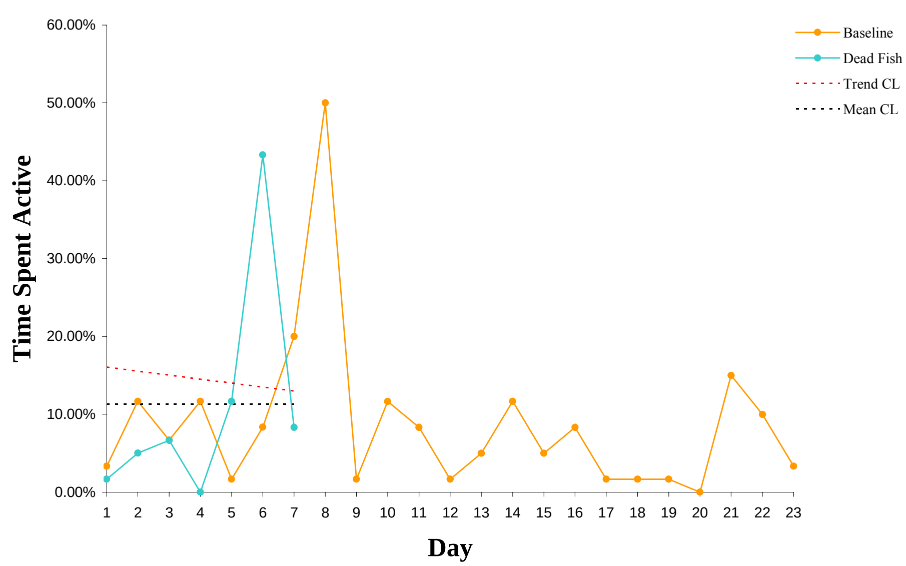

Figure A.2: Percentage of time spent active for Nabalam in the afternoon of dead fish one. The results are not significant.

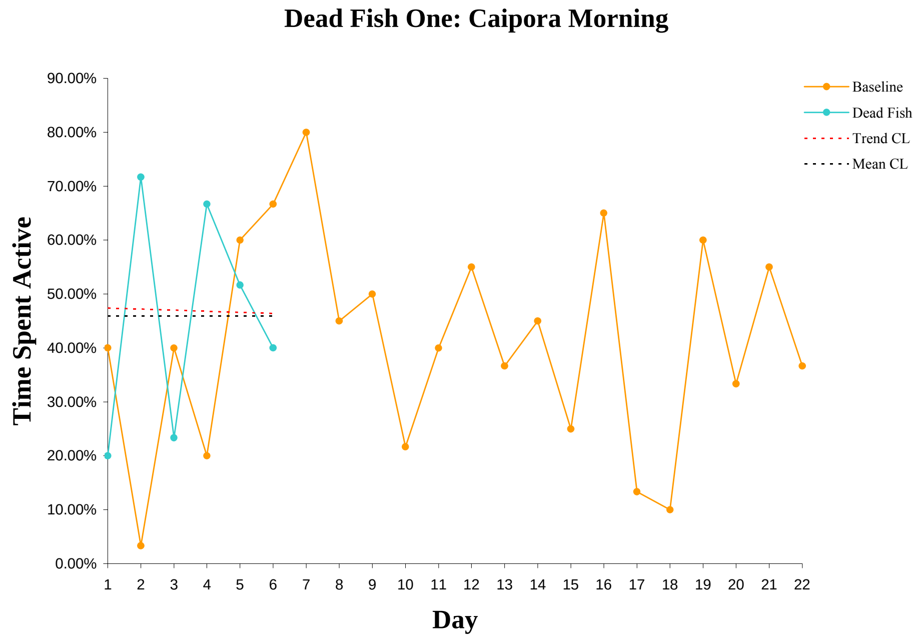

Figure A.3: Percentage of time spent active for Caipora in the morning of dead fish one. The results are not significant.

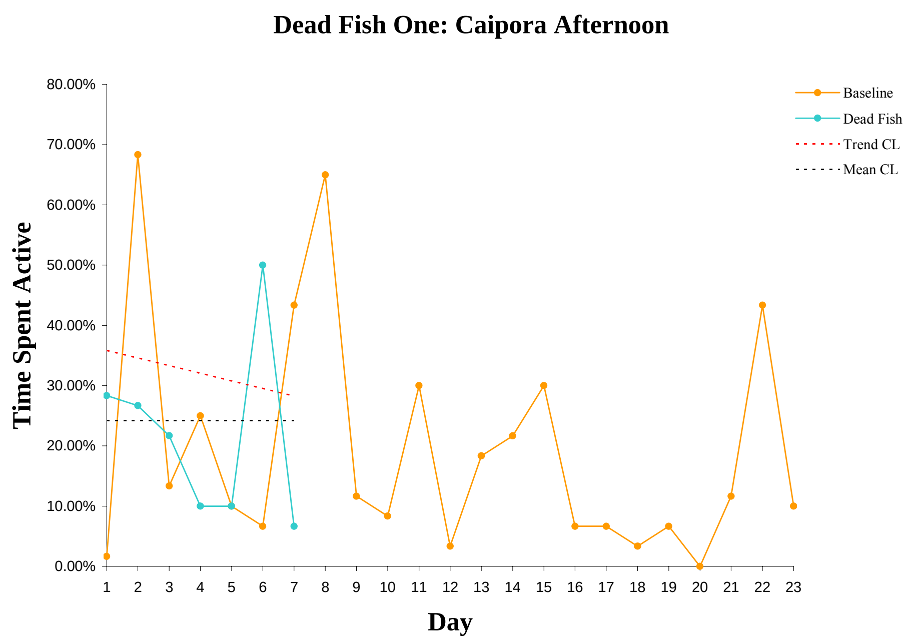

Figure A.4: Percentage of time spent active for Caipora in the afternoon of dead fish one. The results are not significant.

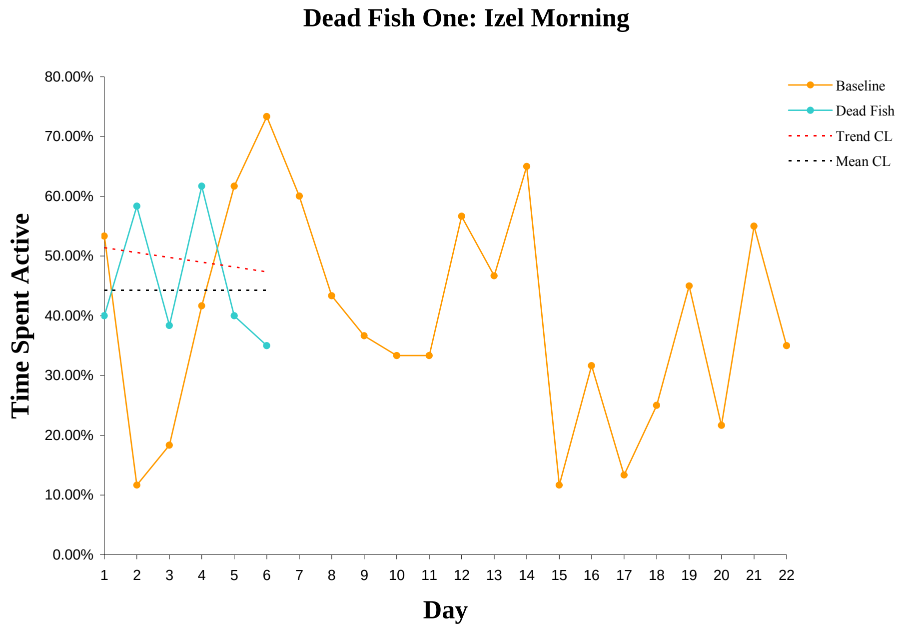

Figure A.5: Percentage of time spent active for Izel in the morning of dead fish one. The results are not significant.

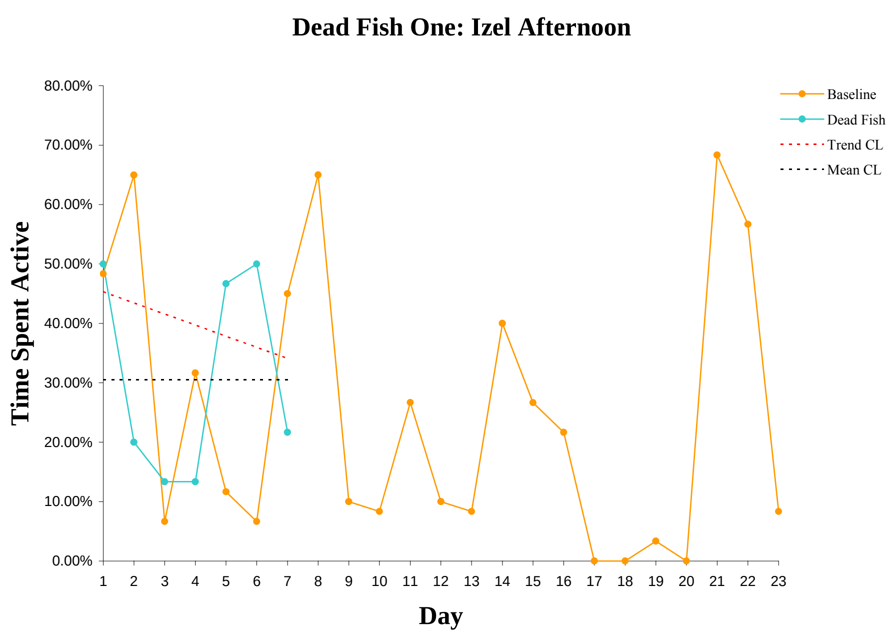

Figure A.6: Percentage of time spent active for Izel in the afternoon of dead fish one. The results are not significant.

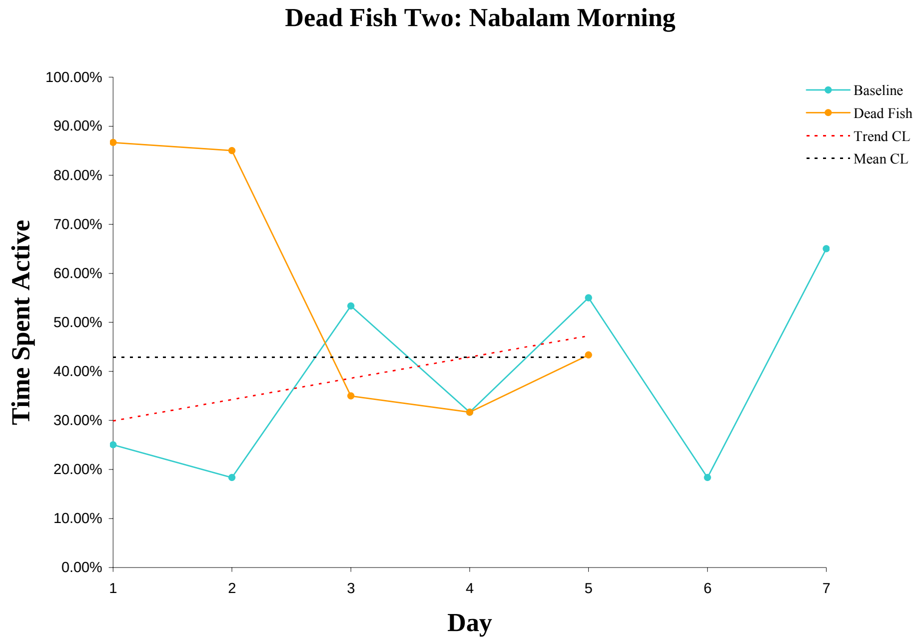

Figure A.7: Percentage of time spent active for Nabalam in the morning of dead fish two. The results are not significant.

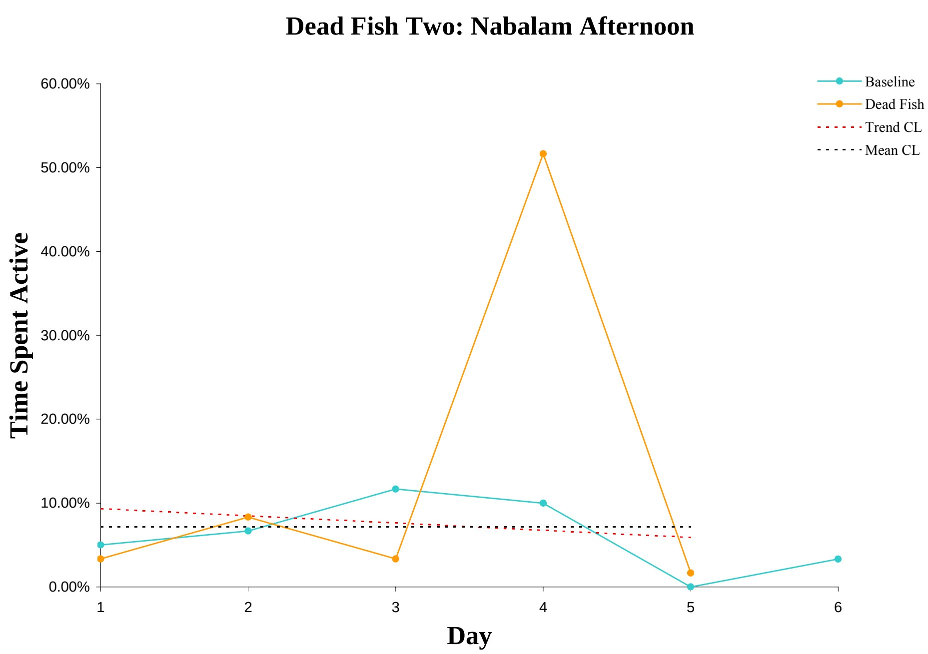

Figure A.8: Percentage of time spent active for Nabalam in the afternoon of dead fish two. The results are not significant.

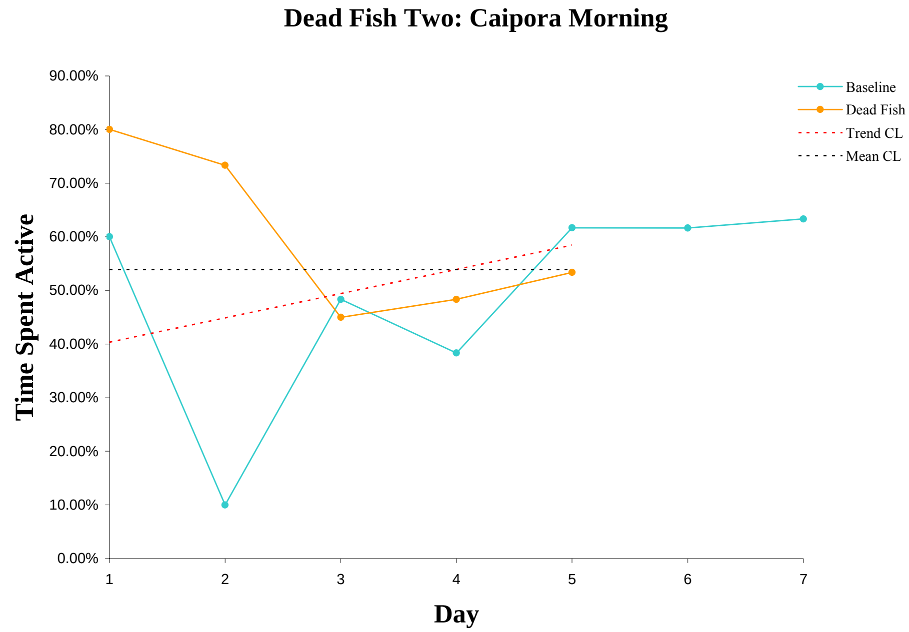

Figure A.9: Percentage of time spent active for Caipora in the morning of dead fish two. The results are not significant.

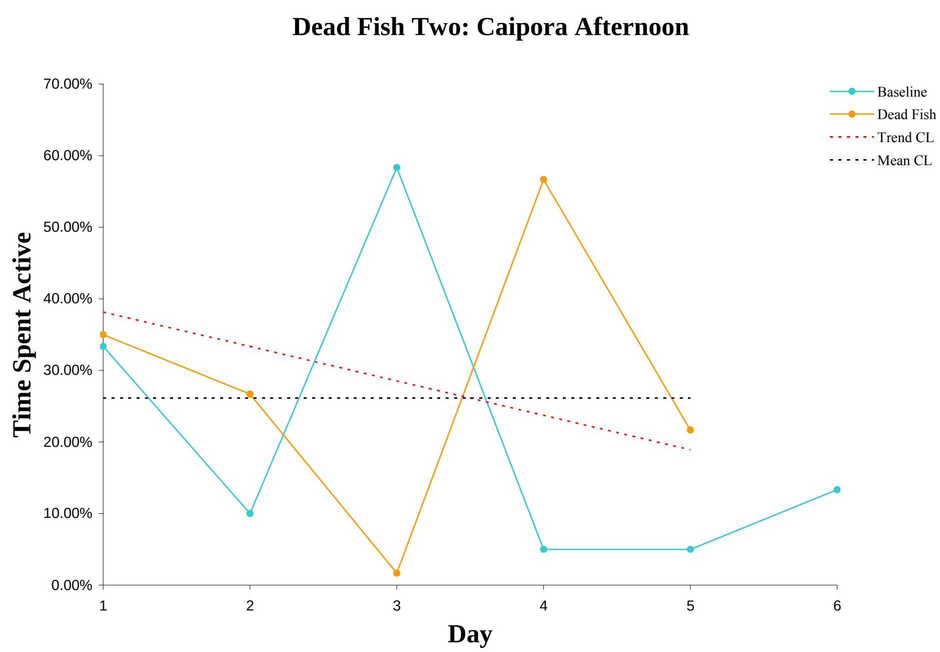

Figure A.10: Percentage of time spent active for Caipora in the afternoon of dead fish two. The results are not significant.

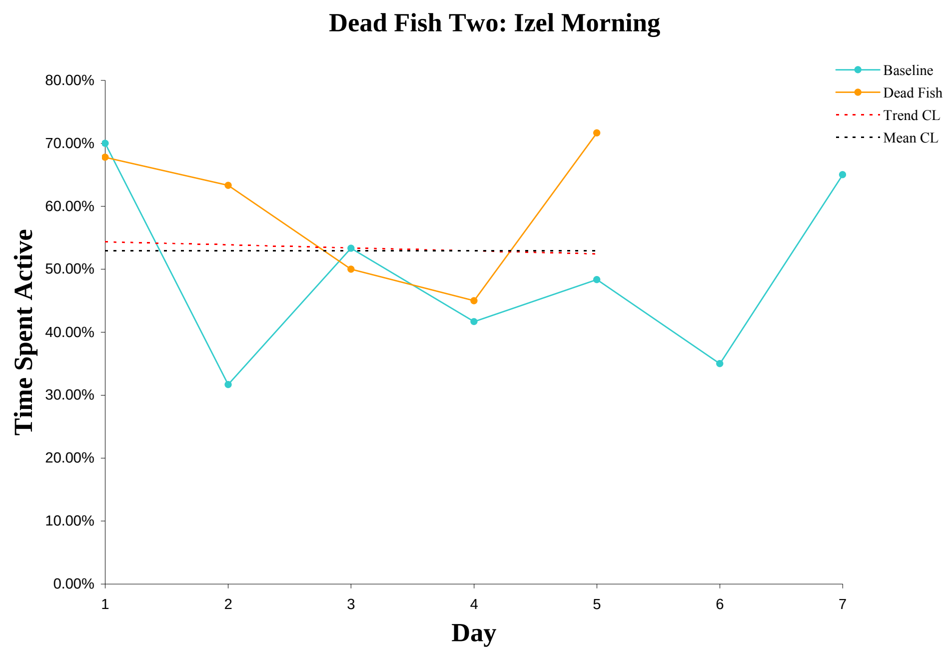

Figure A.11: Percentage of time spent active for Izel in the morning of dead fish two. The results are not significant.

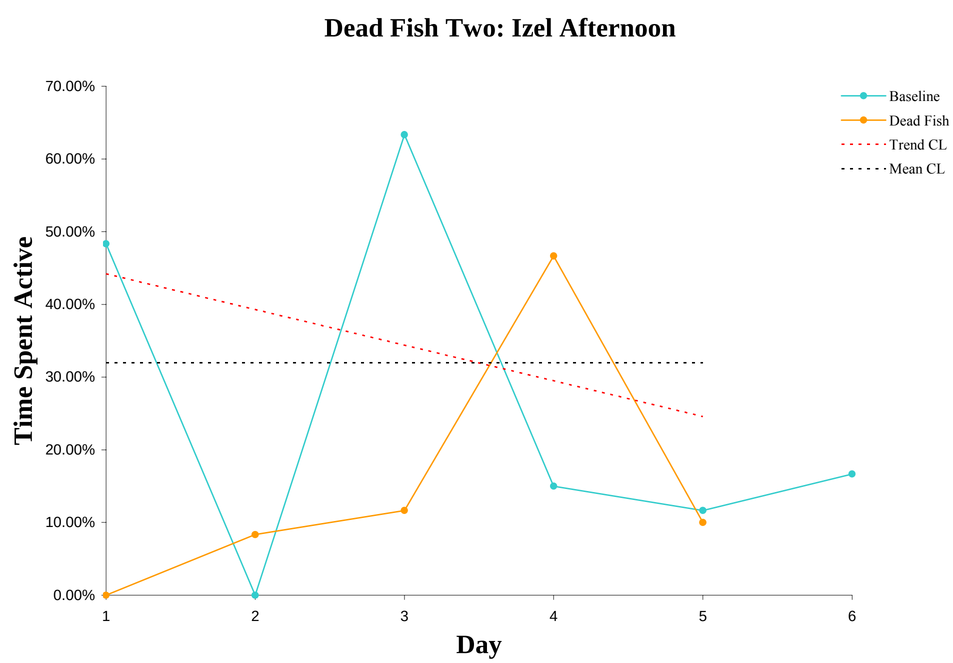

Figure A.12: Percentage of time spent active for Izel in the afternoon of dead fish two. The results are not significant.

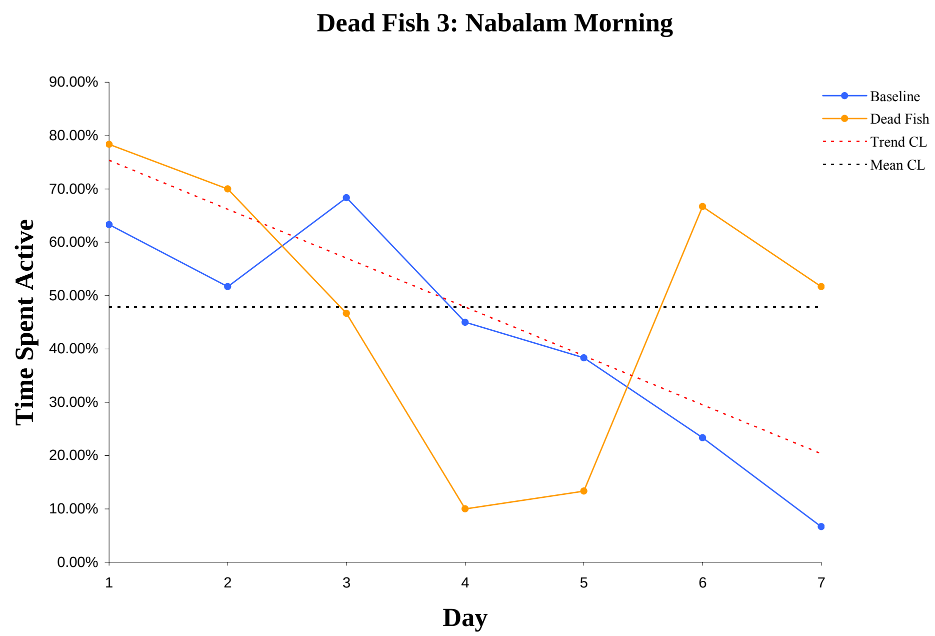

Figure A.13: Percentage of time spent active for Nabalam in the morning of dead fish three. The results are not significant.

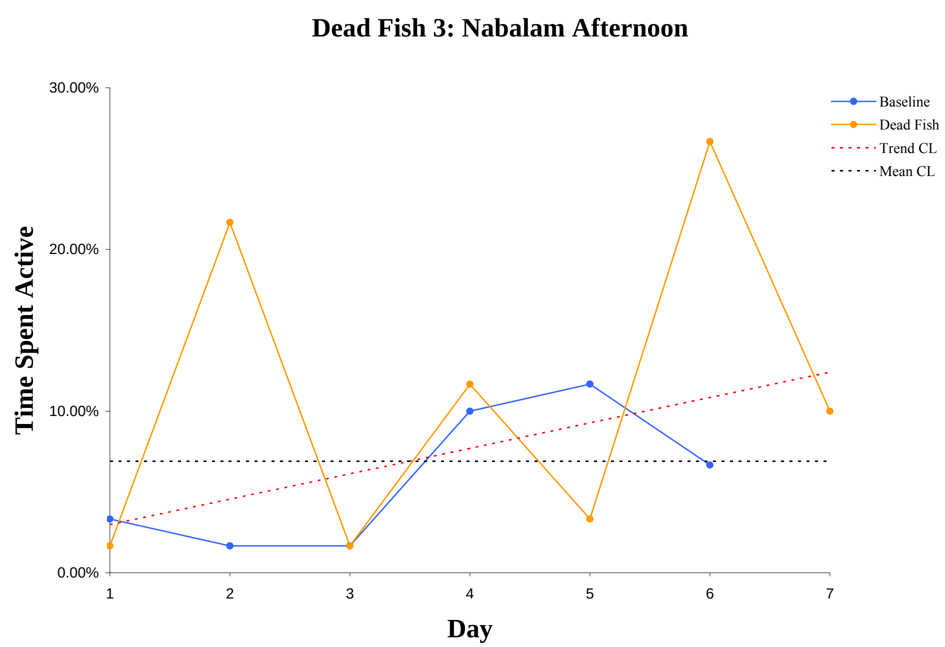

Figure A.14: Percentage of time spent active for Nabalam in the afternoon of dead fish three. The results are not significant.

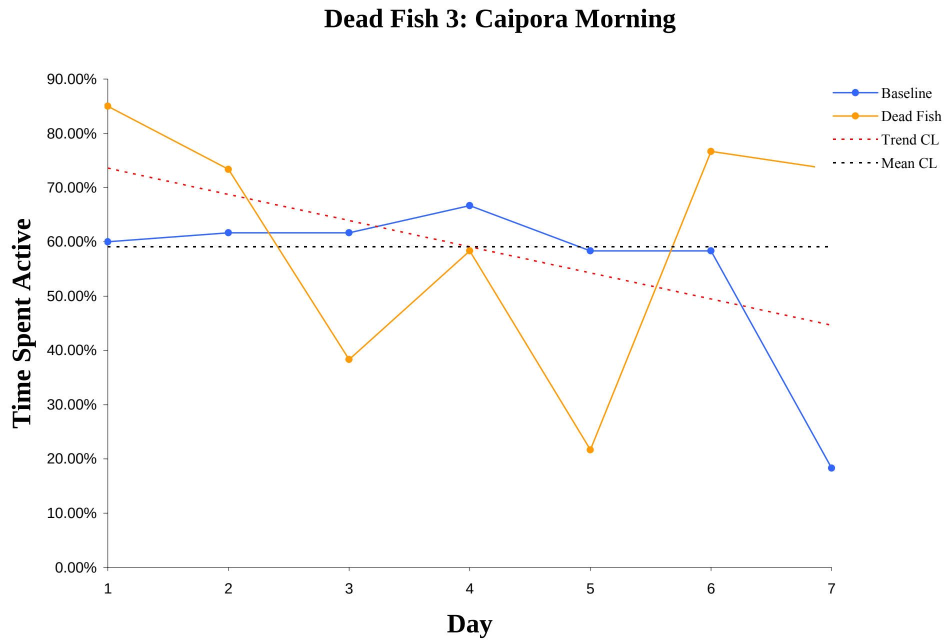

Figure A.15: Percentage of time spent active for Caipora in the morning of dead fish three. The results are not significant.

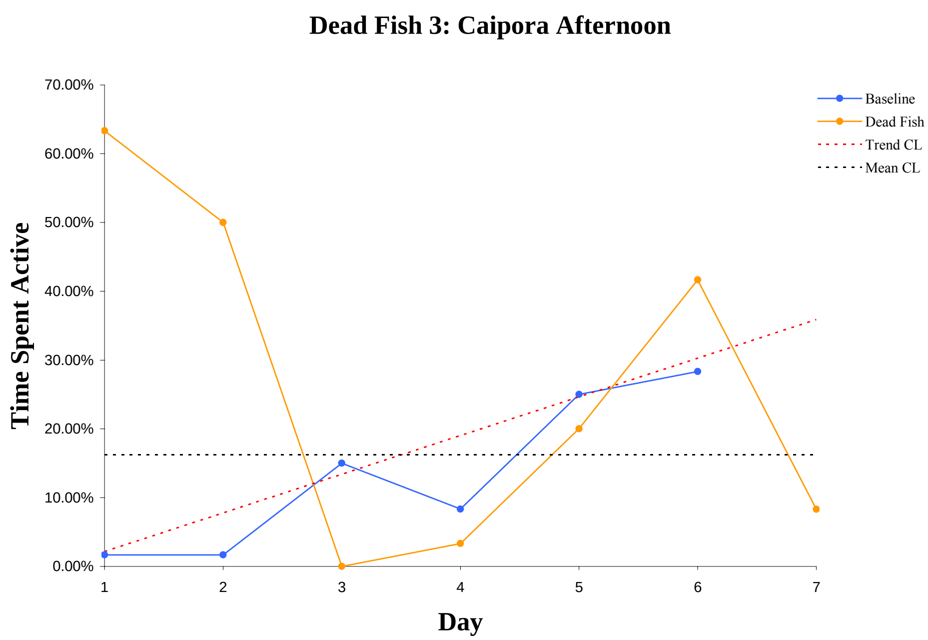

Figure A.16: Percentage of time spent active for Caipora in the afternoon of dead fish three. The results are not significant.

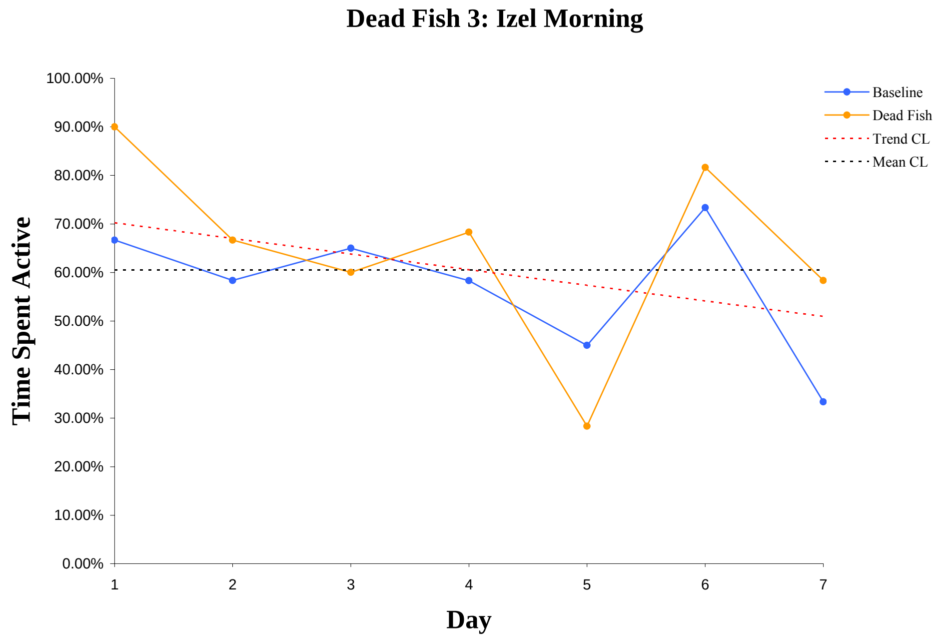

Figure A.17: Percentage of time spent active for Izel in the morning of dead fish three. The results are not significant.

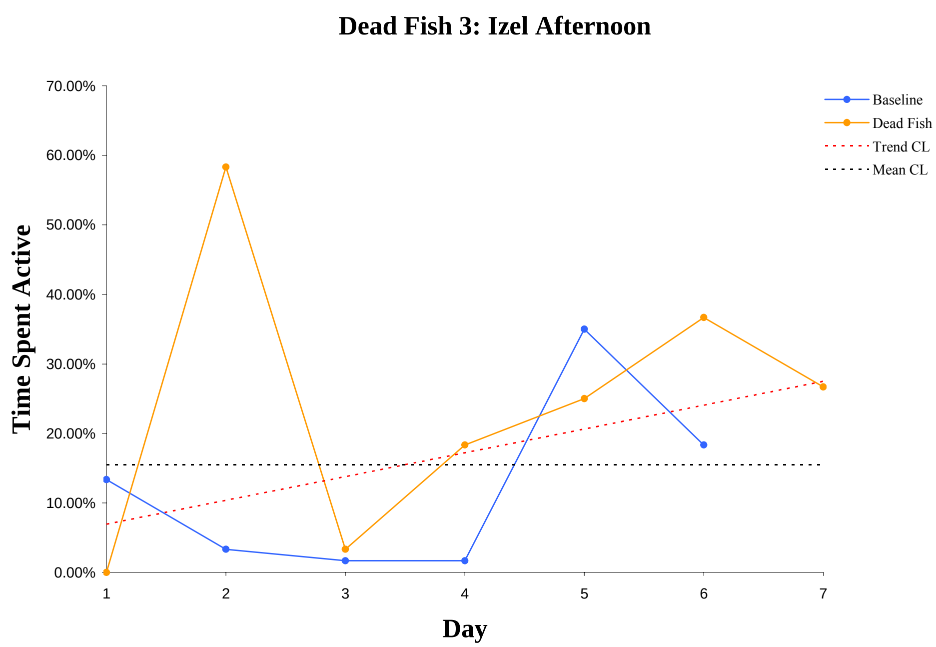

Figure A.18: Percentage of time spent active for Izel in the afternoon of dead fish three. The results are not significant.

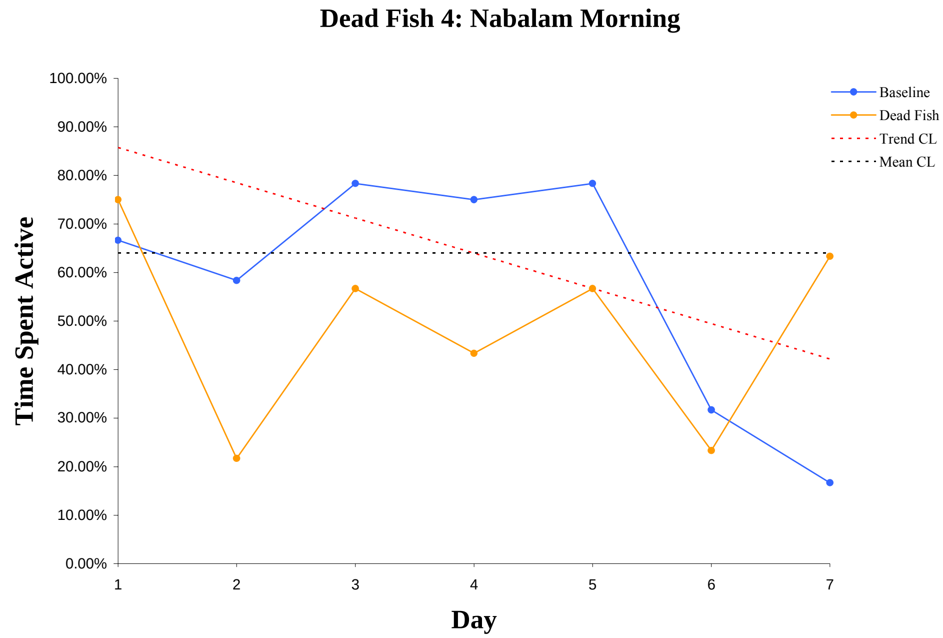

Figure A.19: Percentage of time spent active for Nabalam in the morning of dead fish four. The results are not significant.

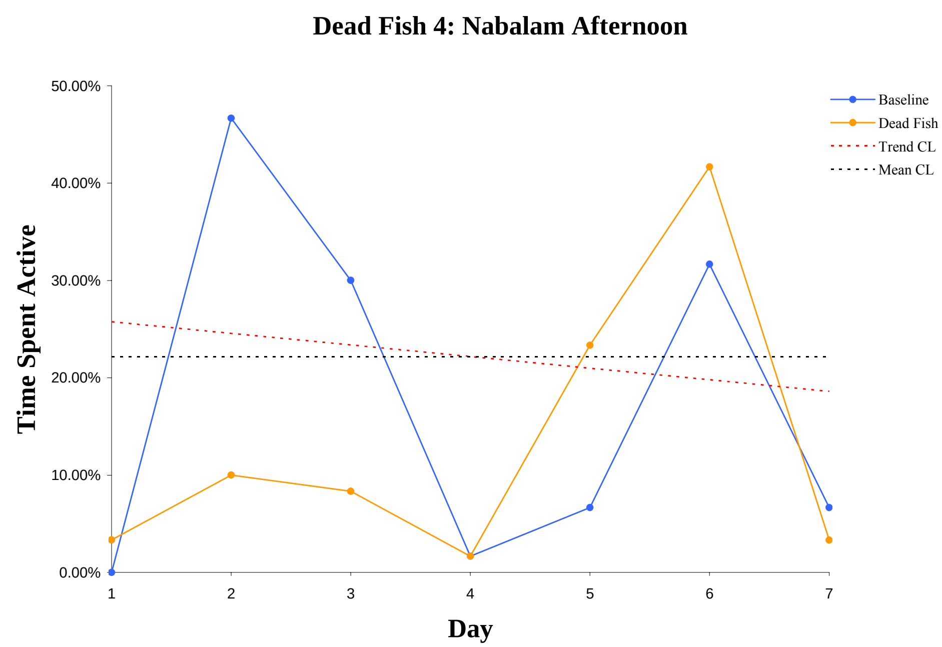

Figure A.20: Percentage of time spent active for Nabalam in the afternoon of dead fish four. The results are not significant.

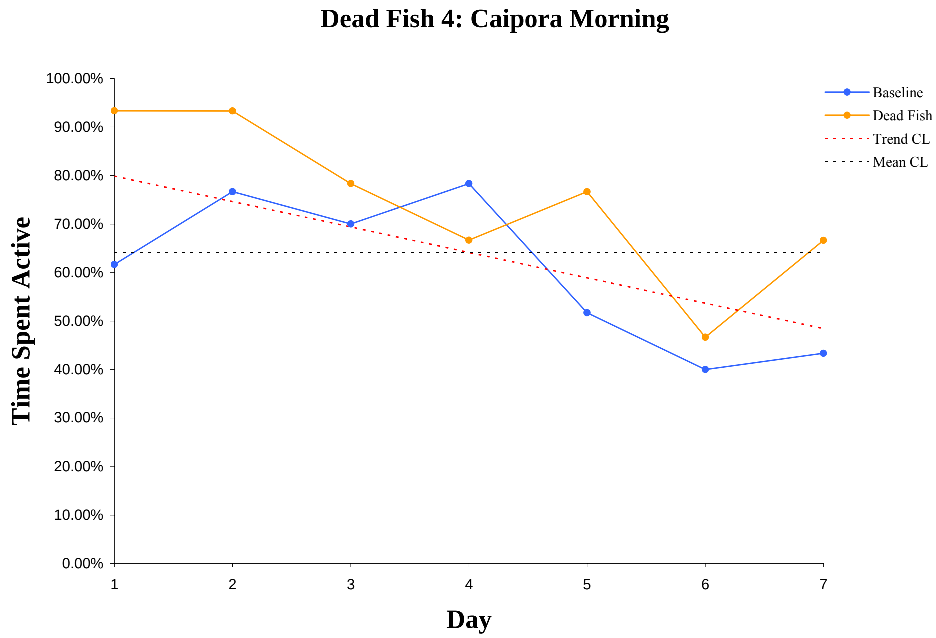

Figure A.21: Percentage of time spent active for Caipora in the morning of dead fish four. The results are not significant.

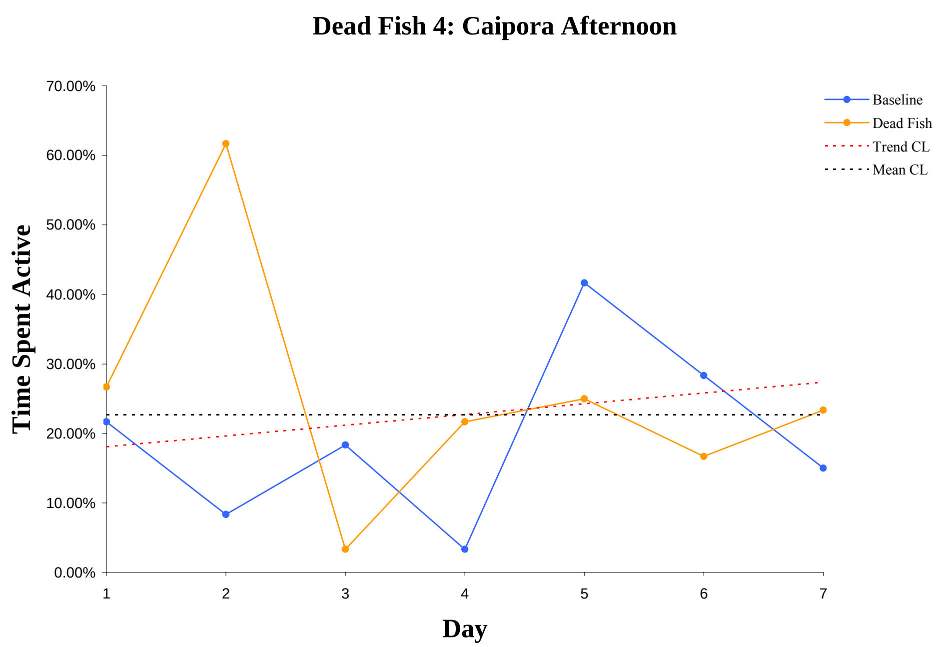

Figure A.22: Percentage of time spent active for Caipora in the afternoon of dead fish four. The results are not significant.

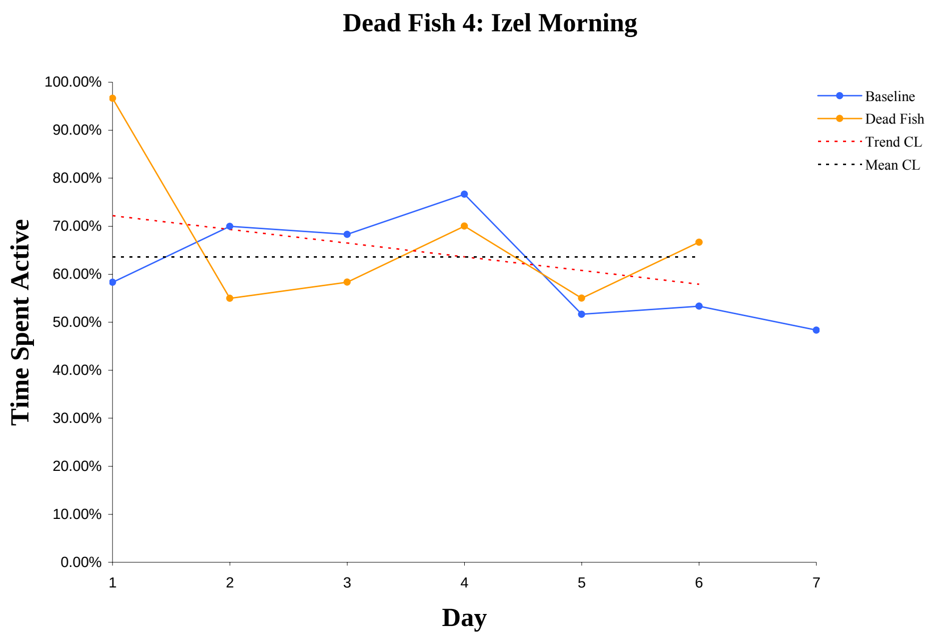

Figure A.23: Percentage of time spent active for Izel in the morning of dead fish four. The results are not significant.

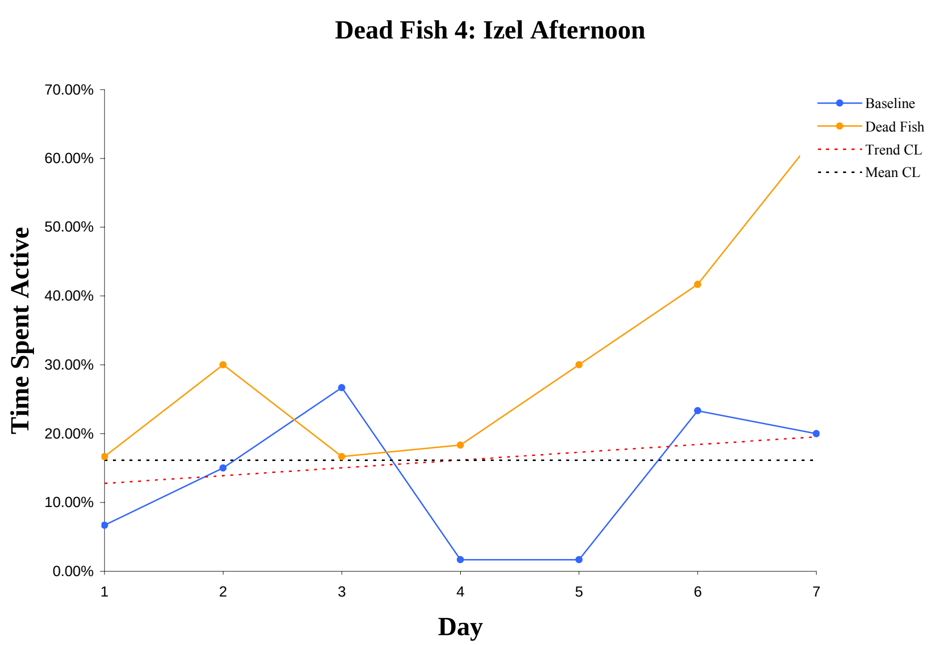

Figure A.24: Percentage of time spent active for Izel in the afternoon of dead fish four. The results are not significant.

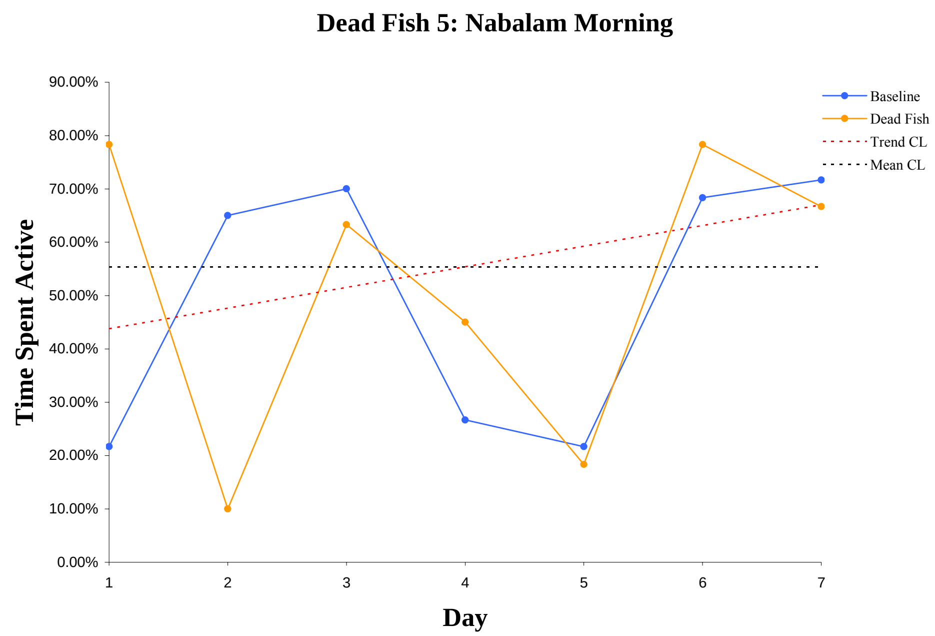

Figure A.25: Percentage of time spent active for Nabalam in the morning of dead fish five. The results are not significant.

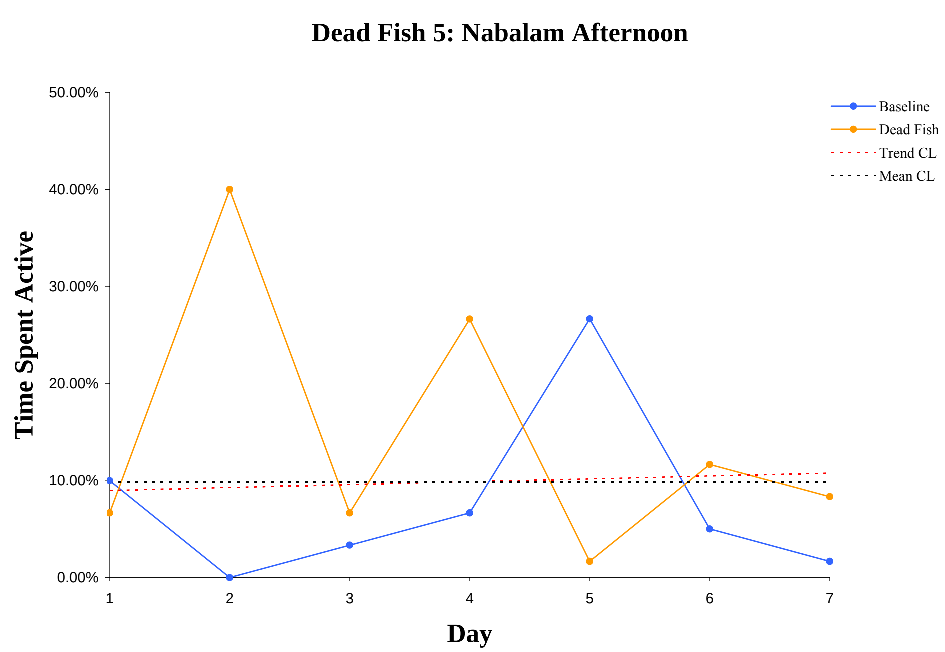

Figure A.26: Percentage of time spent active for Nabalam in the afternoon of dead fish five. The results are not significant.

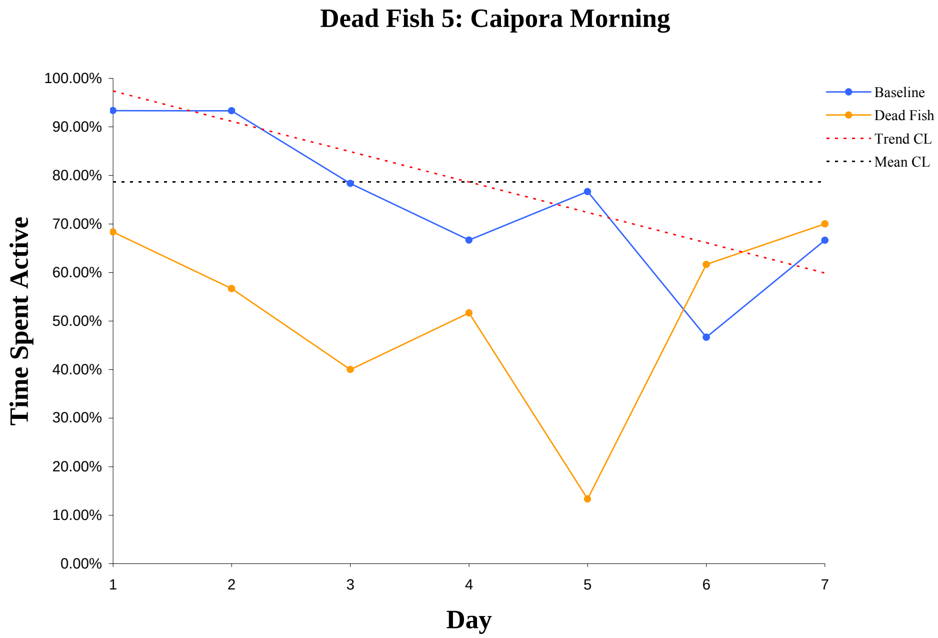

Figure A.27: Percentage of time spent active for Caipora in the morning of dead fish five. The results are not significant.

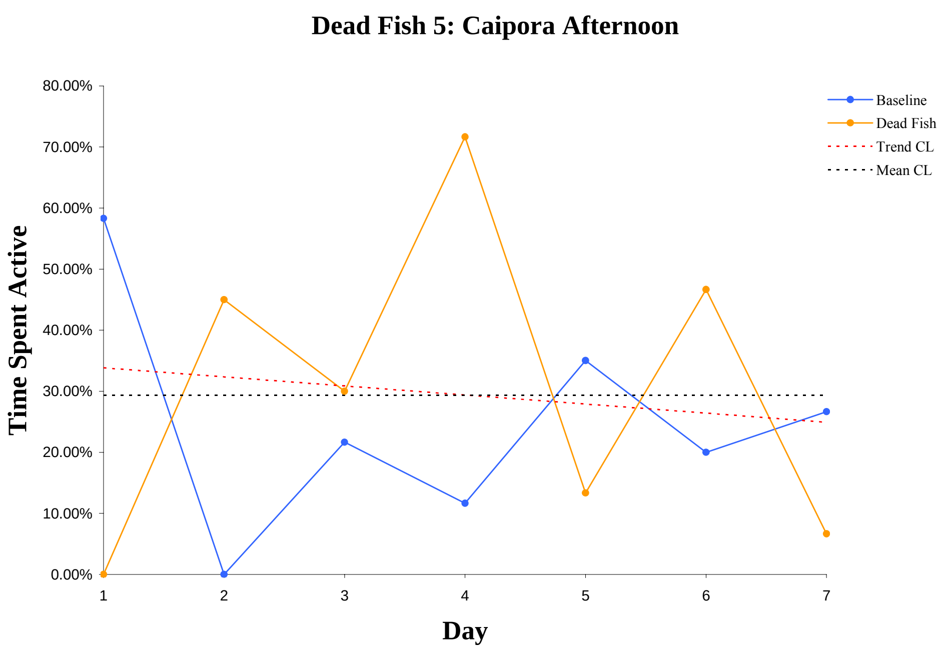

Figure A.28: Percentage of time spent active for Caipora in the afternoon of dead fish five. The results are not significant.

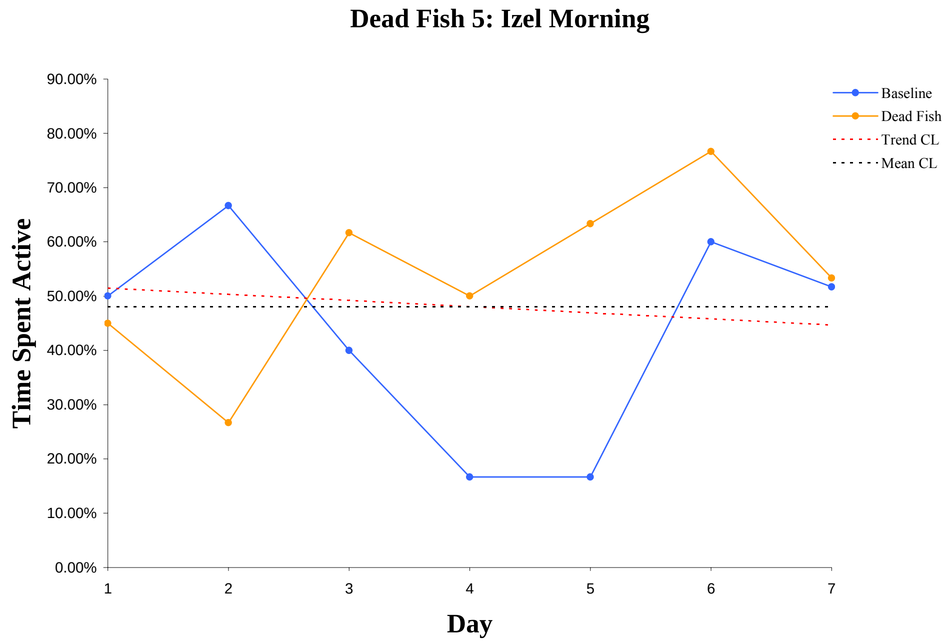

Figure A.29: Percentage of time spent active for Izel in the morning of dead fish five. The results are not significant.

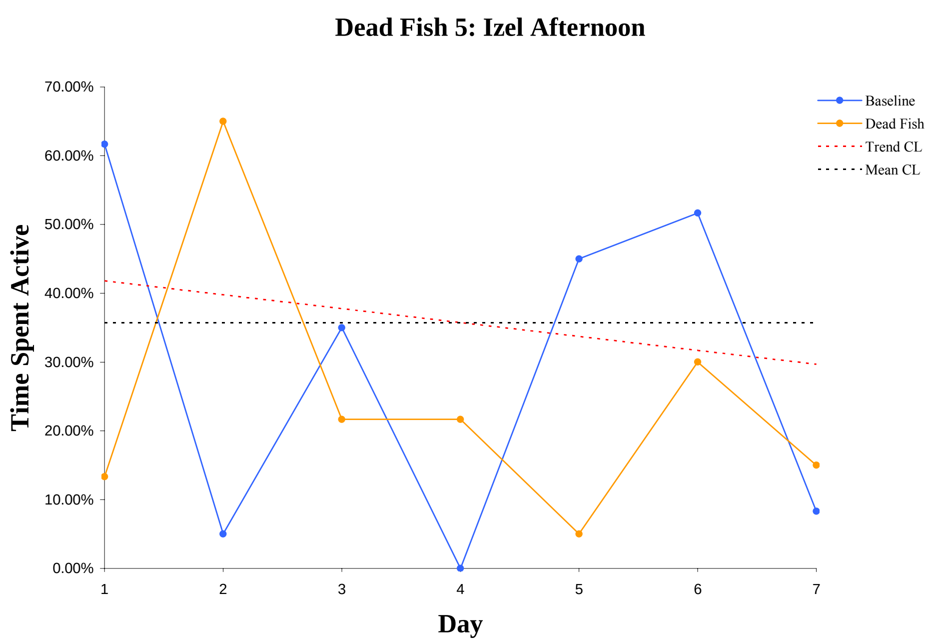

Figure A.30: Percentage of time spent active for Izel in the afternoon of dead fish five. The results are not significant.

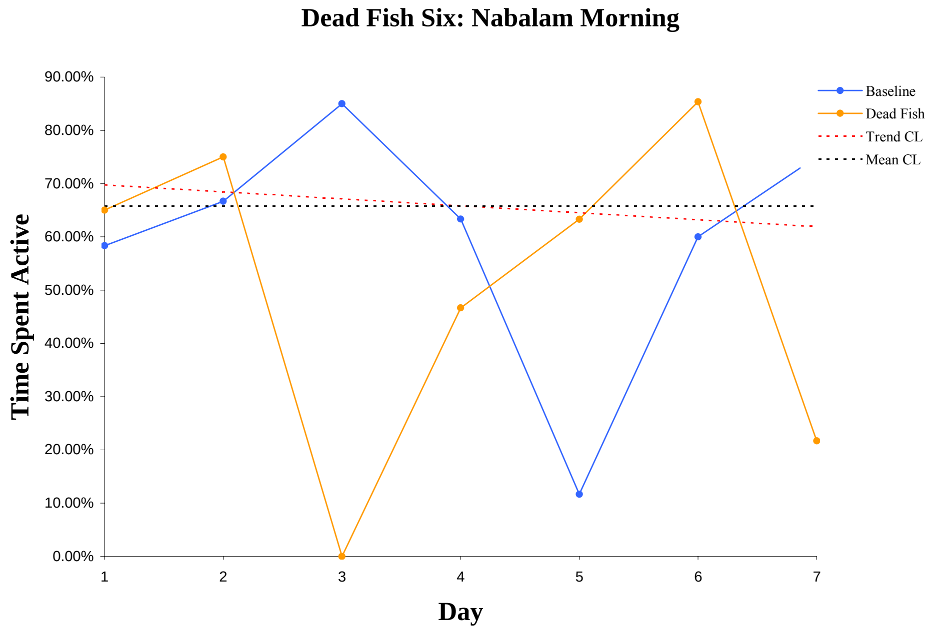

Figure A.31: Percentage of time spent active for Nabalam in the morning of dead fish six. The results are not significant.

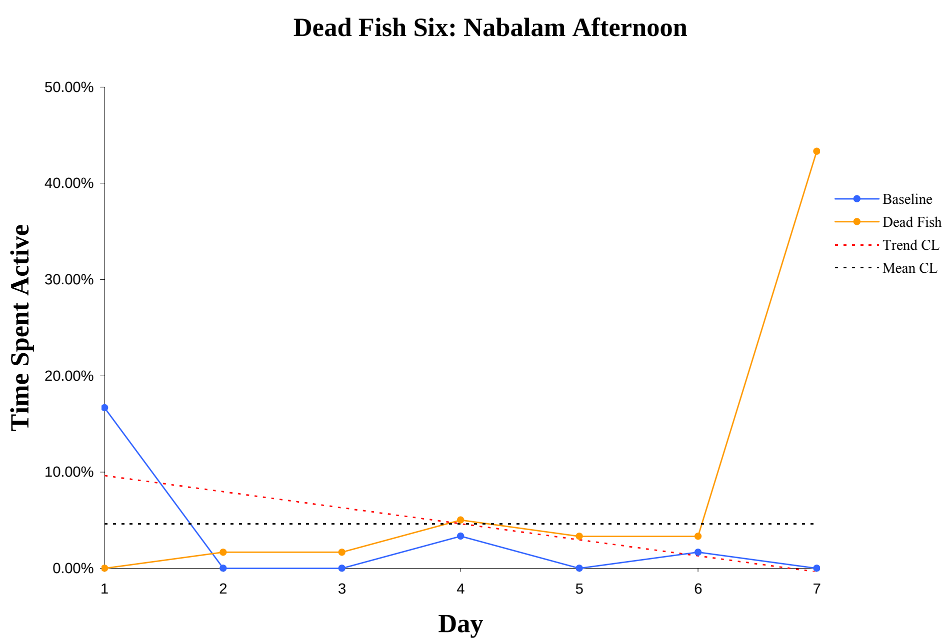

Figure A.32: Percentage of time spent active for Nabalam in the afternoon of dead fish six. The results are not significant.

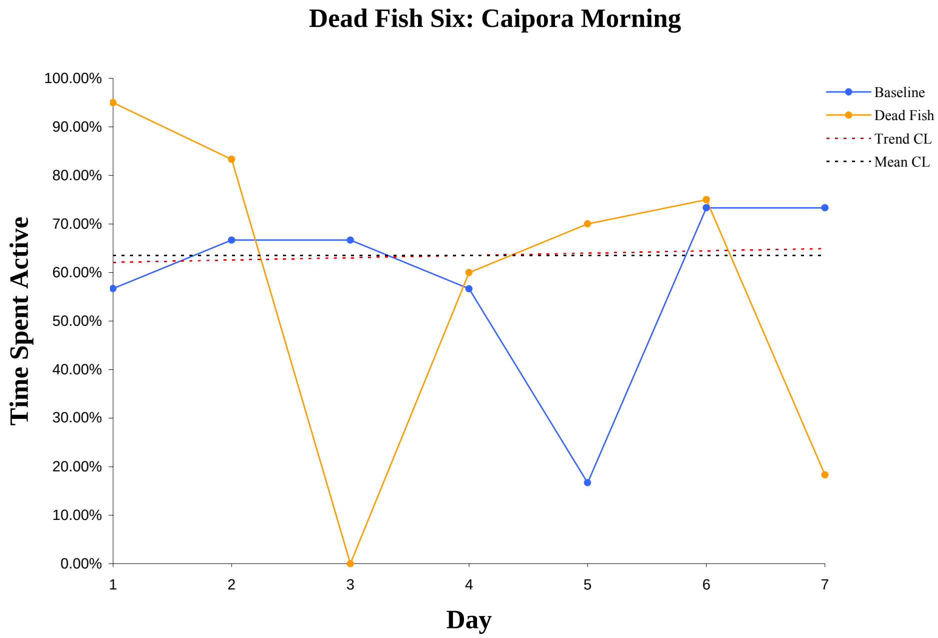

Figure A.33: Percentage of time spent active for Caipora in the morning of dead fish six. The results are not significant.

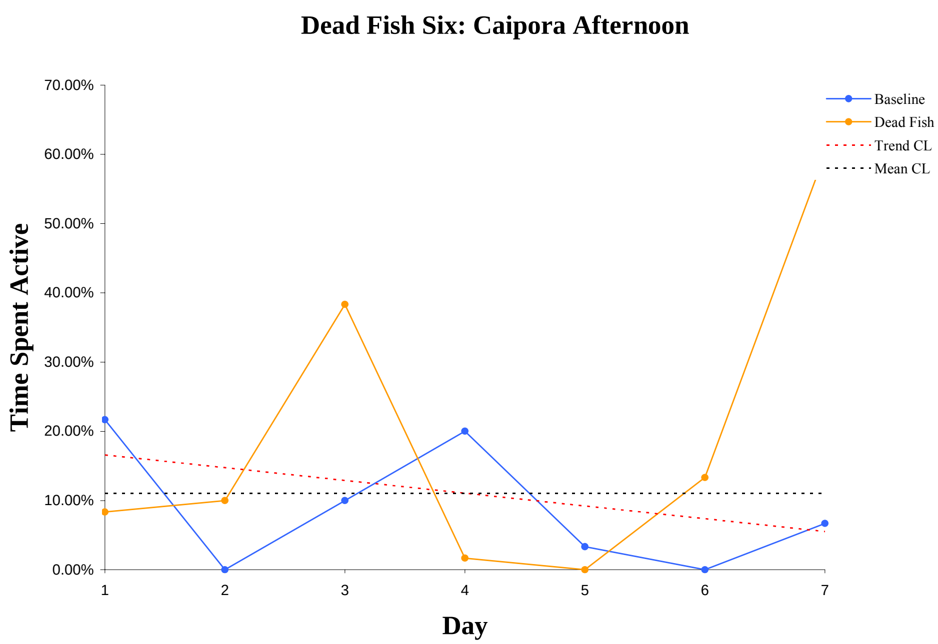

Figure A.34: Percentage of time spent active for Caipora in the afternoon of dead fish six. The results are not significant.

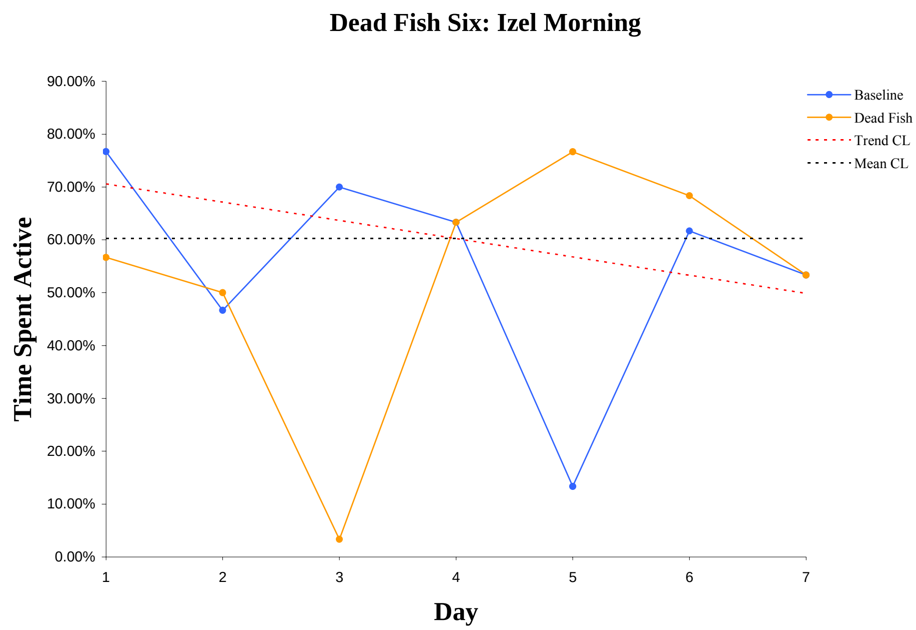

Figure A.35: Percentage of time spent active for Izel in the morning of dead fish six. The results are not significant.

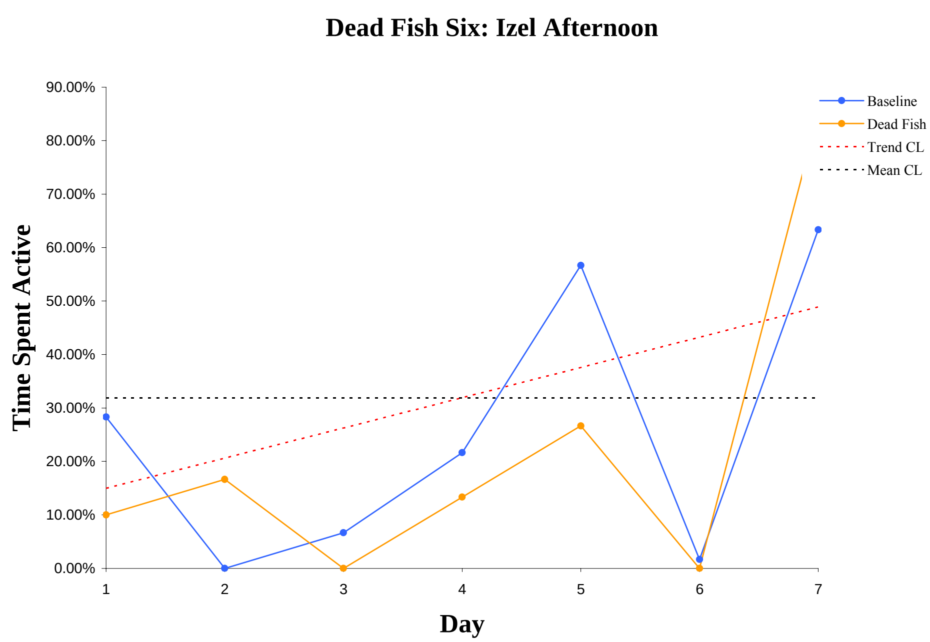

Figure A.36: Percentage of time spent active for Izel in the afternoon of dead fish six. The results are not significant.

APPENDIX B: BEHAVIORAL DIVERSITY

Dead Fish One: Nabalam Morning

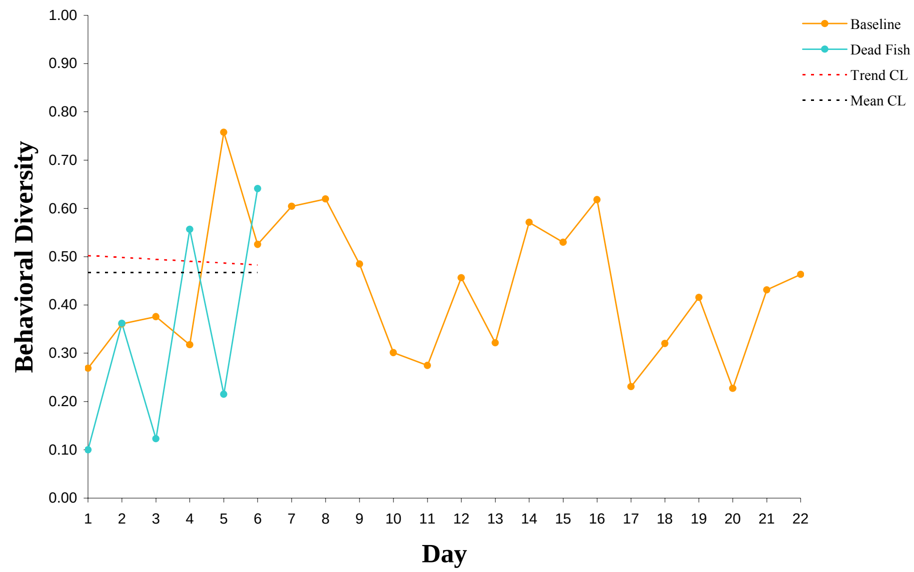

Figure B.1: Behavioral diversity for Nabalam in the morning of dead fish one. The results are not significant.

Dead Fish One: Nabalam Afternoon

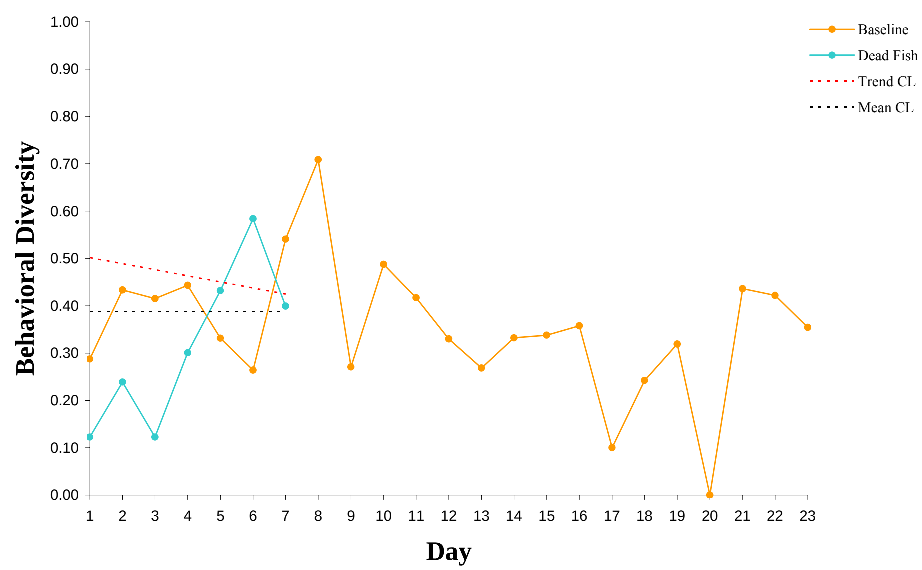

Figure B.2: Behavioral diversity for Nabalam in the afternoon of dead fish one. The results are not significant.

Dead Fish One: Caipora Morning

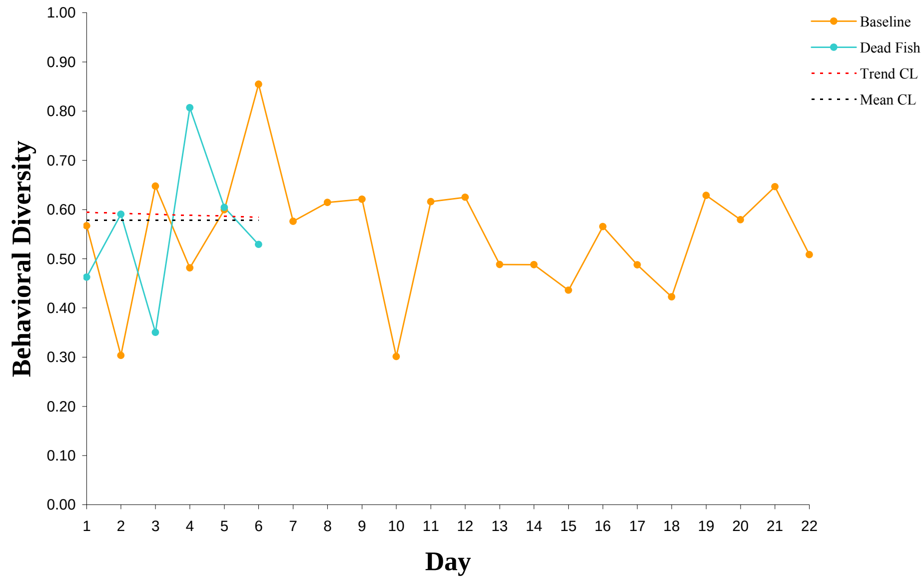

Figure B.3: Behavioral diversity for Caipora in the morning of dead fish one. The results are not significant.

Dead Fish One: Caipora Afternoon

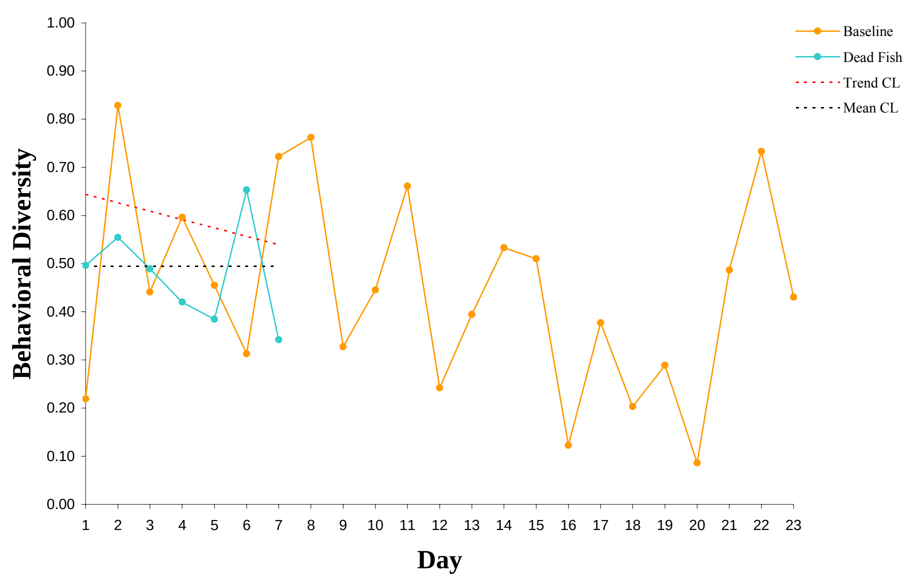

Figure B.4: Behavioral diversity for Caipora in the afternoon of dead fish one. The results are not significant.

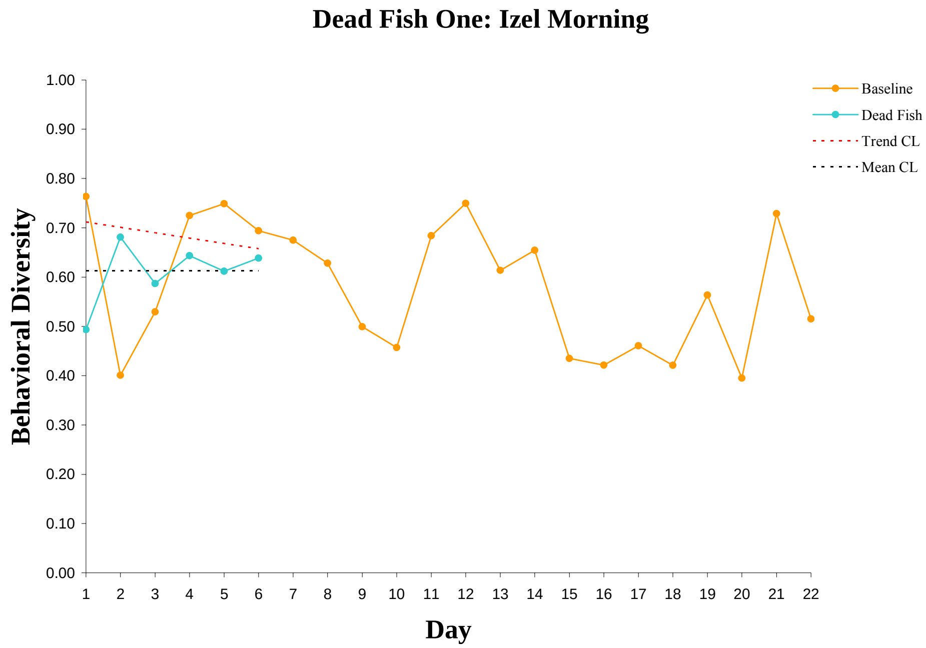

Figure B.5: Behavioral diversity for Izel in the morning of dead fish one. The results are not significant.

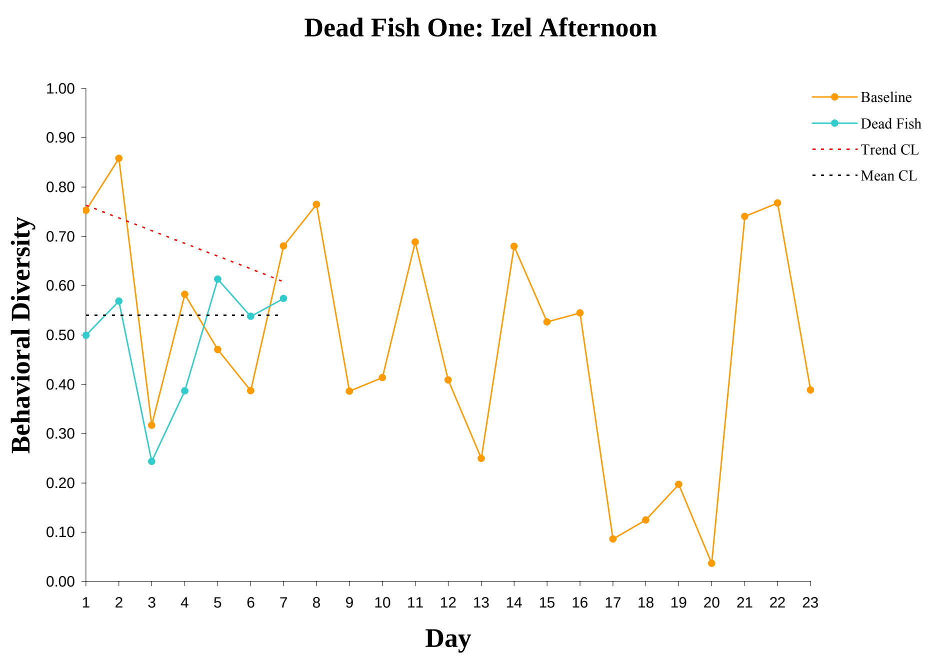

Figure B.6: Behavioral diversity for Izel in the afternoon of dead fish one. The results are not significant.

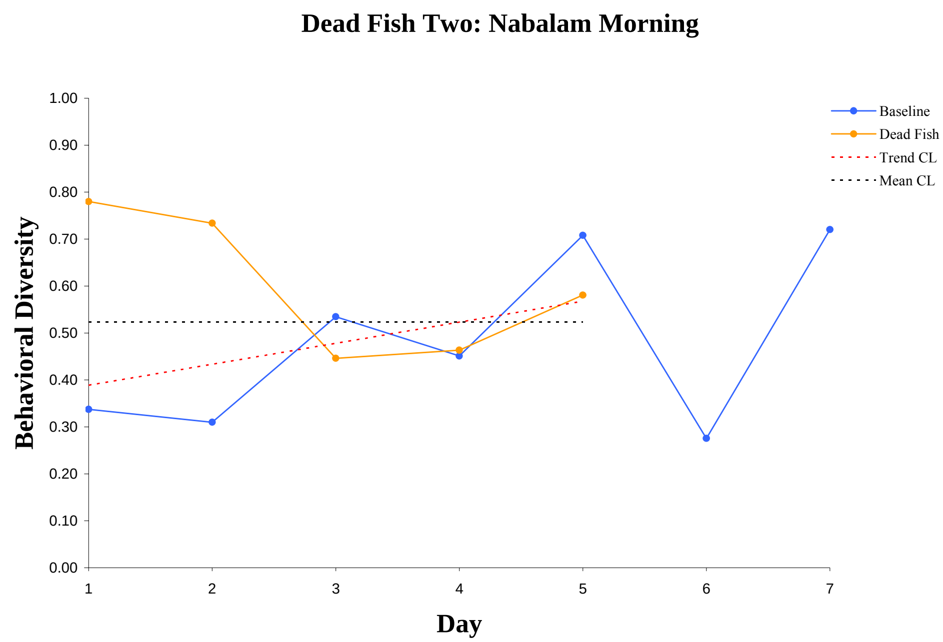

Figure B.7: Behavioral diversity for Nabalam in the morning of dead fish two. The results are not significant.

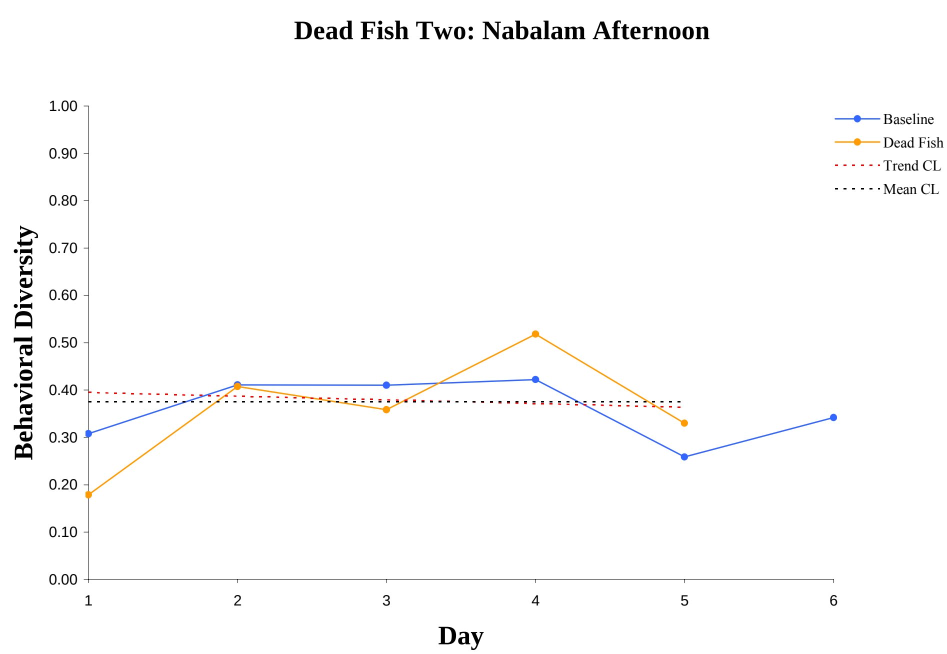

Figure B.8: Behavioral diversity for Nabalam in the afternoon of dead fish two. The results are not significant.

Dead Fish Two: Caipora Morning

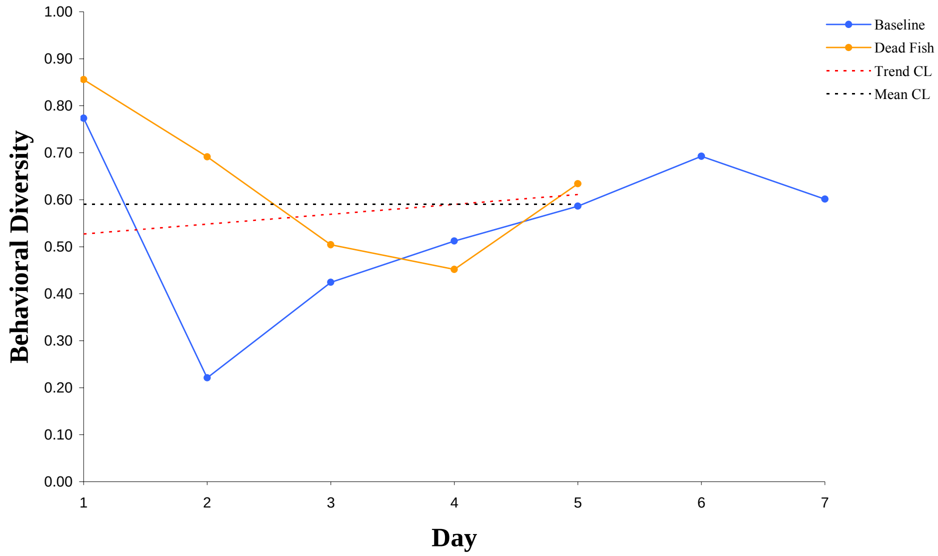

Figure B.9: Behavioral diversity for Caipora in the morning of dead fish two. The results are not significant.

Dead Fish Two: Caipora Afternoon

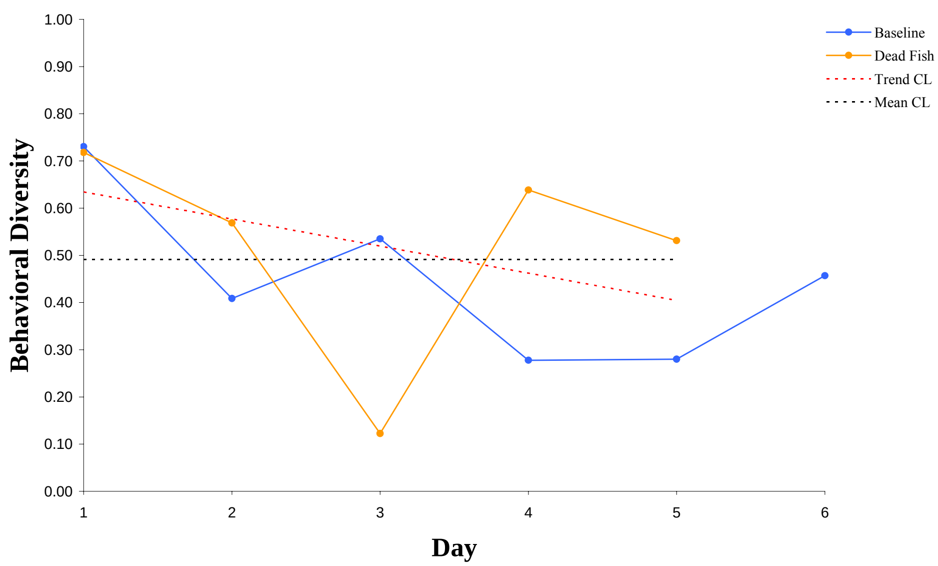

Figure B.10: Behavioral diversity for Caipora in the afternoon of dead fish two. The results are not significant.

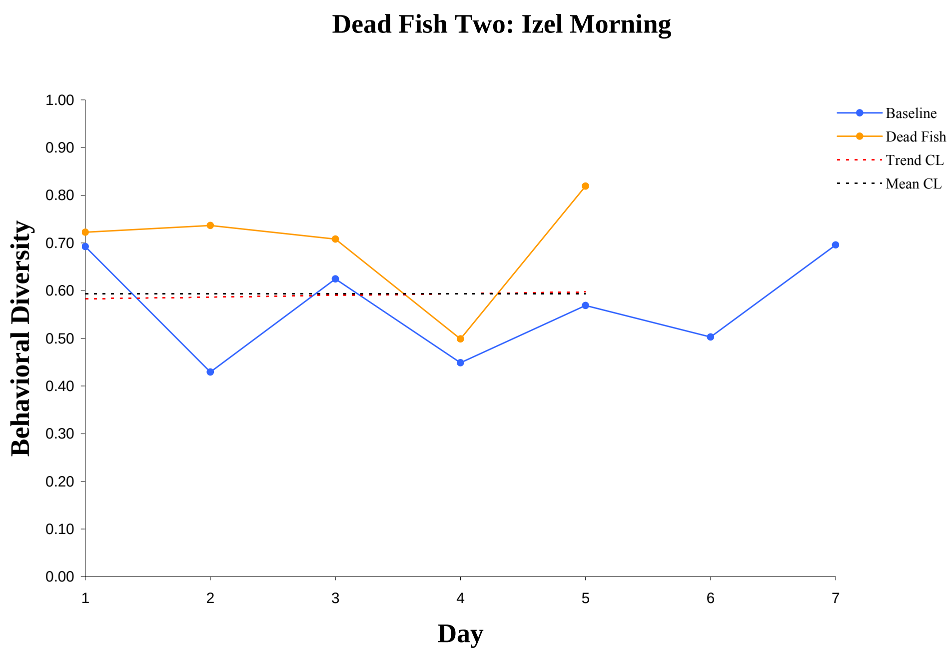

Figure B.11: Behavioral diversity for Izel in the morning of dead fish two. The results are not significant.

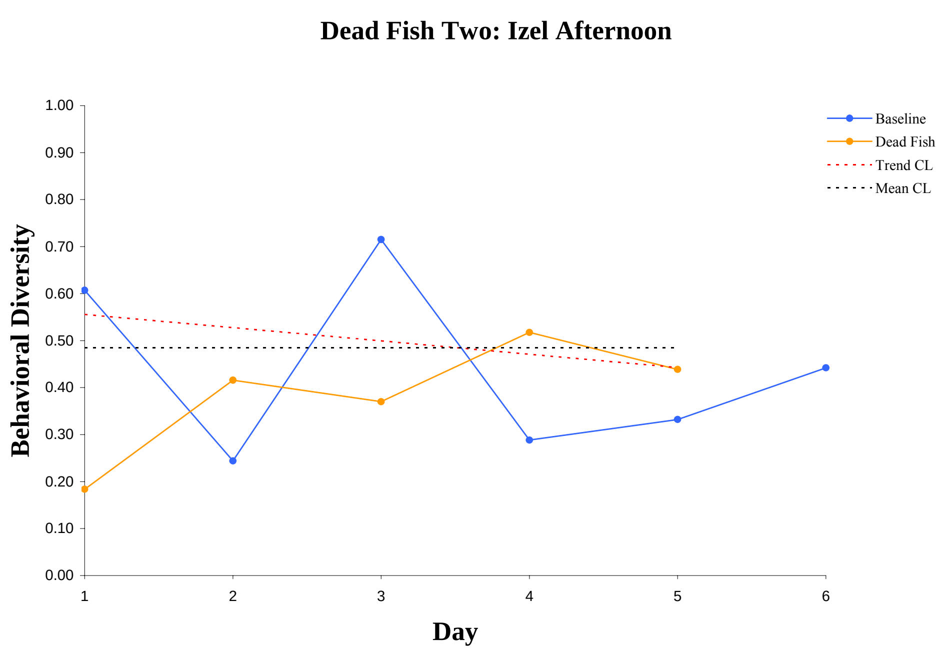

Figure B.12: Behavioral diversity for Izel in the afternoon of dead fish two. The results are not significant.

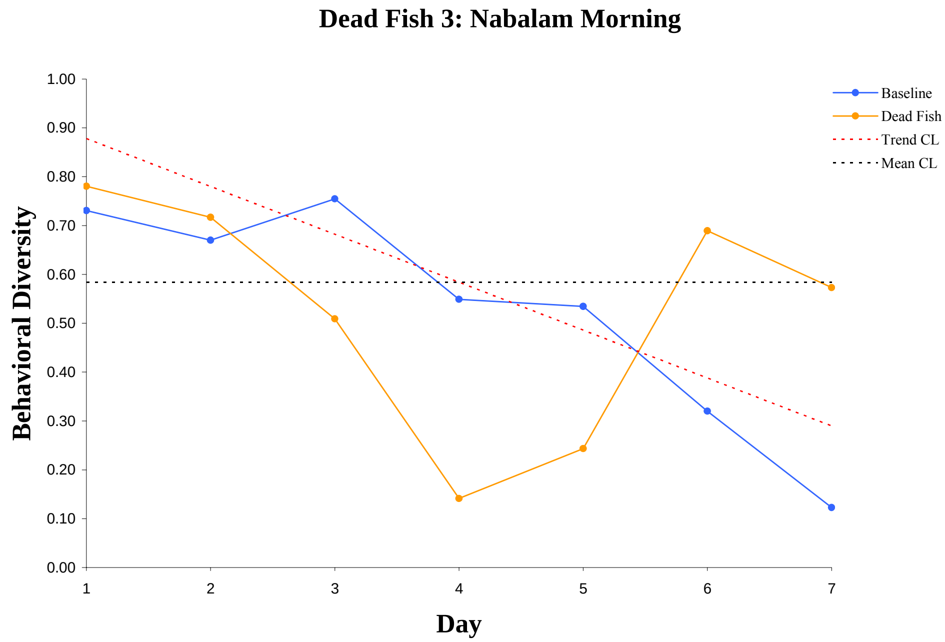

Figure B.13: Behavioral diversity for Nabalam in the morning of dead fish three. The results are not significant.

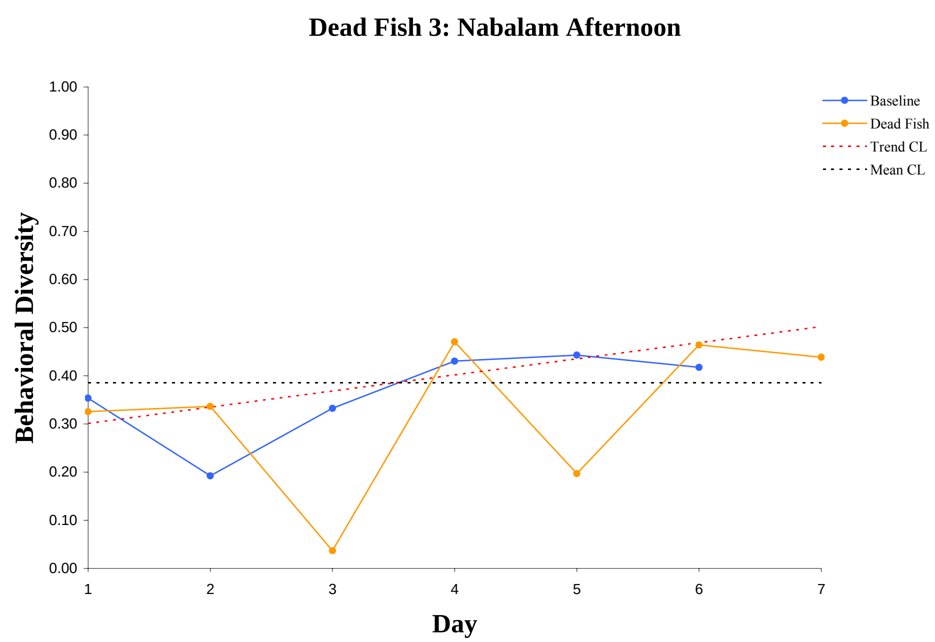

Figure B.14: Behavioral diversity for Nabalam in the afternoon of dead fish three. The results are not significant.

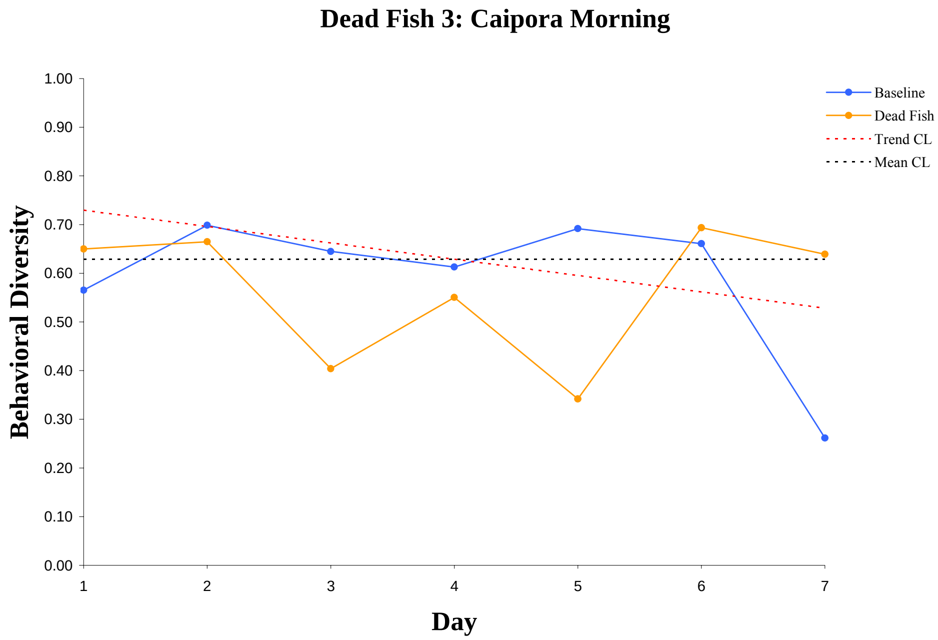

Figure B.15: Behavioral diversity for Caipora in the morning of dead fish three. The results are not significant.

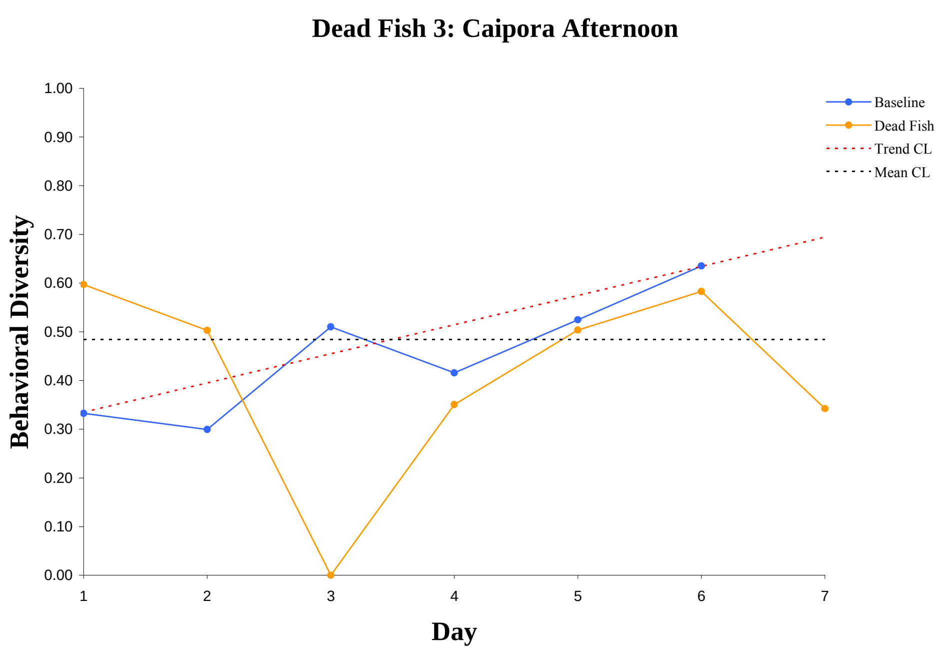

Figure B.16: Behavioral diversity for Caipora in the afternoon of dead fish three. The results are not significant.

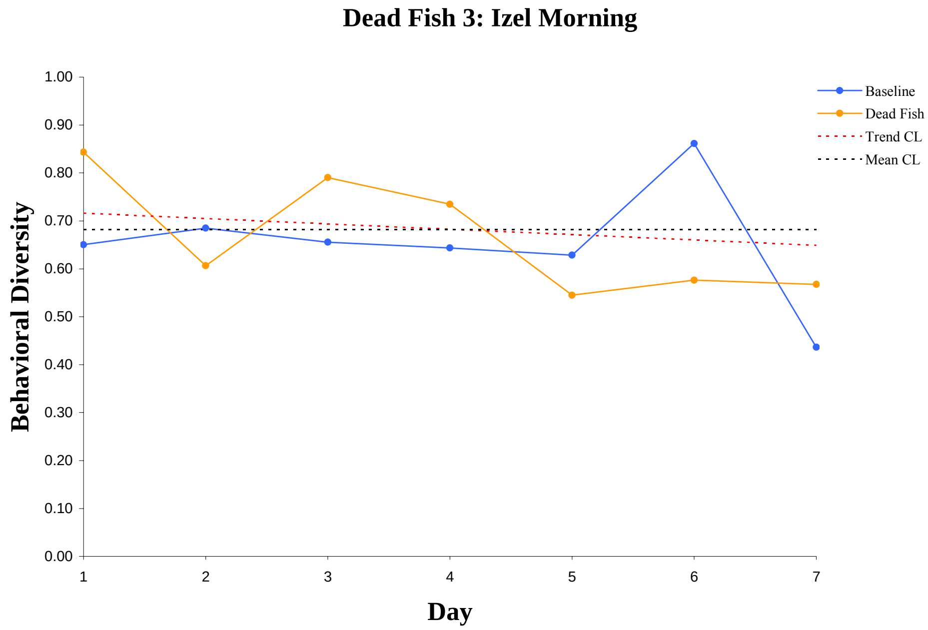

Figure B.17: Behavioral diversity for Izel in the morning of dead fish three. The results are not significant.

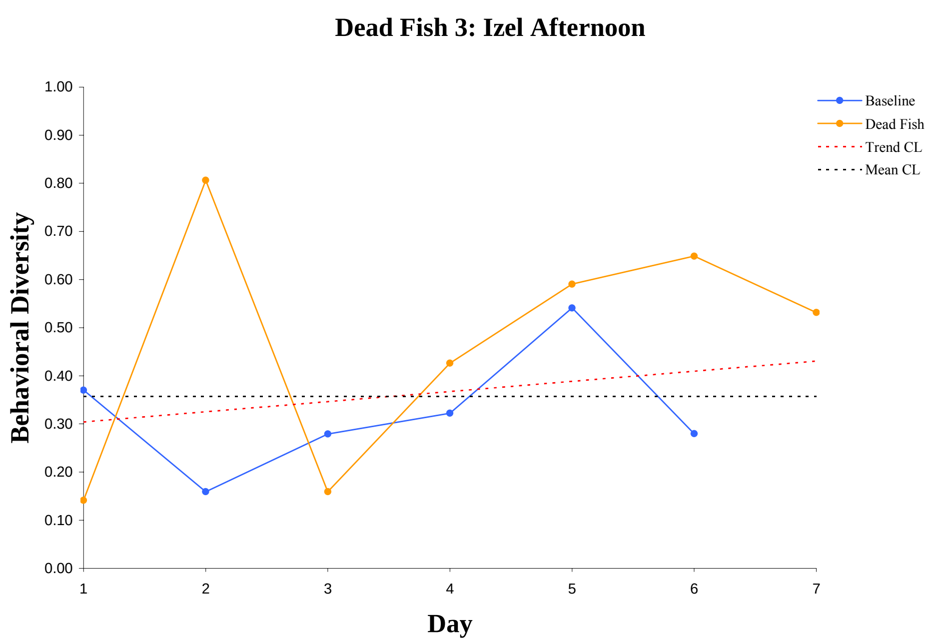

Figure B.18: Behavioral diversity for Izel in the afternoon of dead fish three. The results are not significant.

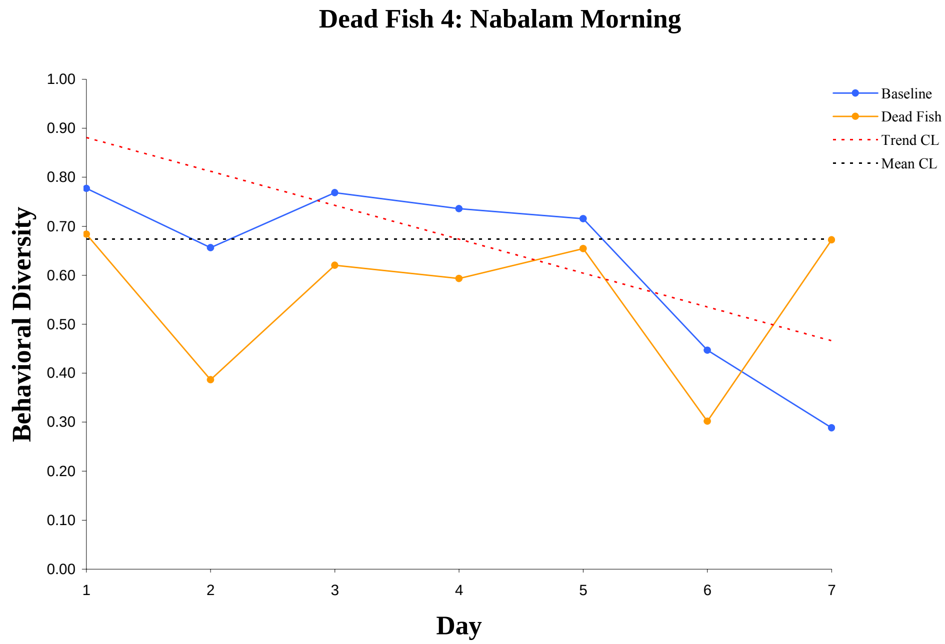

Figure B.19: Behavioral diversity for Nabalam in the morning of dead fish four. The results are not significant.

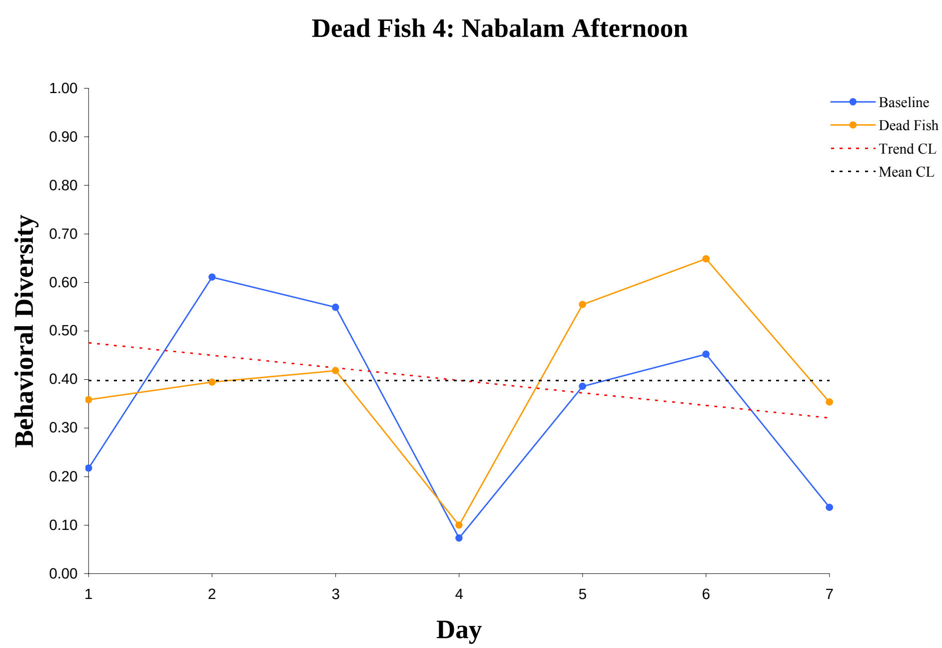

Figure B.20: Behavioral diversity for Nabalam in the afternoon of dead fish four. The results are not significant.

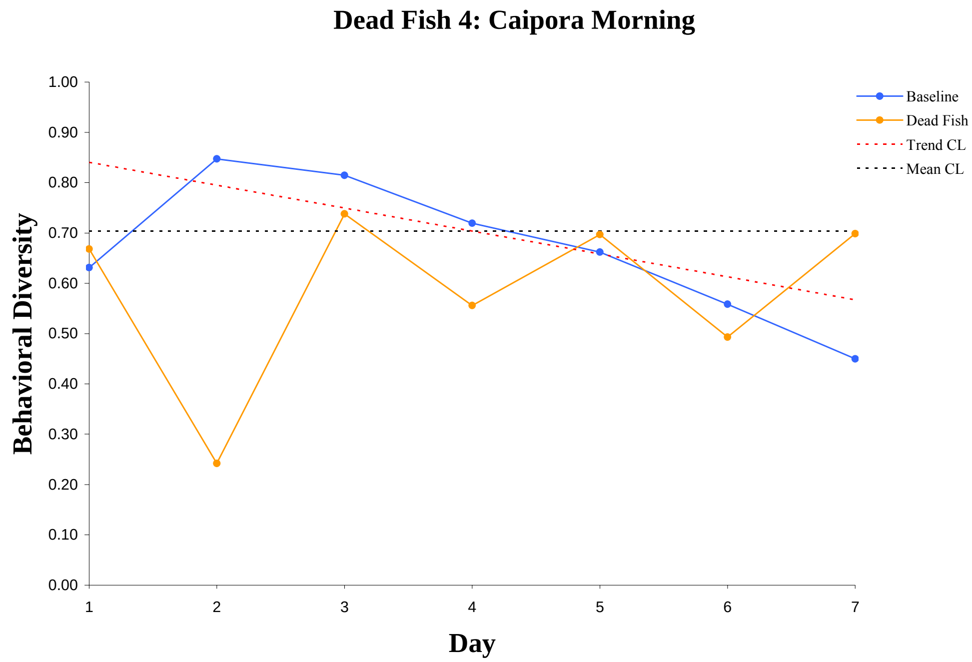

Figure B.21: Behavioral diversity for Caipora in the morning of dead fish four. The results are not significant.

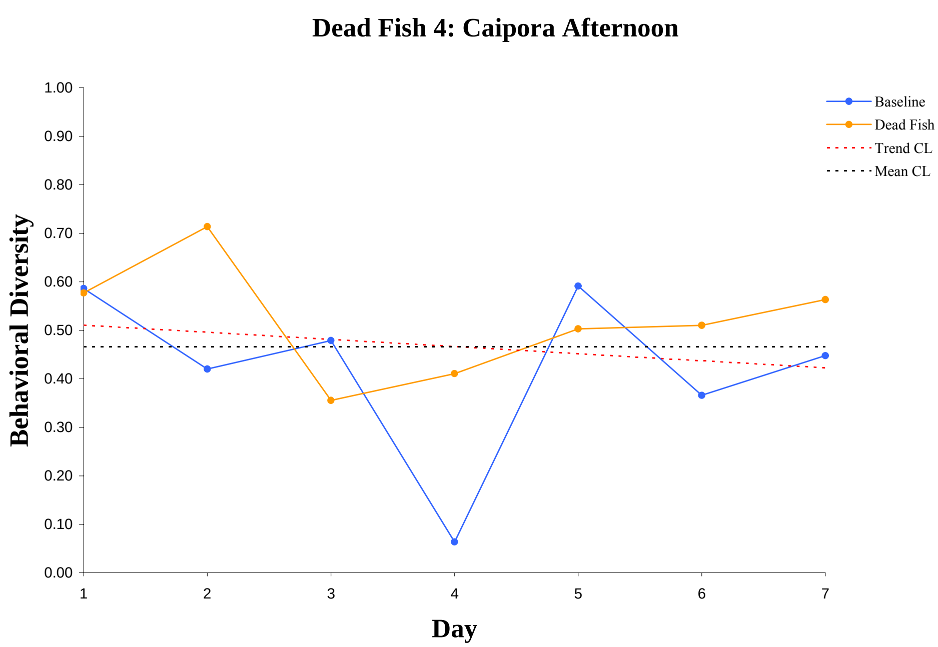

Figure B.22: Behavioral diversity for Caipora in the afternoon of dead fish four. The results are not significant.

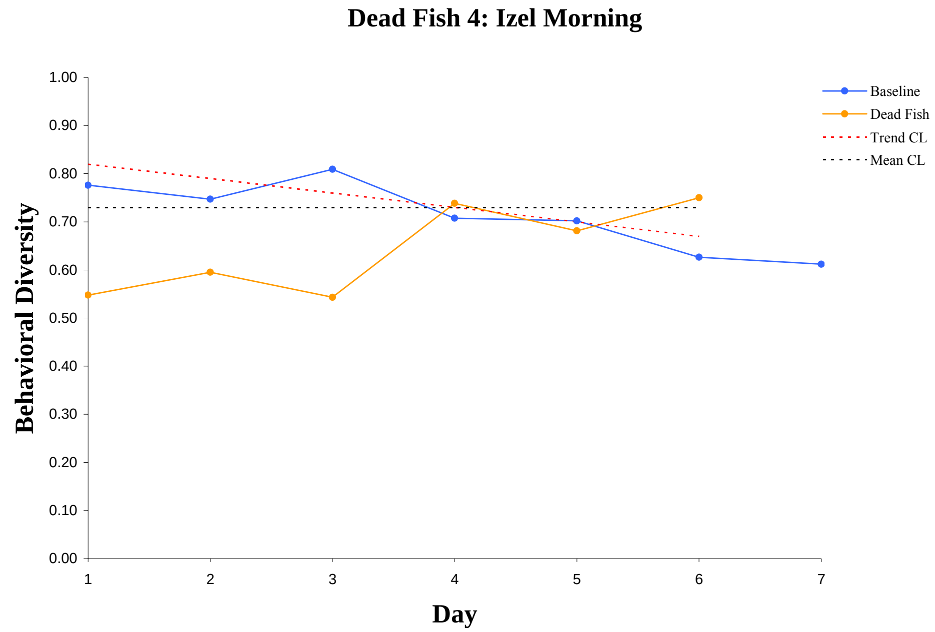

Figure B.23: Behavioral diversity for Izel in the morning of dead fish four. The results are not significant.

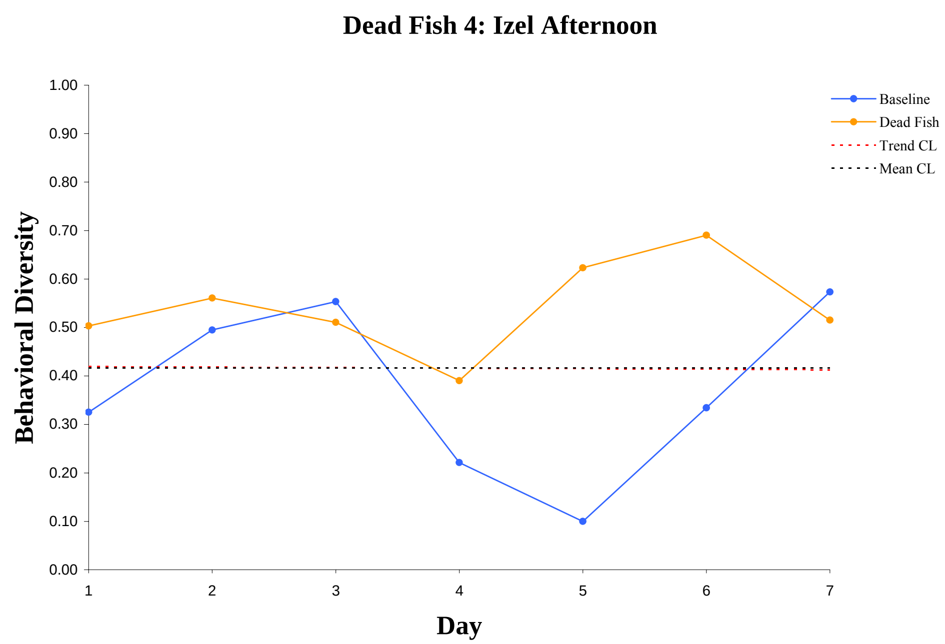

Figure B.24: Behavioral diversity for Izel in the afternoon of dead fish four. The results are not significant.

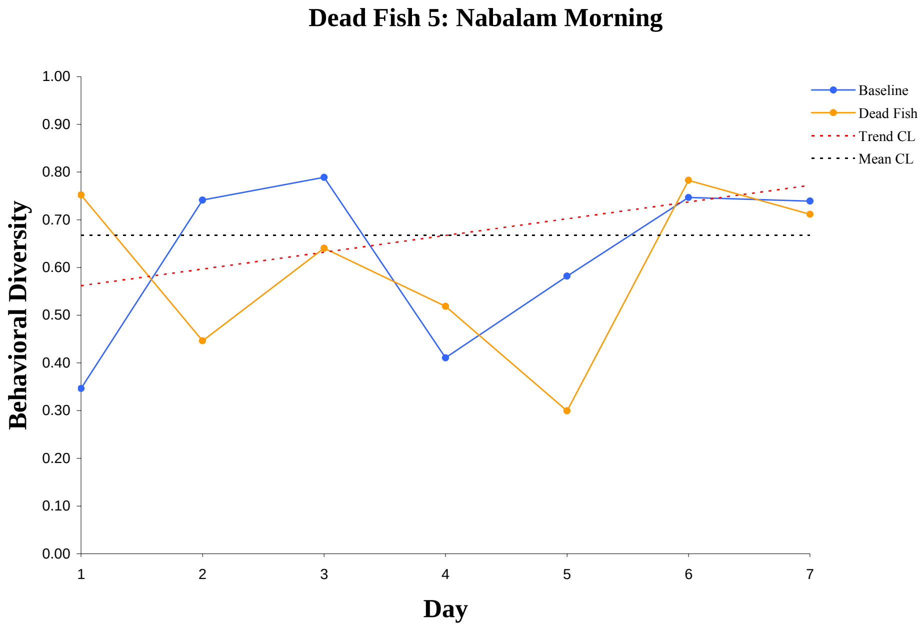

Figure B.25: Behavioral diversity for Nabalam in the morning of dead fish five. The results are not significant.

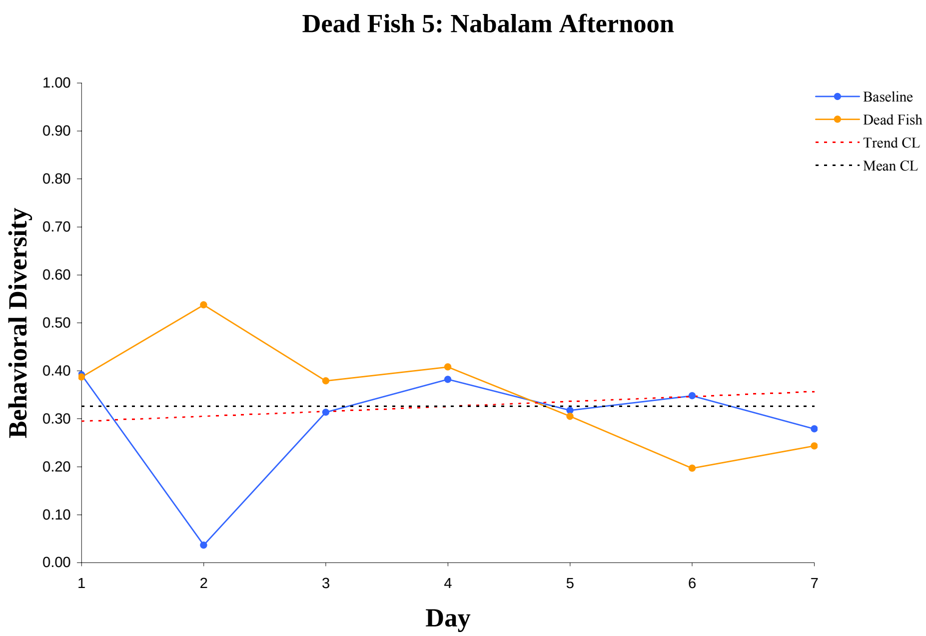

Figure B.26: Behavioral diversity for Nabalam in the afternoon of dead fish five. The results are not significant.

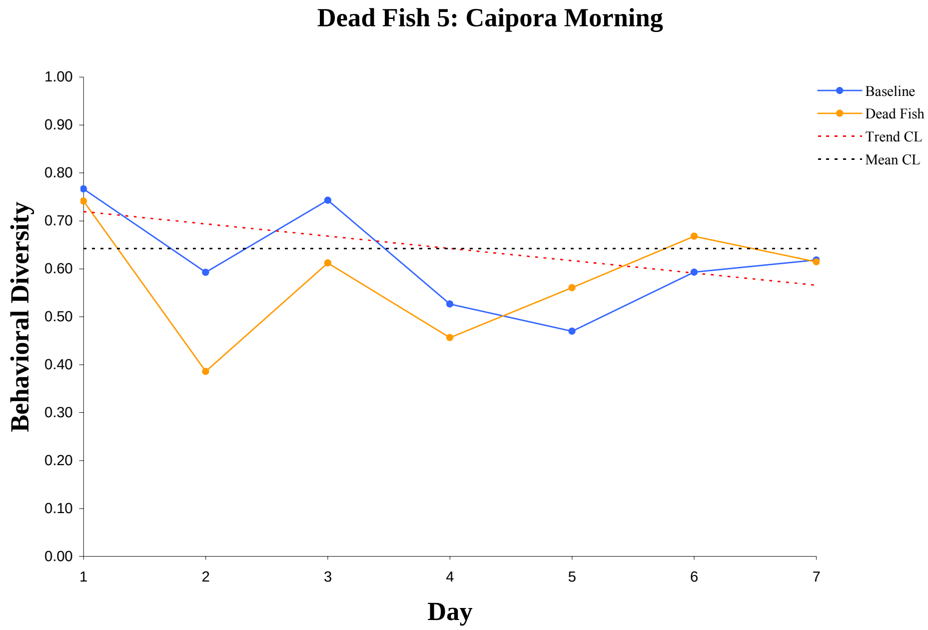

Figure B.27: Behavioral diversity for Caipora in the morning of dead fish five. The results are not significant.

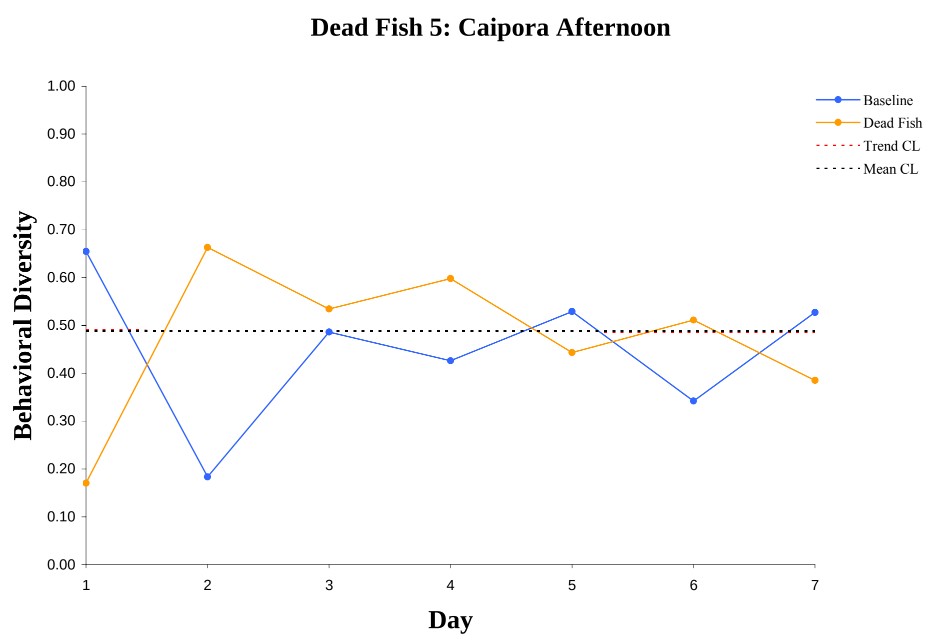

Figure B.28: Behavioral diversity for Caipora in the afternoon of dead fish five. The results are not significant.

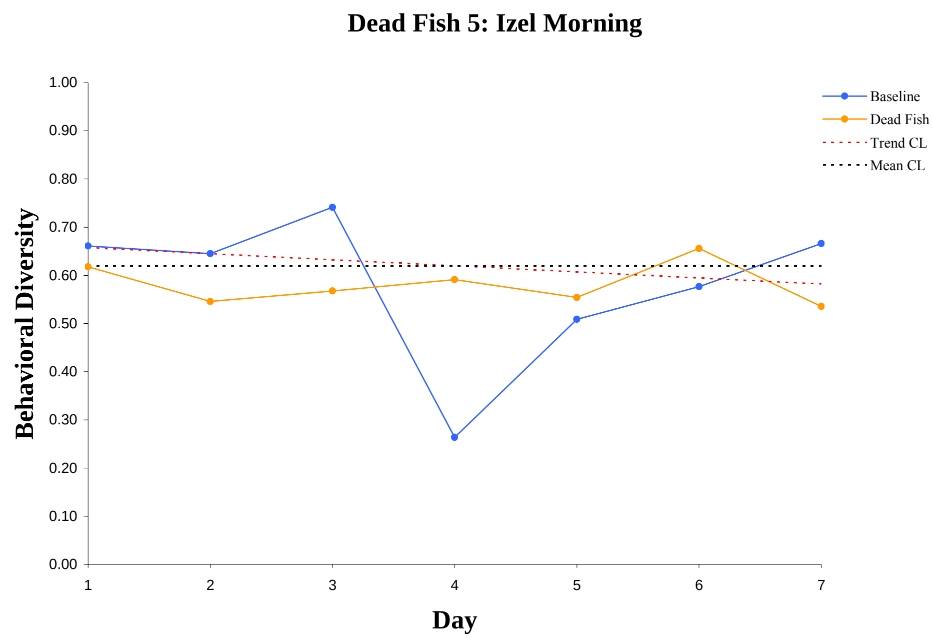

Figure B.29: Behavioral diversity for Izel in the morning of dead fish five. The results are not significant.

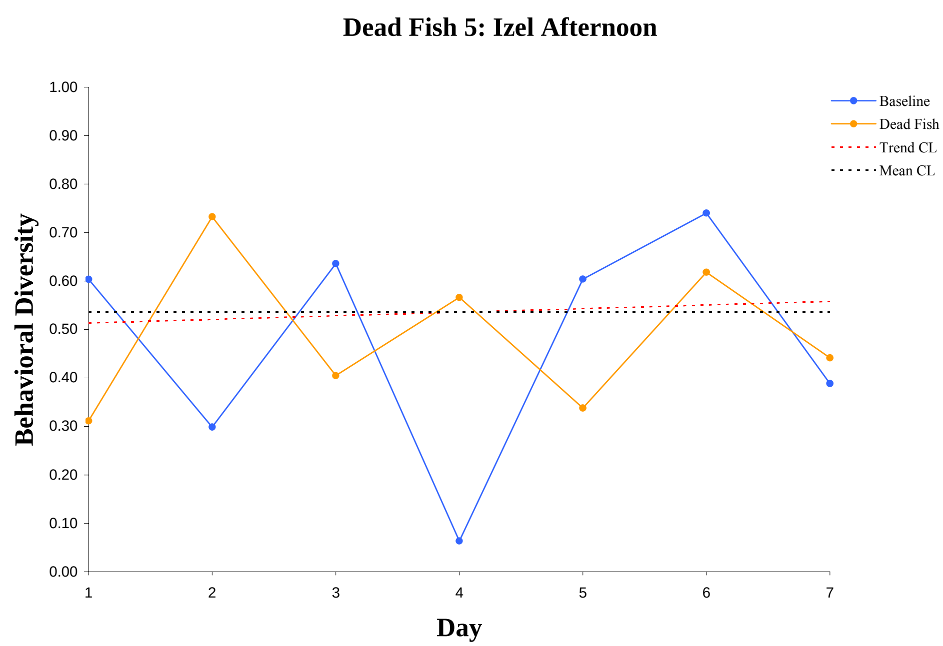

Figure B.30: Behavioral diversity for Izel in the afternoon of dead fish five. The results are not significant.

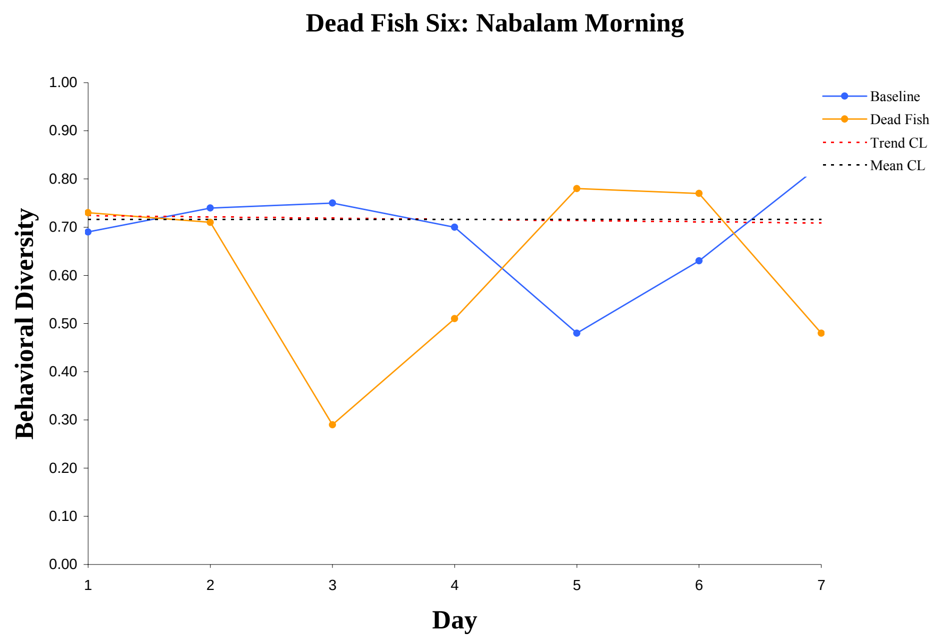

Figure B.31: Behavioral diversity for Nabalam in the morning of dead fish six. The results are not significant.

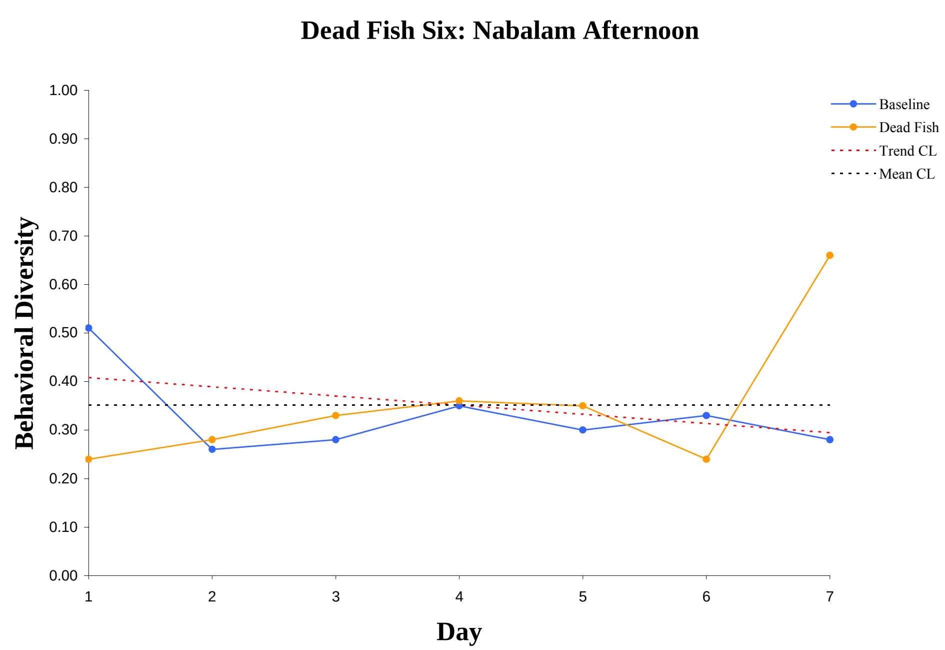

Figure B.32: Behavioral diversity for Nabalam in the afternoon of dead fish six. The results are not significant.

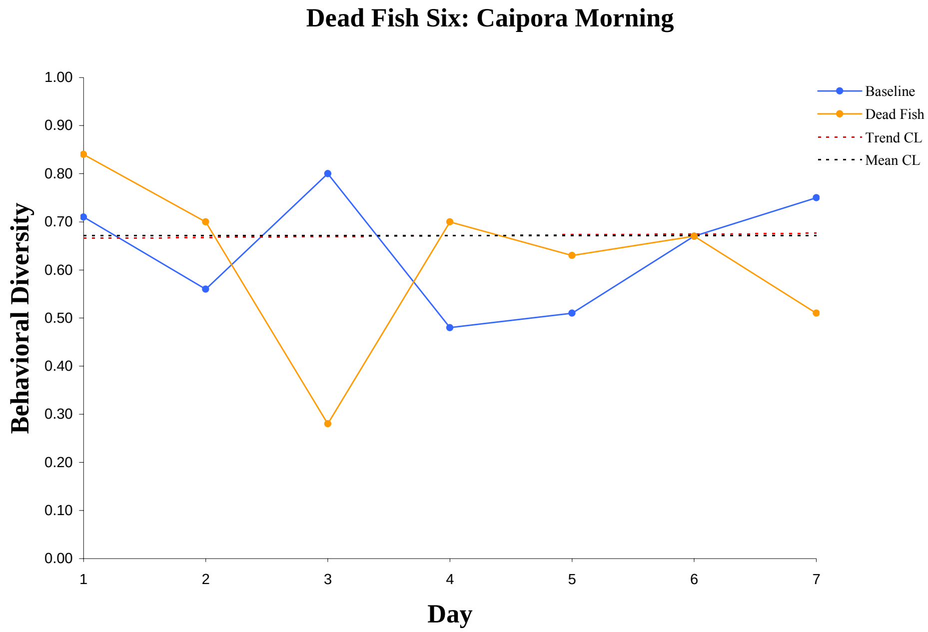

Figure B.33: Behavioral diversity for Caipora in the morning of dead fish six. The results are not significant.

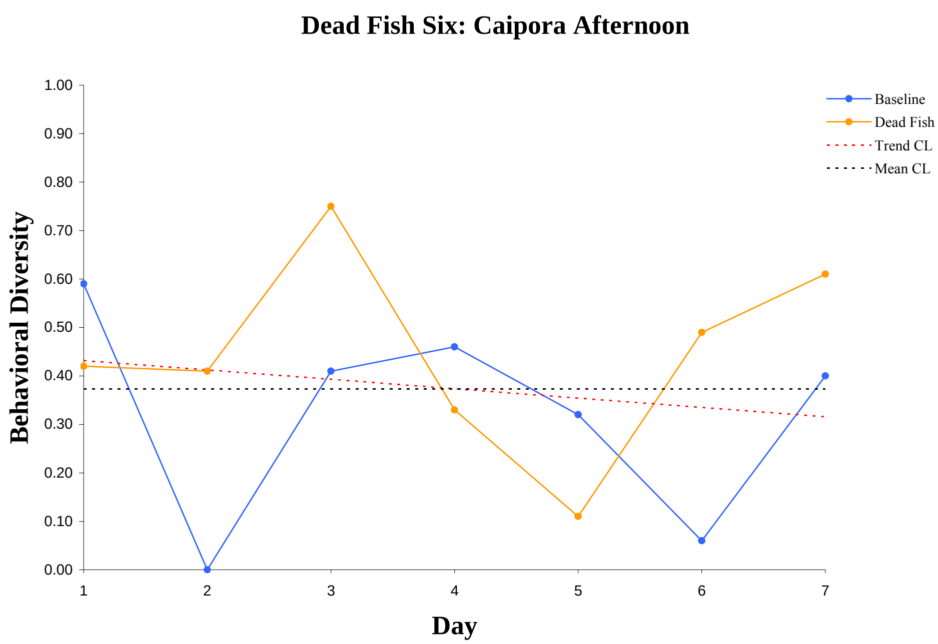

Figure B.34: Behavioral diversity for Caipora in the afternoon of dead fish six. The results are not significant.

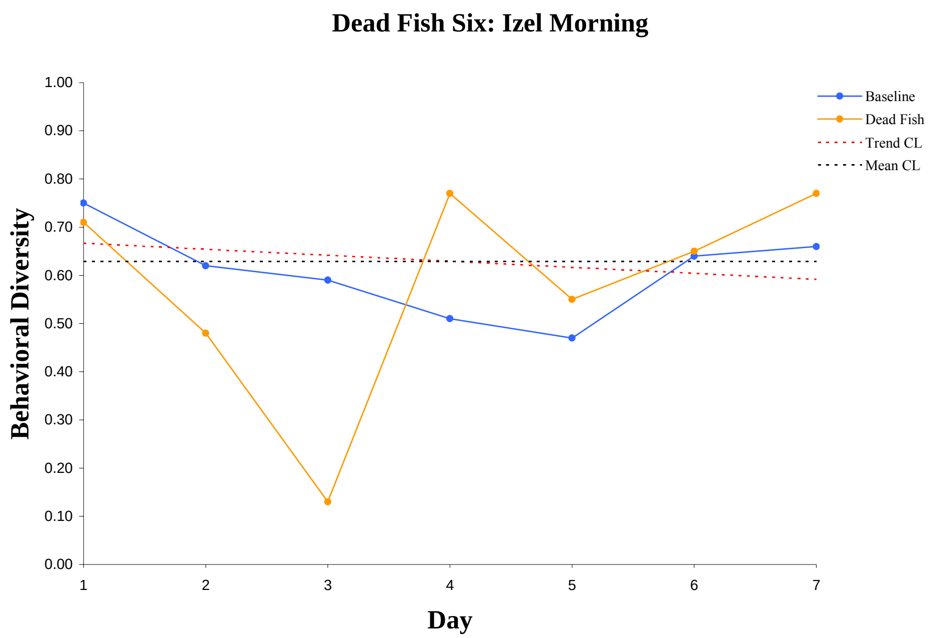

Figure B.35: Behavioral diversity for Izel in the morning of dead fish six. The results are not significant.

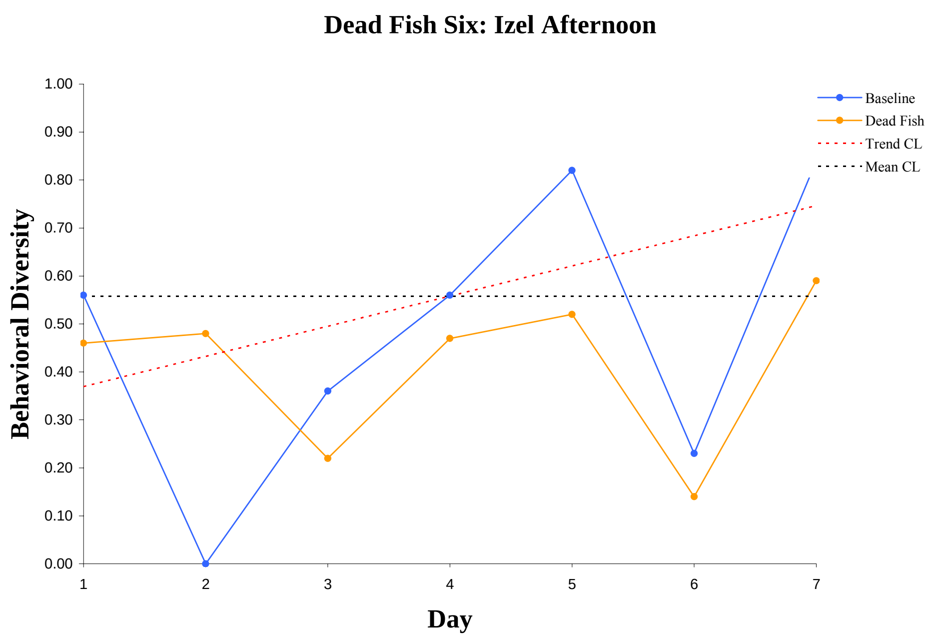

Figure B.36: Behavioral diversity for Izel in the afternoon of dead fish six. The results are not significant.

APPENDIX C: CORTICOSTERONE

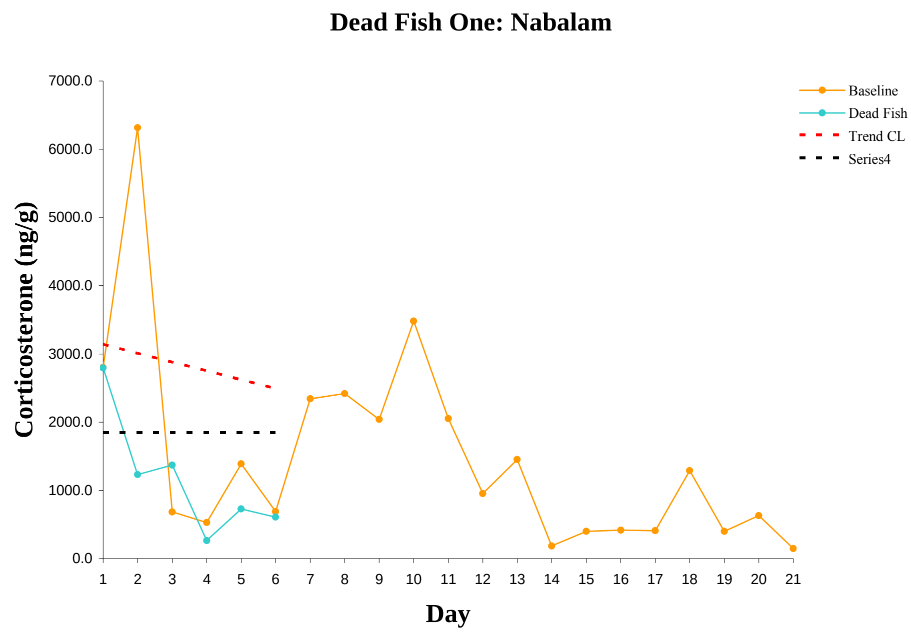

Figure C.1: Fecal corticosterone levels for Nabalam for dead fish one. The results are not significant.

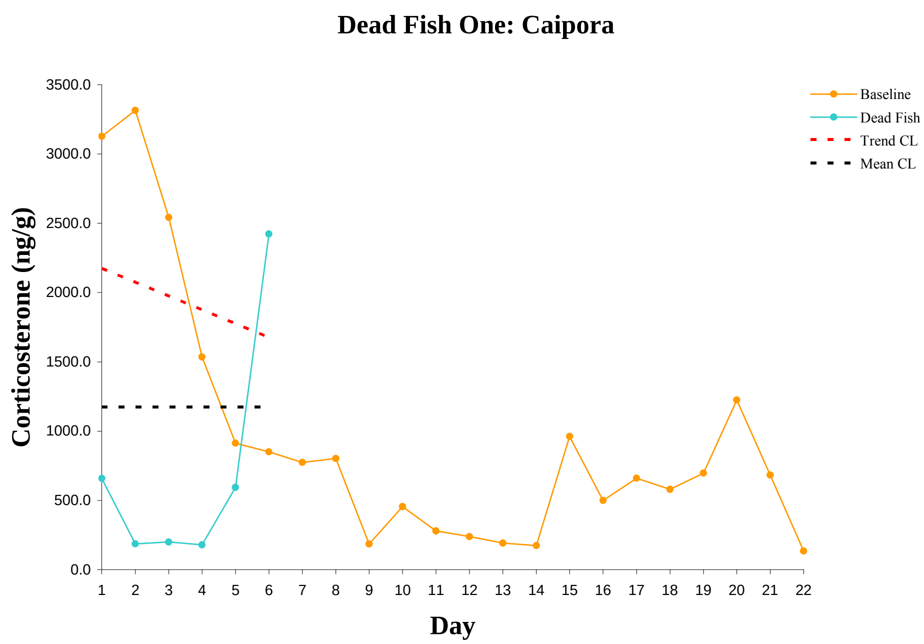

Figure C.2: Fecal corticosterone levels for Caipora for dead fish one. The results are not significant.

Dead Fish One: Izel

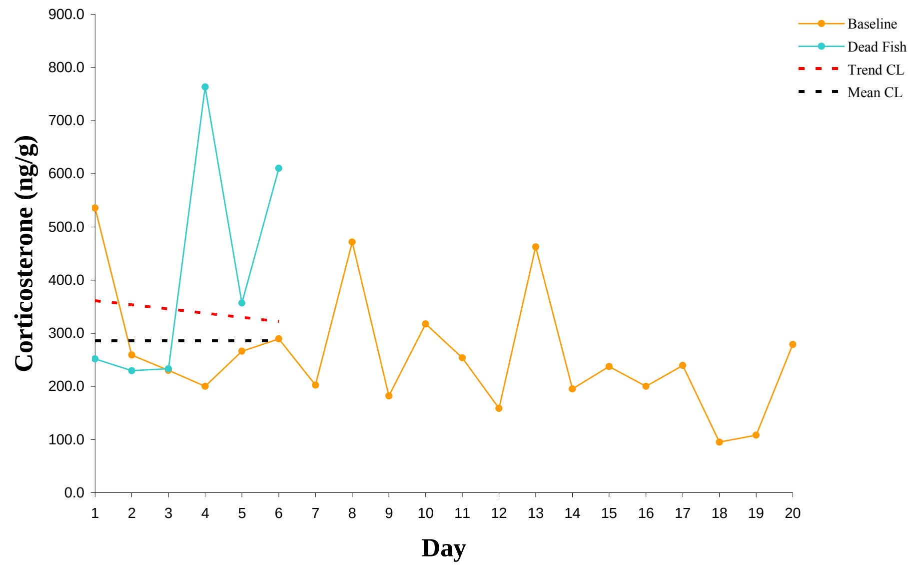

Figure C.3: Fecal corticosterone levels for Izel for dead fish one. The results are not significant.

Dead Fish Two: Nabalam

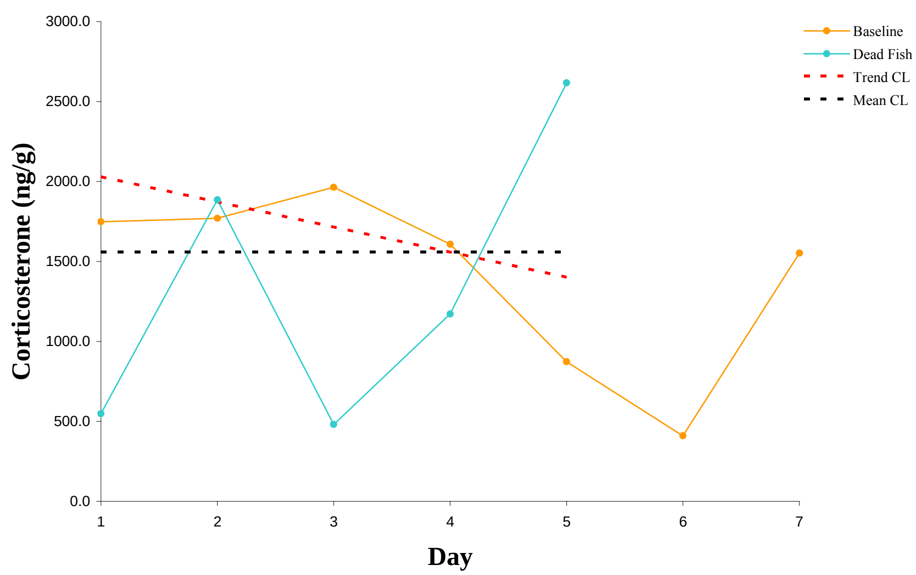

Figure C.4: Fecal corticosterone levels for Nabalam for dead fish two. The results are not significant.

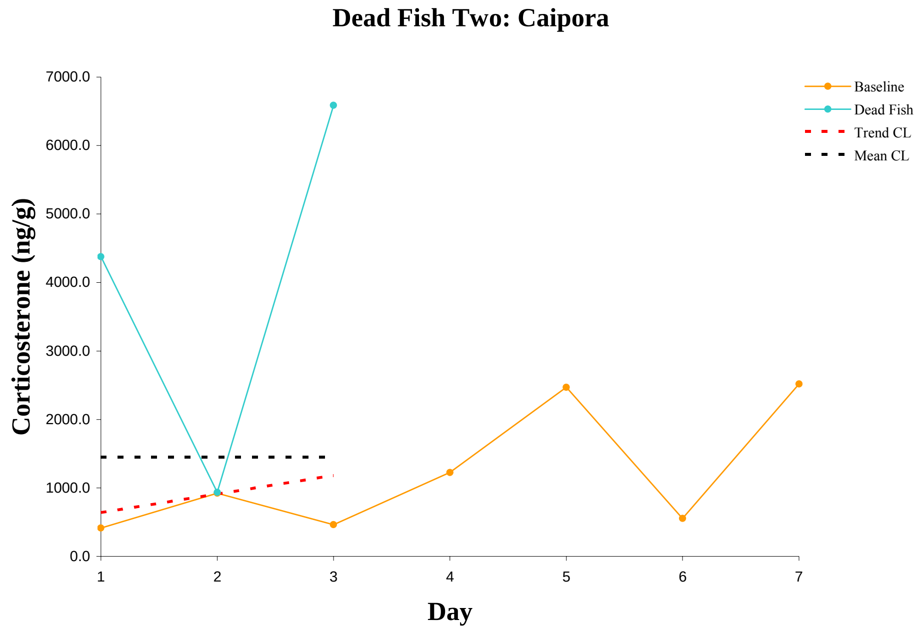

Figure C.5: Fecal corticosterone levels for Caipora for dead fish two. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

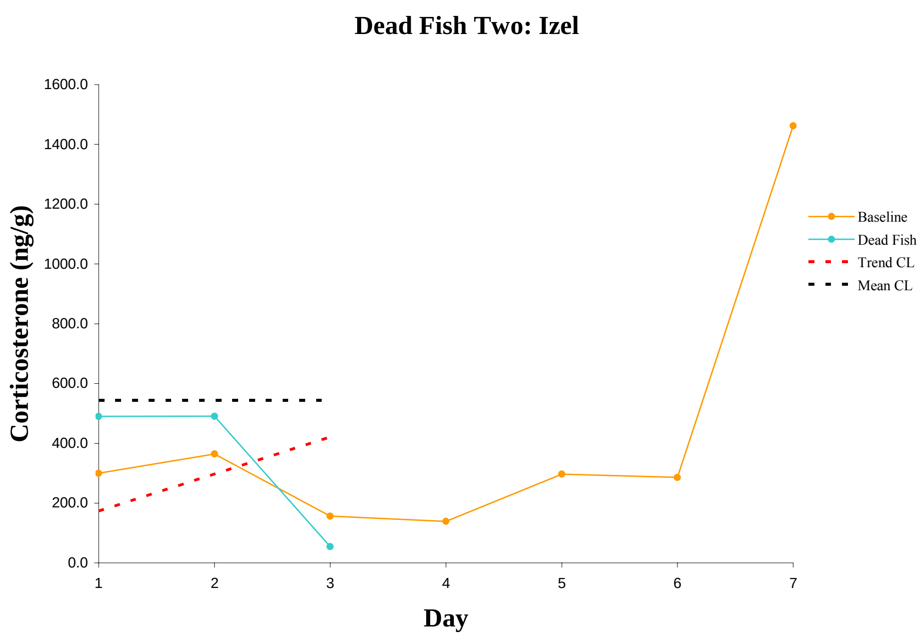

Figure C.6: Fecal corticosterone levels for Izel for dead fish two. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

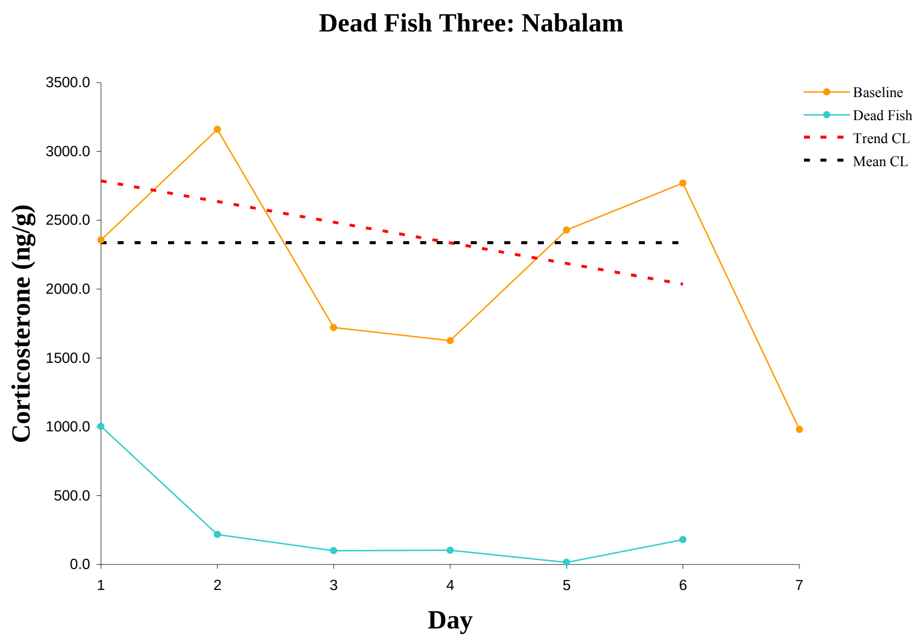

Figure C.7: Fecal corticosterone levels for Nabalam for dead fish three. The results are significant.

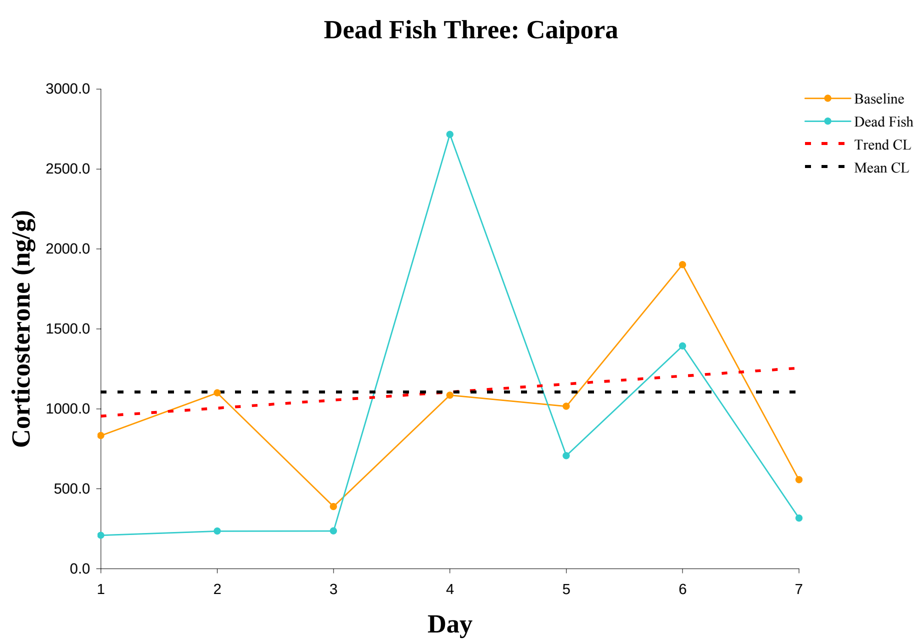

Figure C.8: Fecal corticosterone levels for Caipora for dead fish three. The results are not significant.

Dead Fish Three: Izel

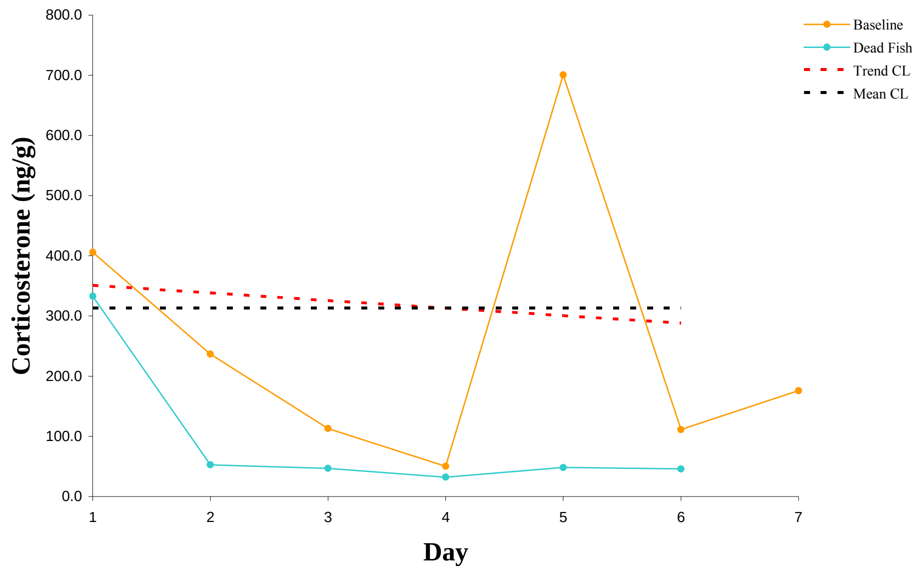

Figure C.9: Fecal corticosterone levels for Izel for dead fish three. The results are not significant.

Dead Fish Four: Nabalam

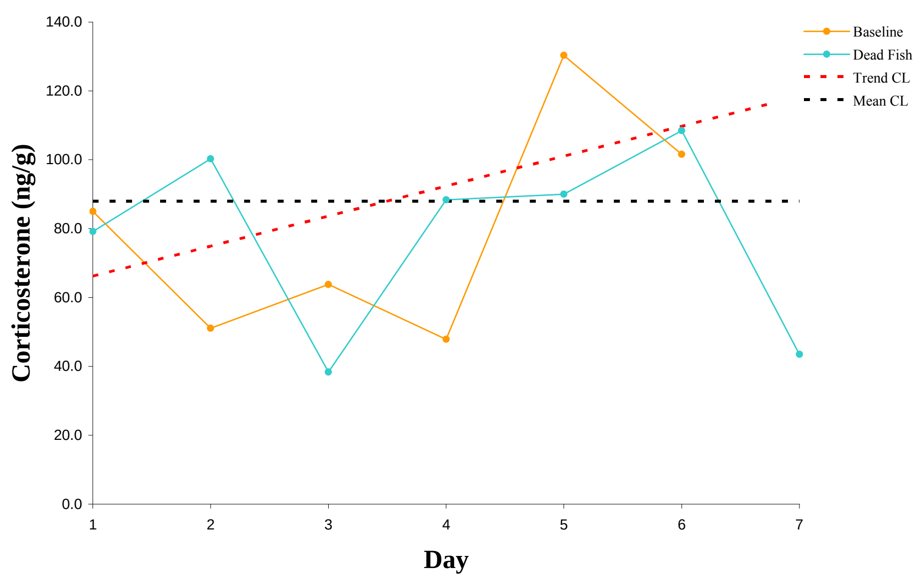

Figure C.10: Fecal corticosterone levels for Nabalam for dead fish four. The results are not significant.

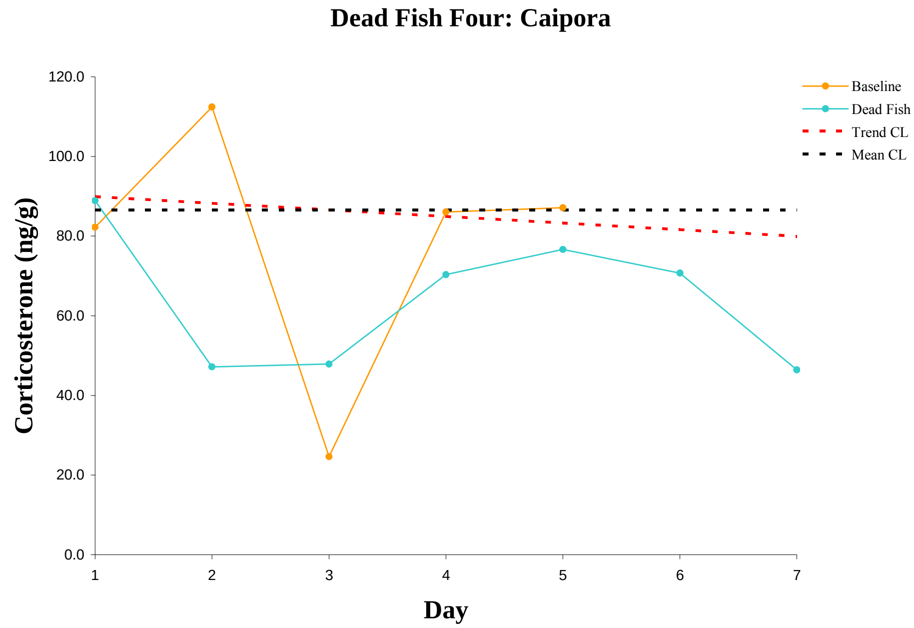

Figure C.11: Fecal corticosterone levels for Caipora for dead fish four. The results are significant.

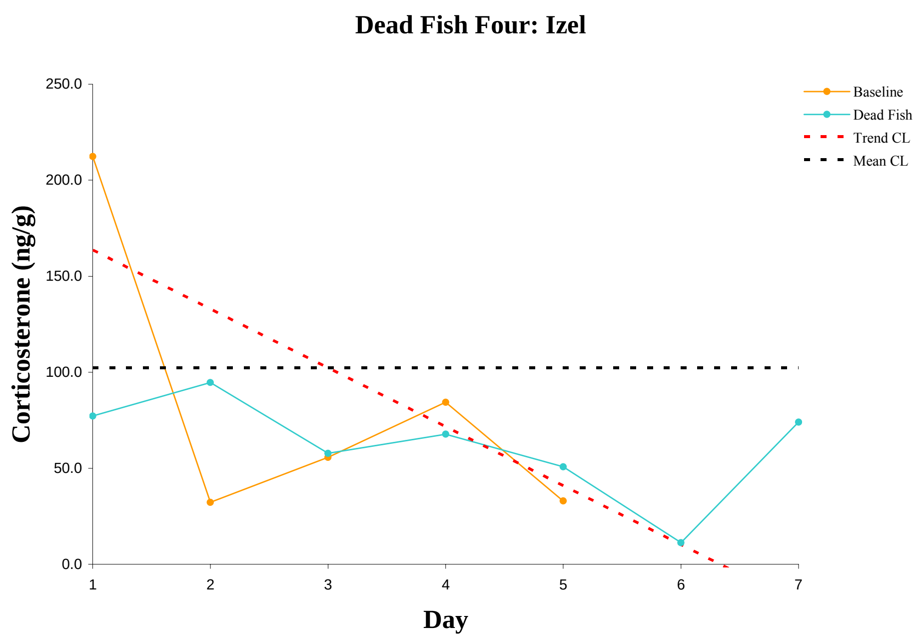

Figure C.12: Fecal corticosterone levels for Izel for dead fish four. The results are not significant.

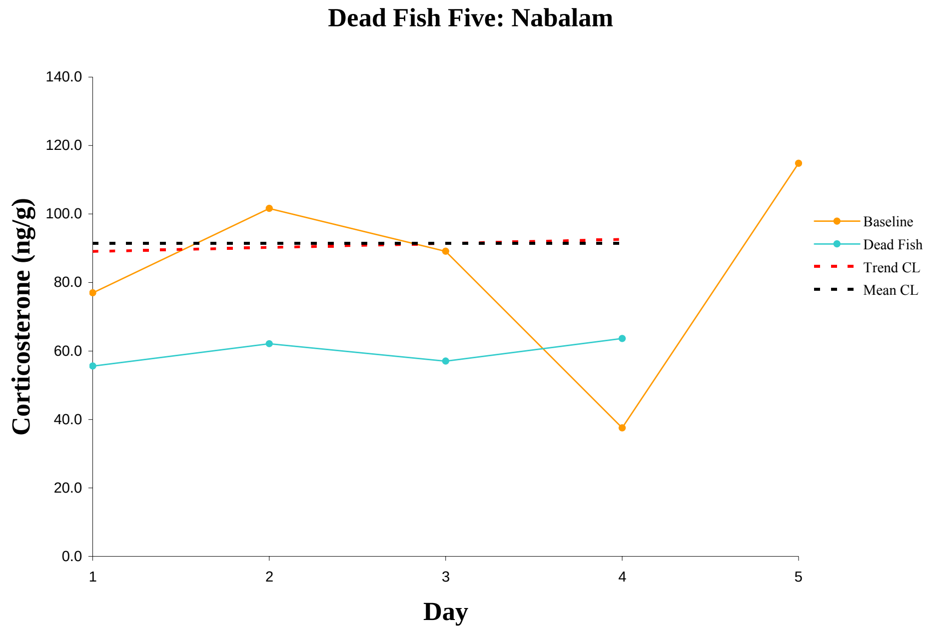

Figure C.13: Fecal corticosterone levels for Nabalam for dead fish five. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

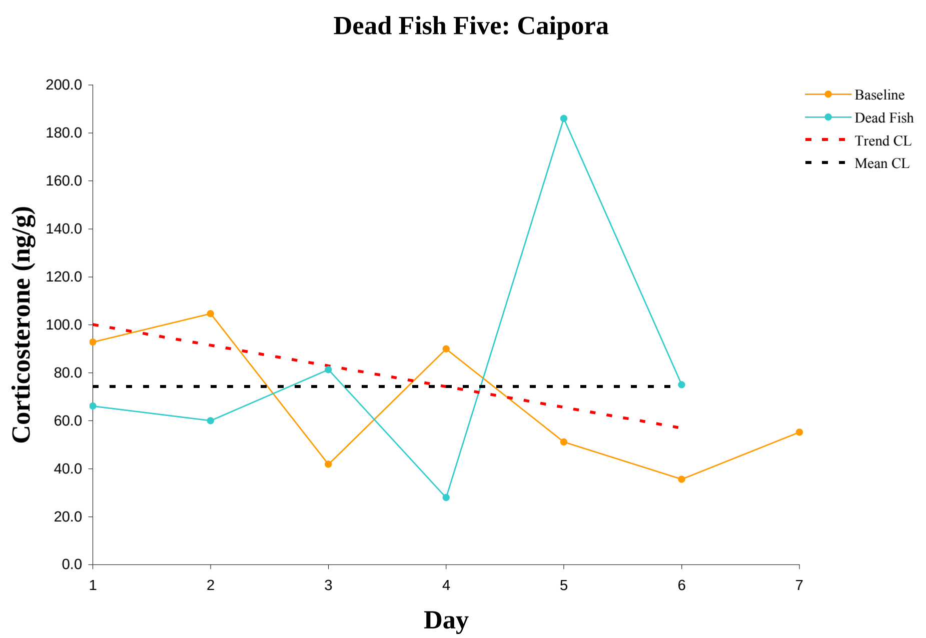

Figure C.14: Fecal corticosterone levels for Caipora for dead fish five. The results are not significant.

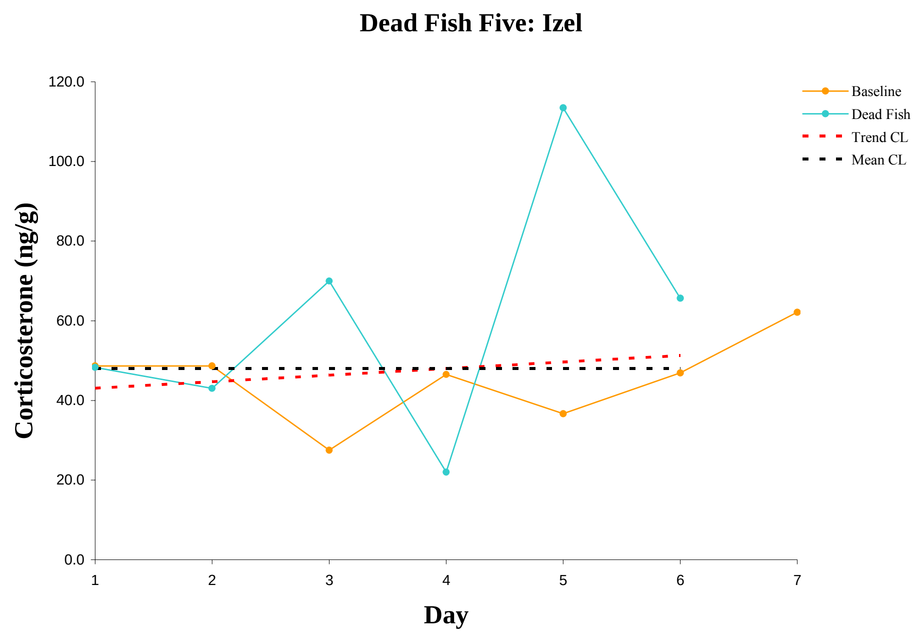

Figure C.15: Fecal corticosterone levels for Izel for dead fish five. The results are not significant.

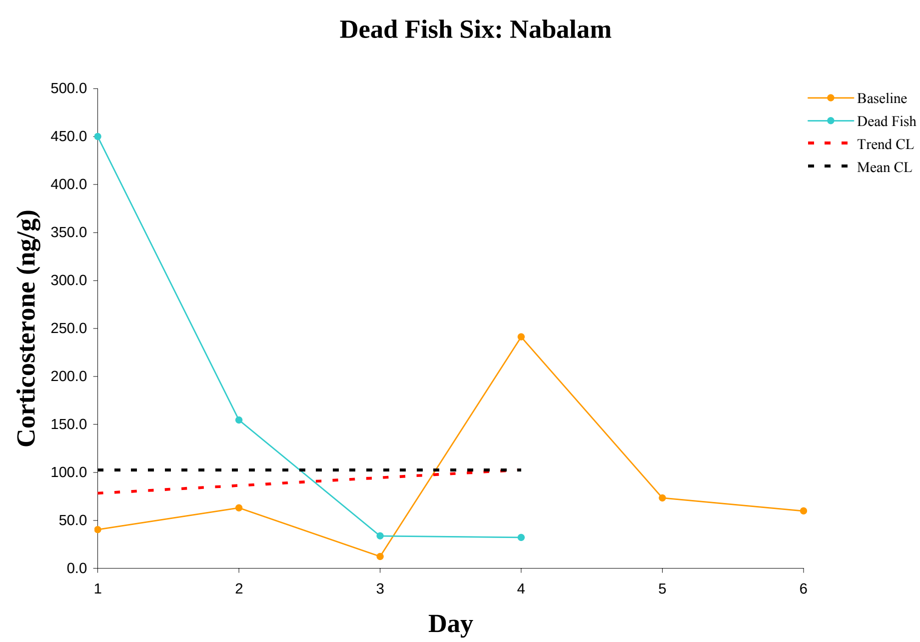

Figure C.16: Fecal corticosterone levels for Nabalam for dead fish six. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

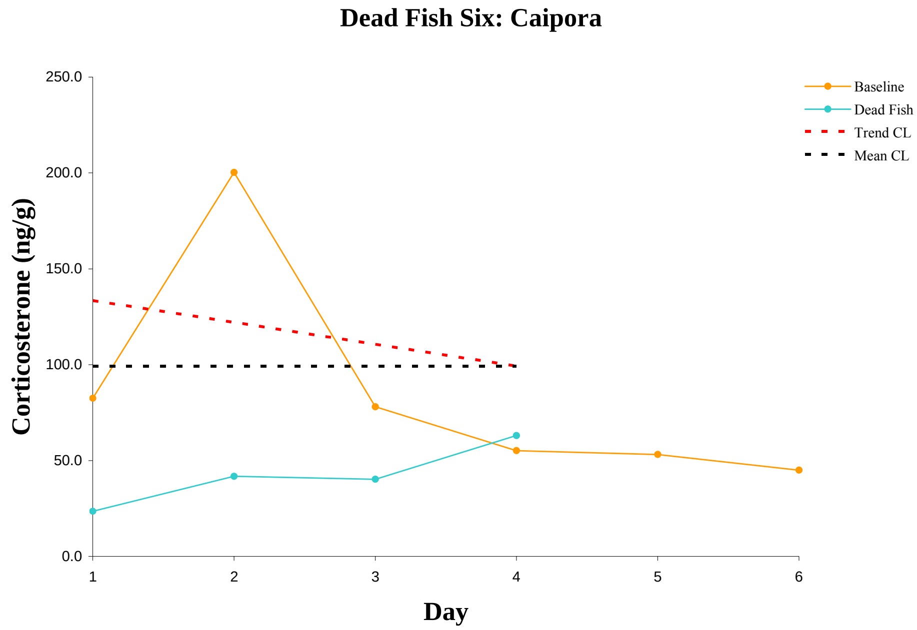

Figure C.17: Fecal corticosterone levels for Caipora for dead fish six. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

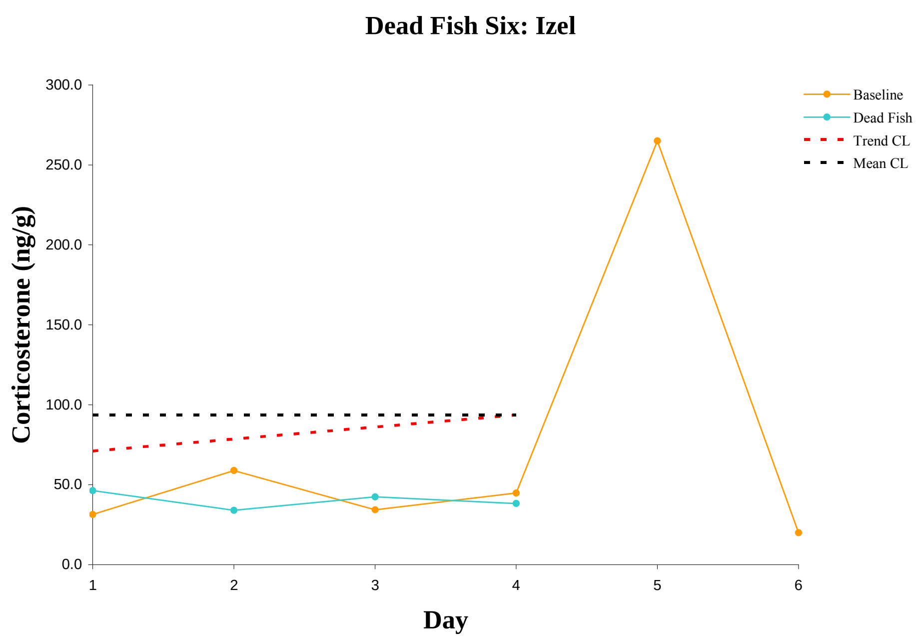

Figure C.18: Fecal corticosterone levels for Izel for dead fish six. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

APPENDIX D: CORTISOL

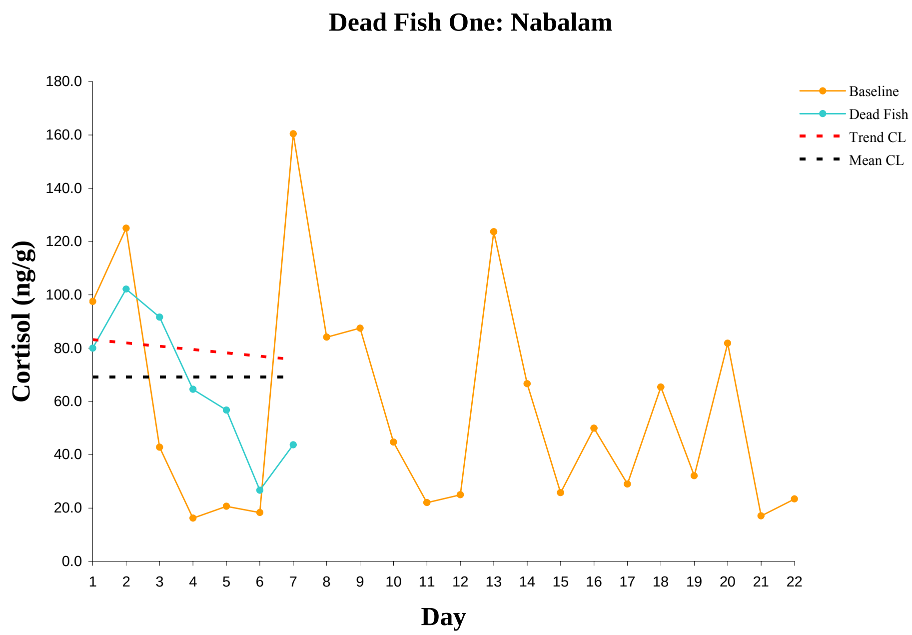

Figure D.1: Fecal cortisol levels for Nabalam for dead fish one. The results are not significant.

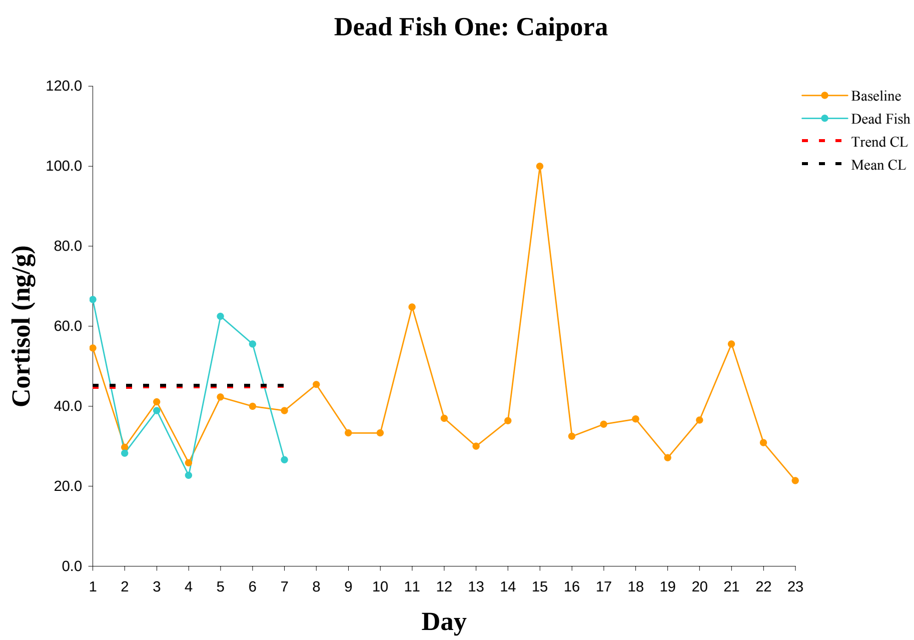

Figure D.2: Fecal cortisol levels for Caipora for dead fish one. The results are not significant

Dead Fish One: Izel

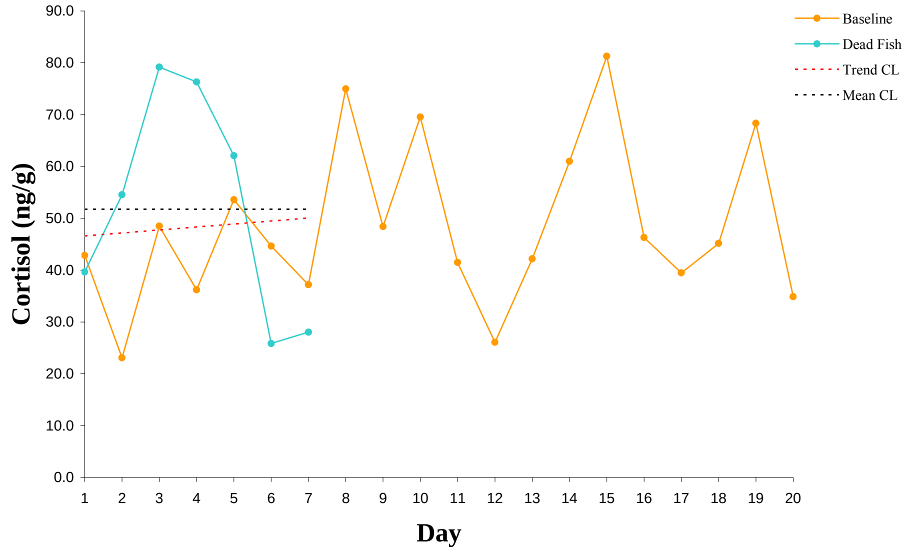

Figure D.3: Fecal cortisol levels for Izel for dead fish one. The results are not significant.

Dead Fish Two: Nabalam

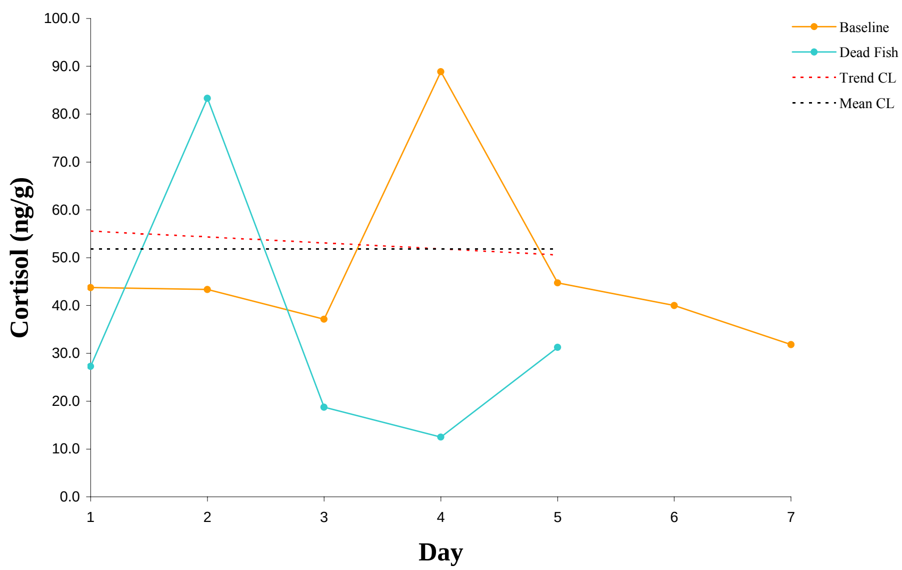

Figure D.4: Fecal cortisol levels for Nabalam for dead fish two. The results are not significant.

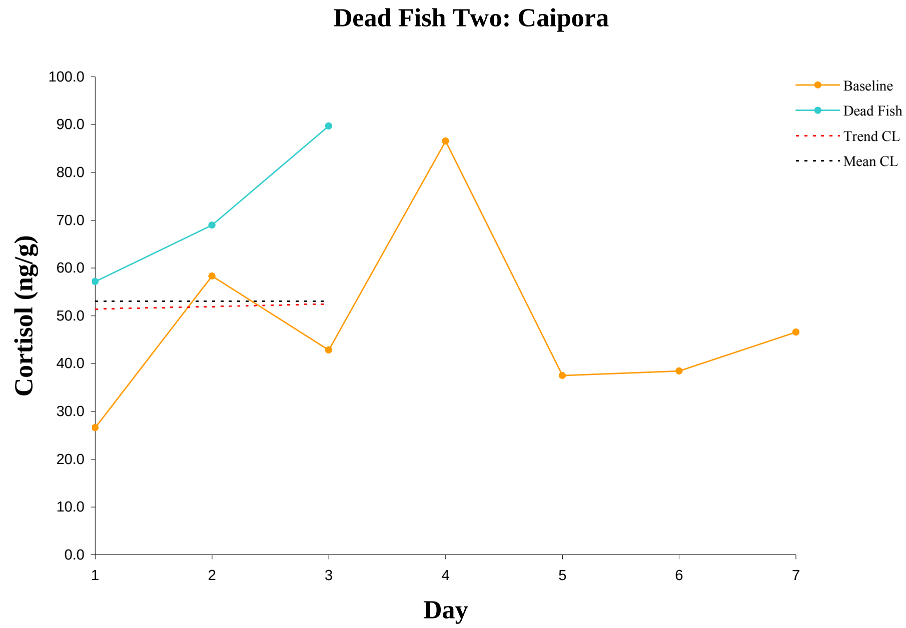

Figure D.5: Fecal cortisol levels for Caipora for dead fish two. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

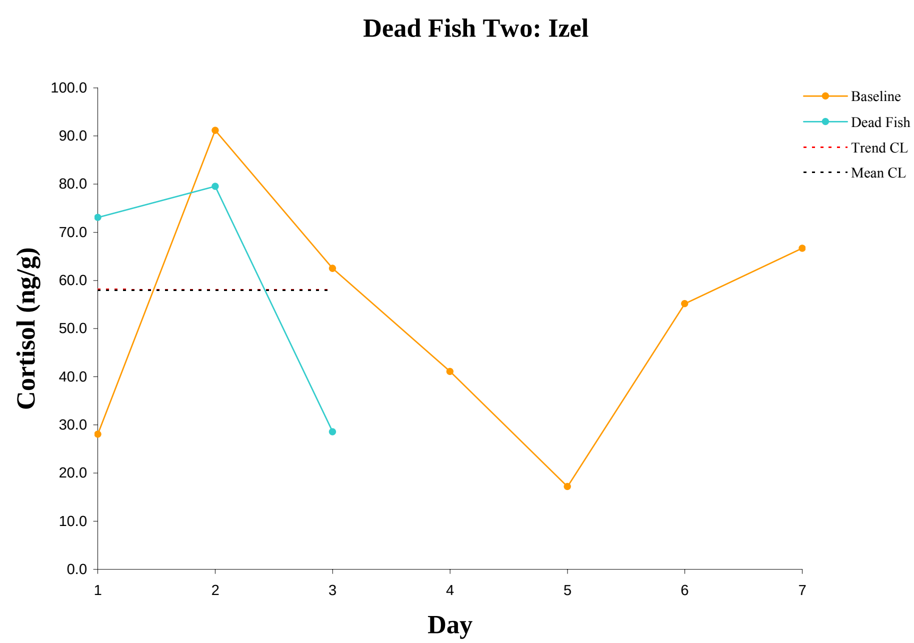

Figure D.6: Fecal cortisol levels for Izel for dead fish two. There is insufficient data for the week of dead fish presentation to determine if there is a significant difference between it and baseline levels.

APPENDIX E: PERCENTAGE OF TIME SPENT VISIBLE

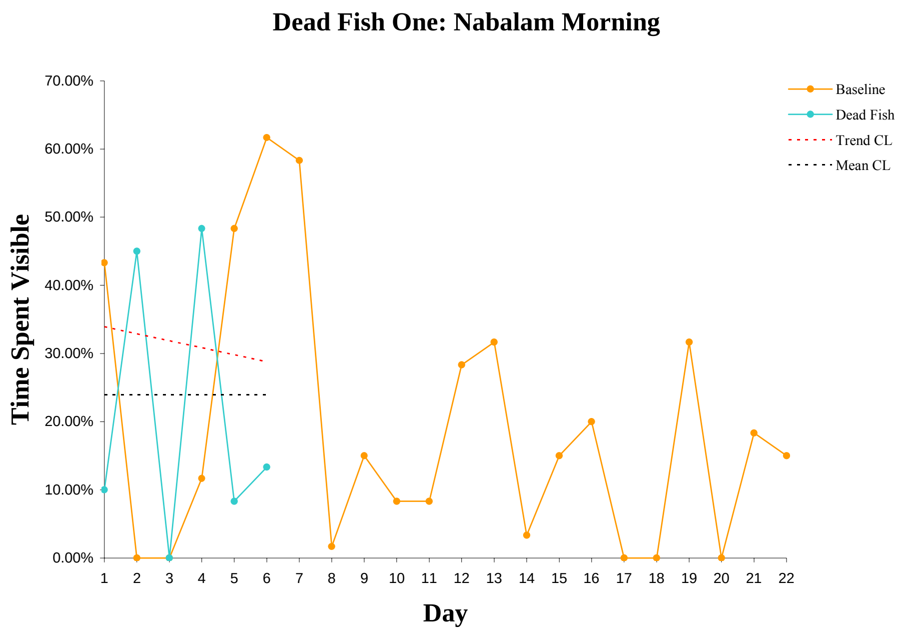

Figure E.1: Percentage of time spent visible for Nabalam in the morning of dead fish one. The results are not significant.

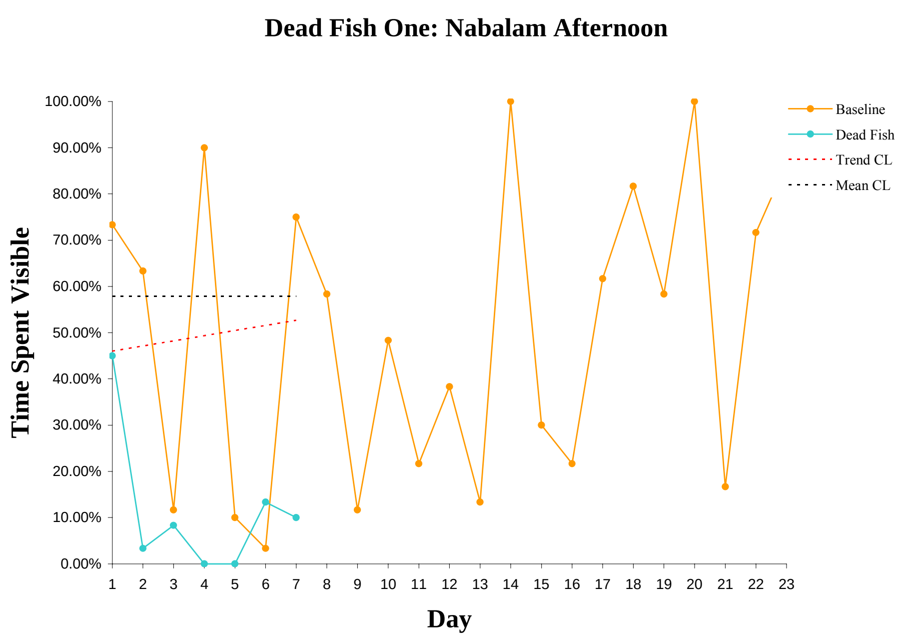

Figure E.2: Percentage of time spent visible for Nabalam in the afternoon of dead fish one. The results are not significant.

Dead Fish One: Caipora Morning

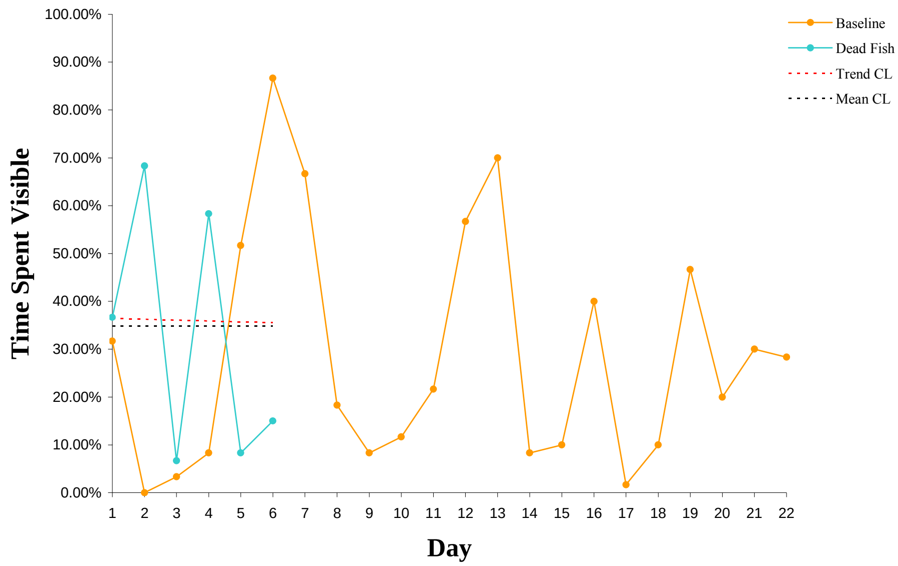

Figure E.3: Percentage of time spent visible for Caipora in the morning of dead fish one. The results are not significant.

Dead Fish One: Caipora Afternoon

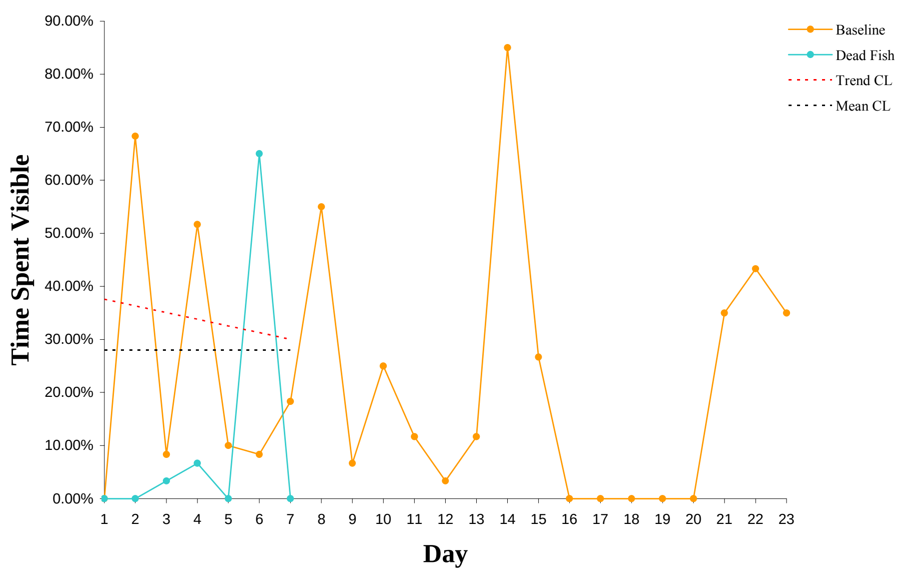

Figure E.4: Percentage of time spent visible for Caipora in the afternoon of dead fish one. The results are not significant.

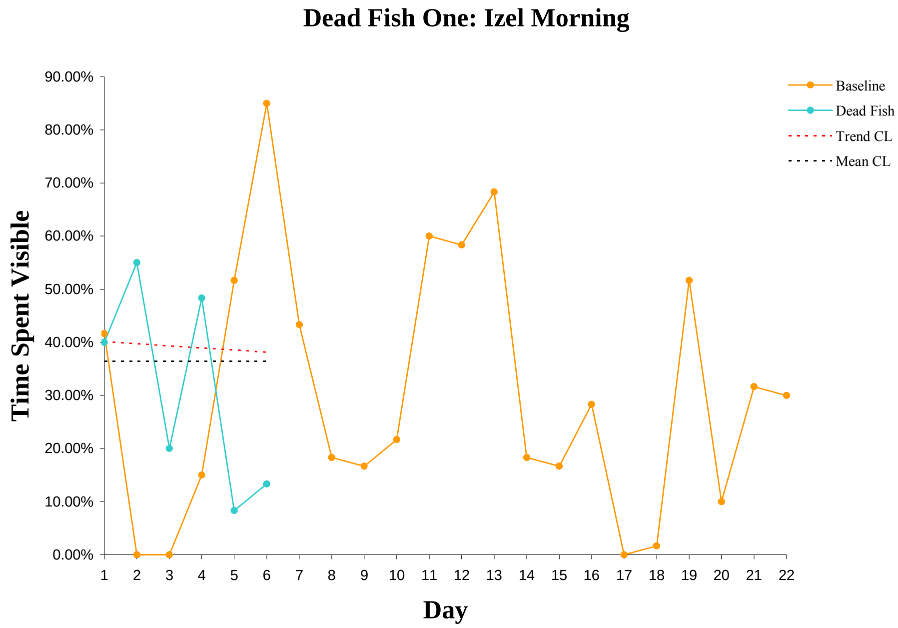

Figure E.5: Percentage of time spent visible for Izel in the morning of dead fish one. The results are not significant.

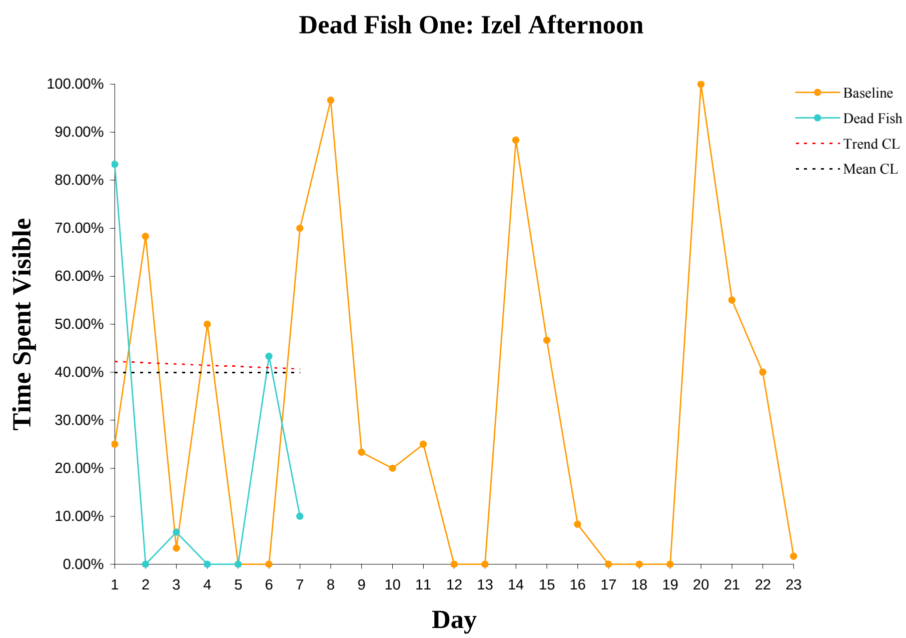

Figure E.6: Percentage of time spent visible for Izel in the afternoon of dead fish one. The results are not significant.

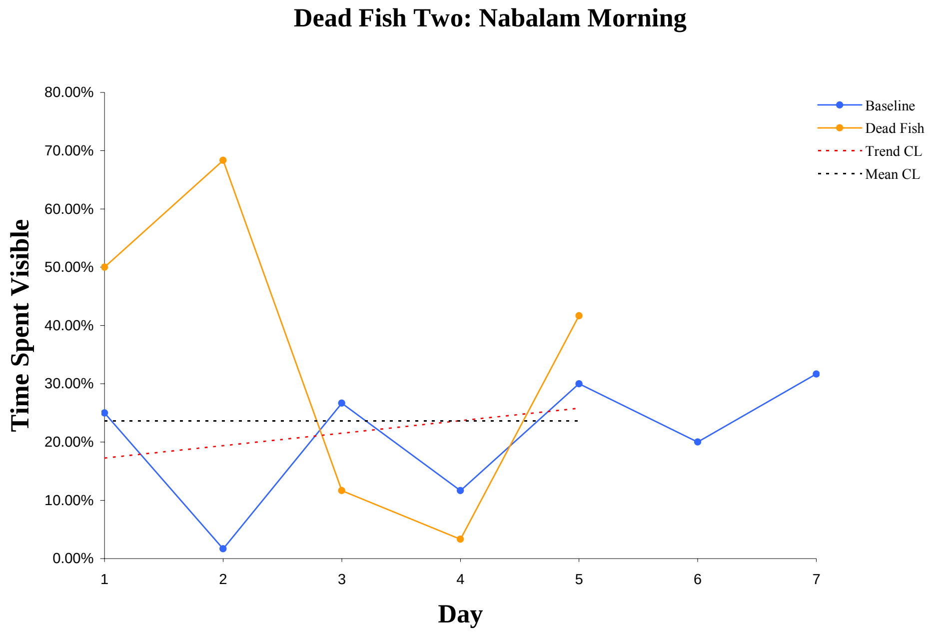

Figure E.7: Percentage of time spent visible for Nabalam in the morning of dead fish two. The results are not significant.

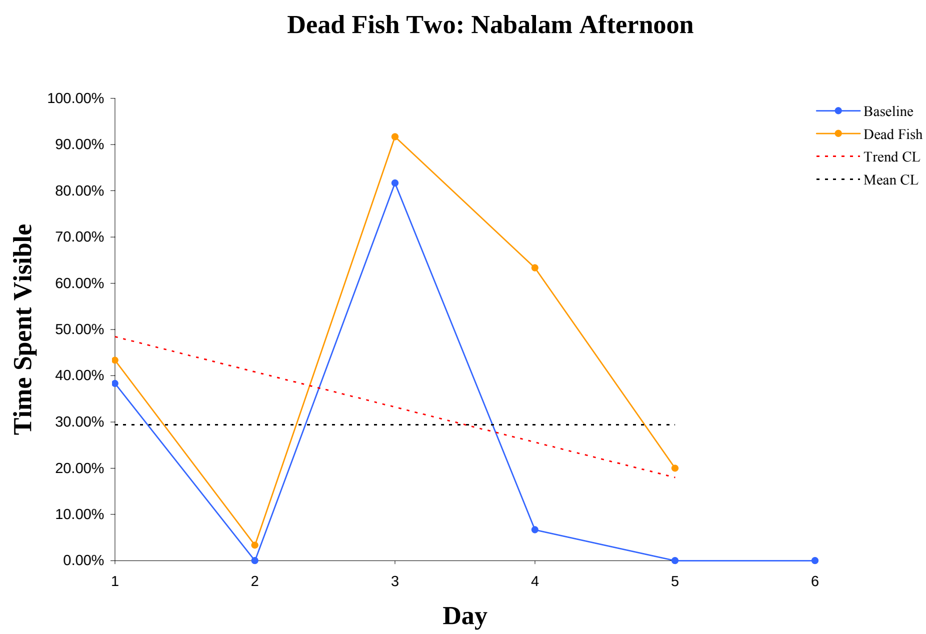

Figure E.8: Percentage of time spent visible for Nabalam in the afternoon of dead fish two. The results are not significant.

Dead Fish Two: Caipora Morning

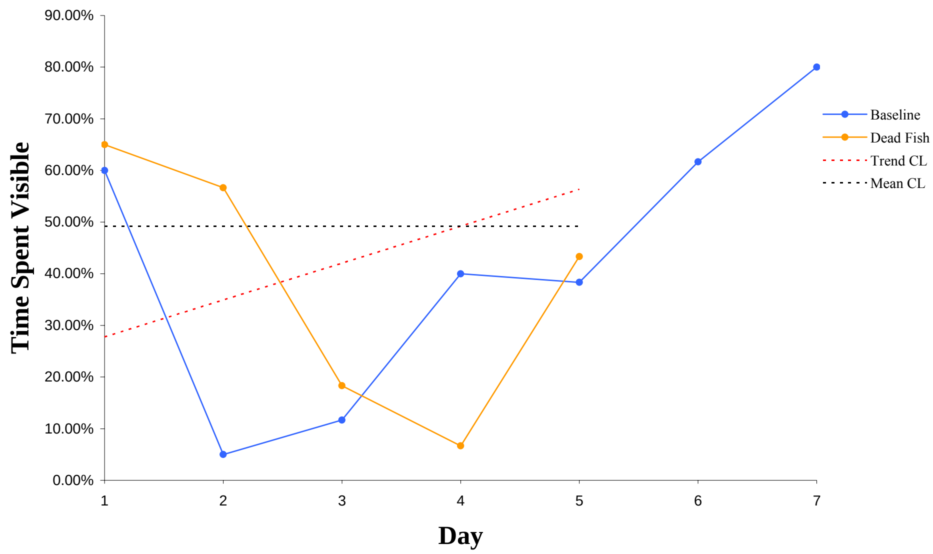

Figure E.9: Percentage of time spent visible for Caipora in the morning of dead fish two. The results are not significant.

Dead Fish Two: Caipora Afternoon

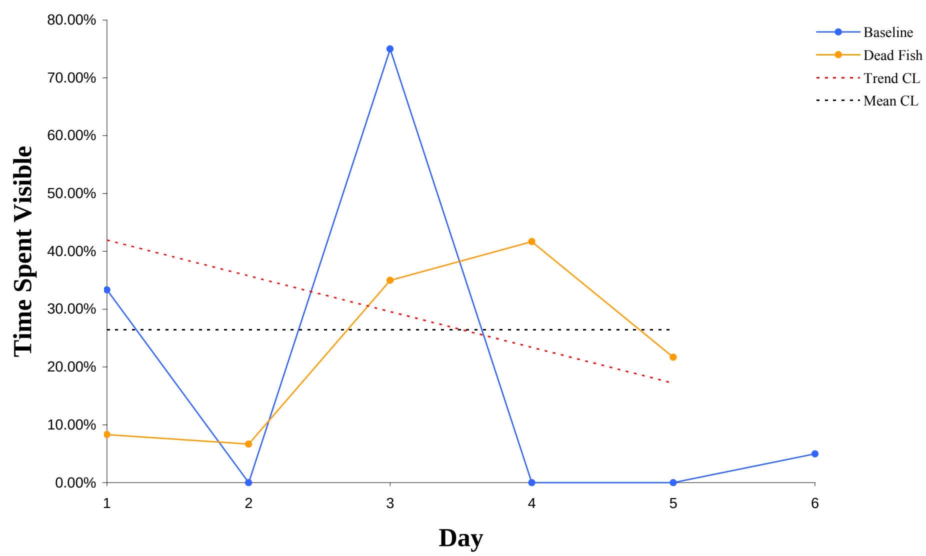

Figure E.10: Percentage of time spent visible for Caipora in the afternoon of dead fish two. The results are not significant.

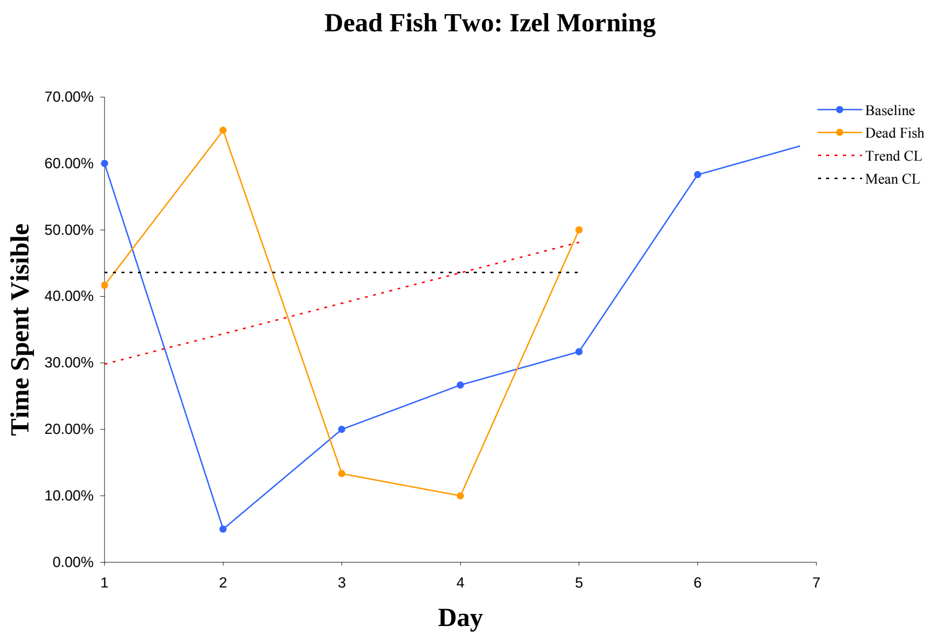

Figure E.11: Percentage of time spent visible for Izel in the morning of dead fish two. The results are not significant.

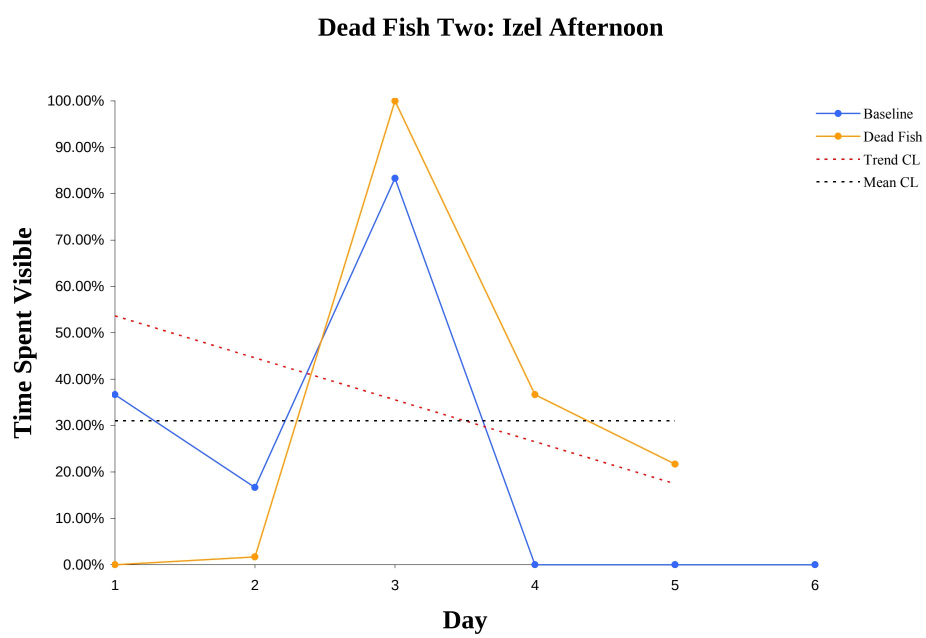

Figure E.12: Percentage of time spent visible for Izel in the afternoon of dead fish two. The results are not significant.

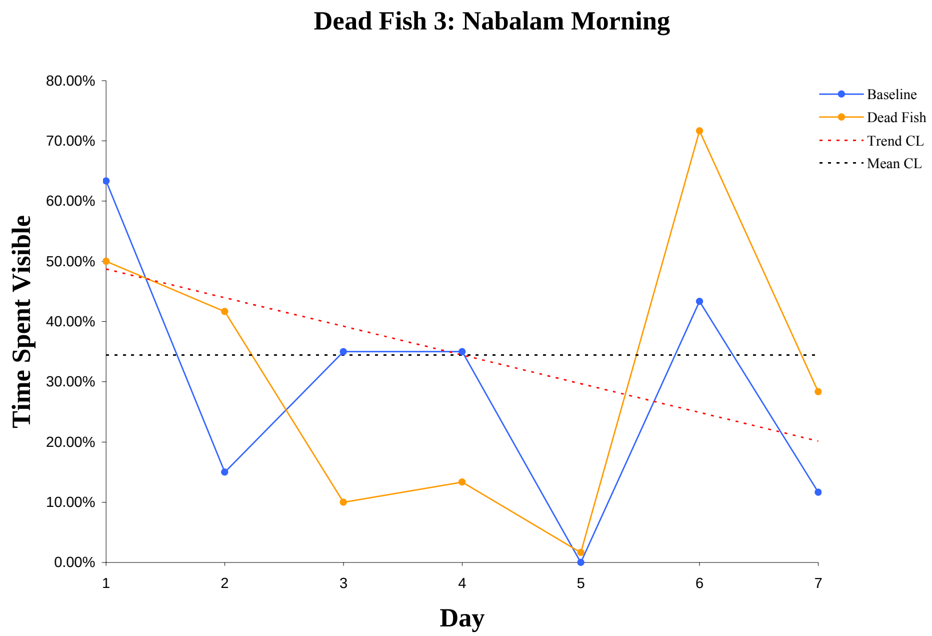

Figure E.13: Percentage of time spent visible for Nabalam in the morning of dead fish three. The results are not significant.

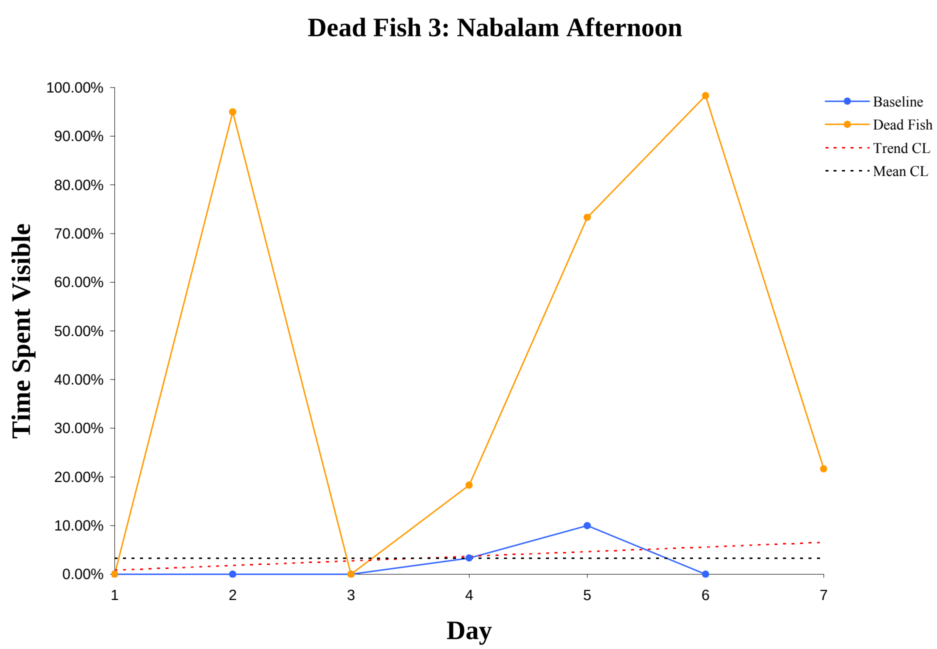

Figure E.14: Percentage of time spent visible for Nabalam in the afternoon of dead fish three. The results are not significant.

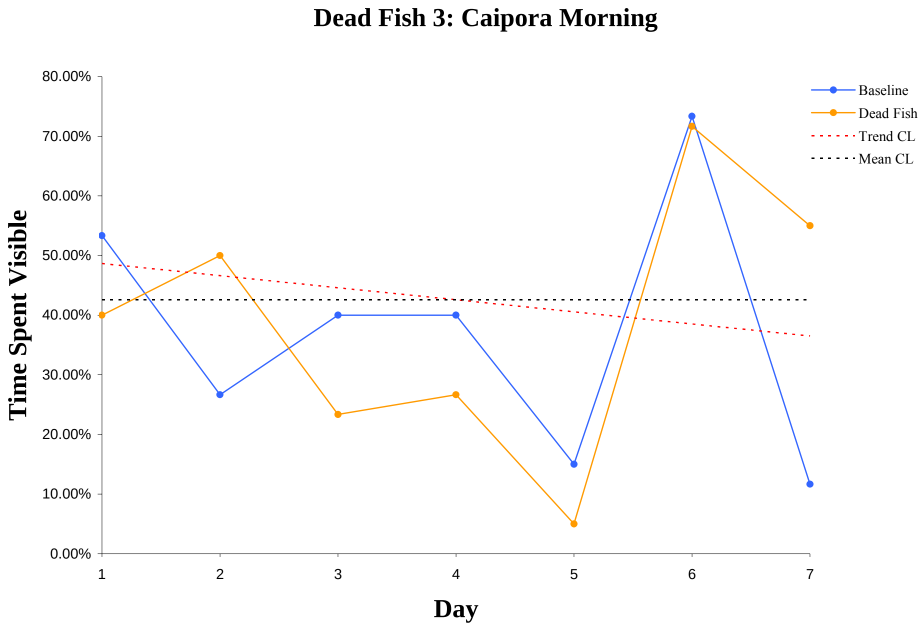

Figure E.15: Percentage of time spent visible for Caipora in the morning of dead fish three. The results are not significant.

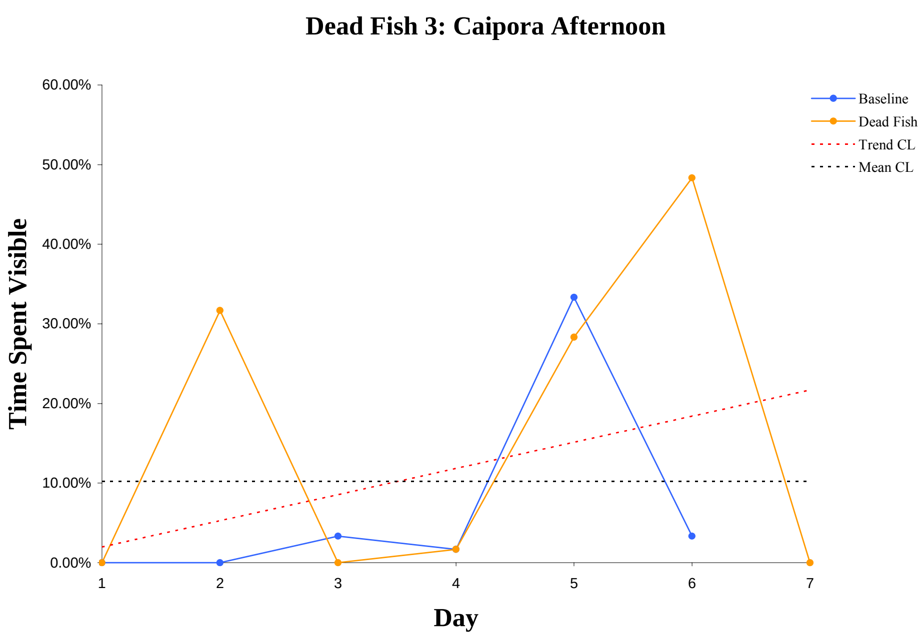

Figure E.16: Percentage of time spent visible for Caipora in the afternoon of dead fish three. The results are not significant.

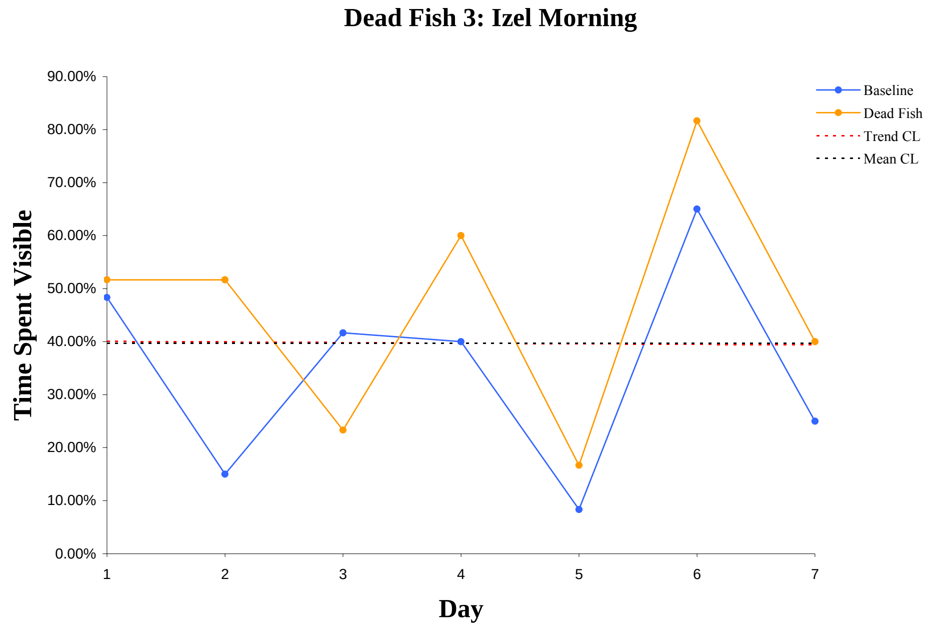

Figure E.17: Percentage of time spent visible for Izel in the morning of dead fish three. The results are not significant.

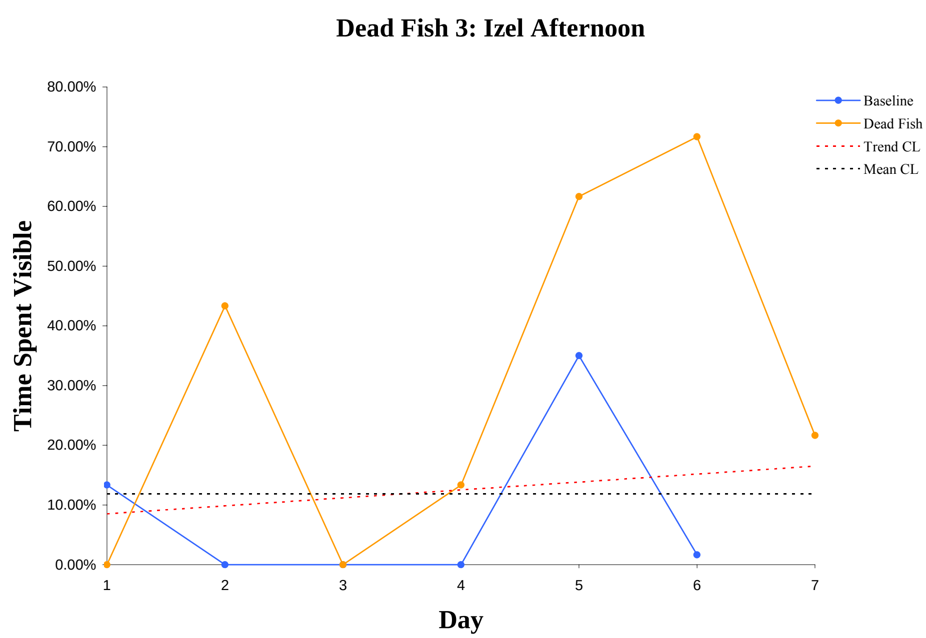

Figure E.18: Percentage of time spent visible for Izel in the afternoon of dead fish three. The results are not significant.

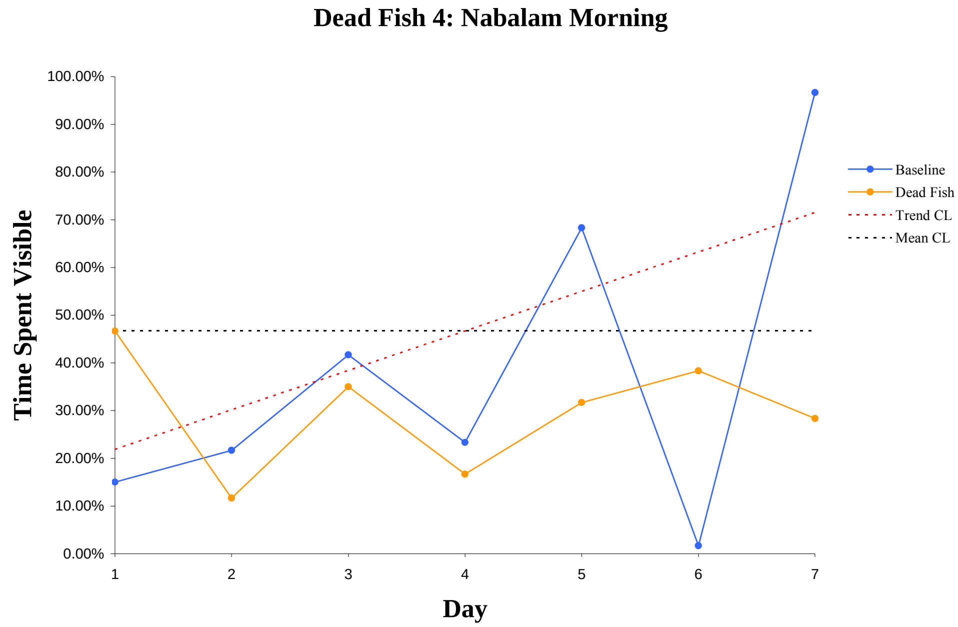

Figure E.19: Percentage of time spent visible for Nabalam in the morning of dead fish four. The results are not significant.

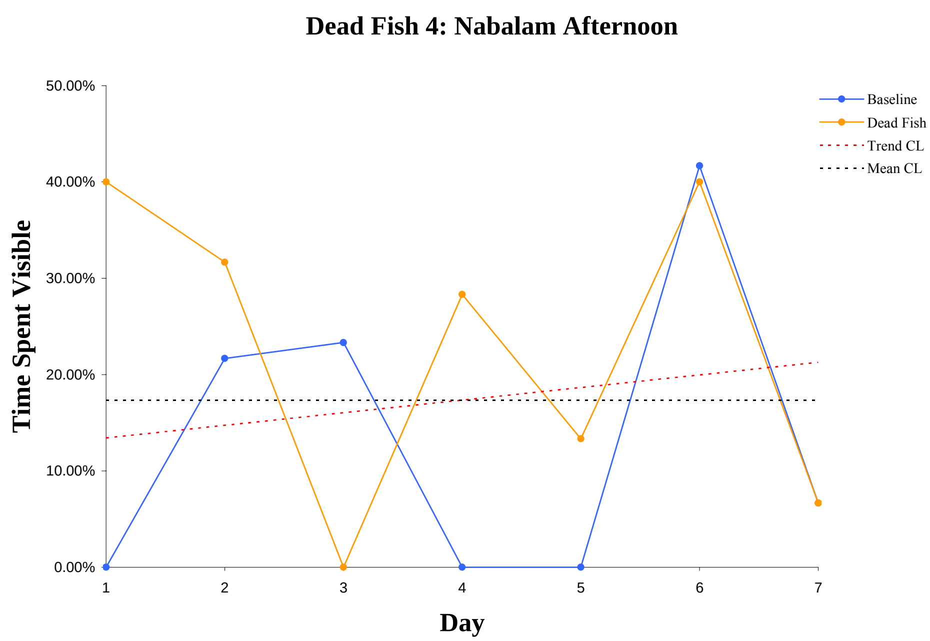

Figure E.20: Percentage of time spent visible for Nabalam in the afternoon of dead fish four. The results are not significant.

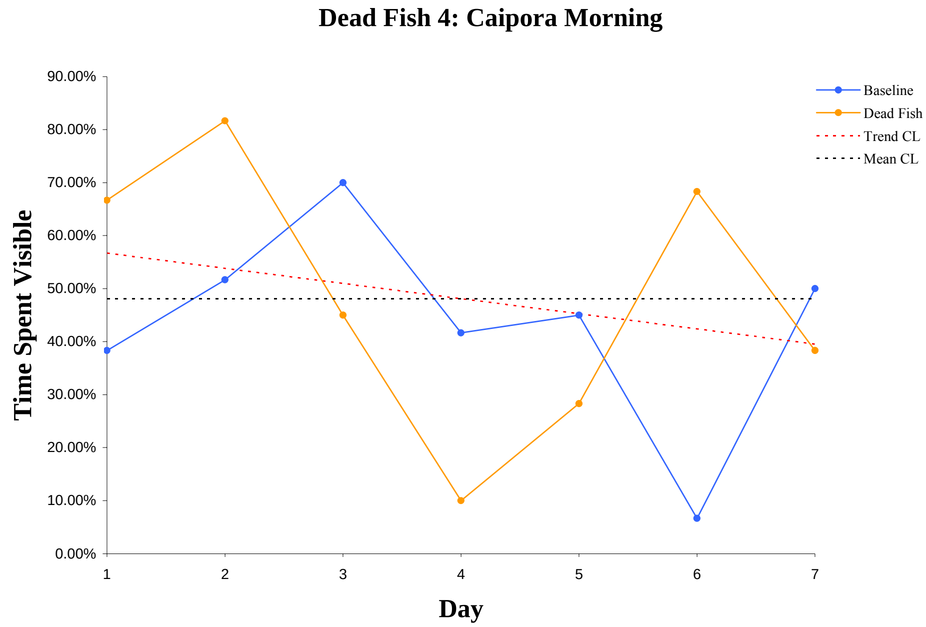

Figure E.21: Percentage of time spent visible for Caipora in the morning of dead fish four. The results are not significant.

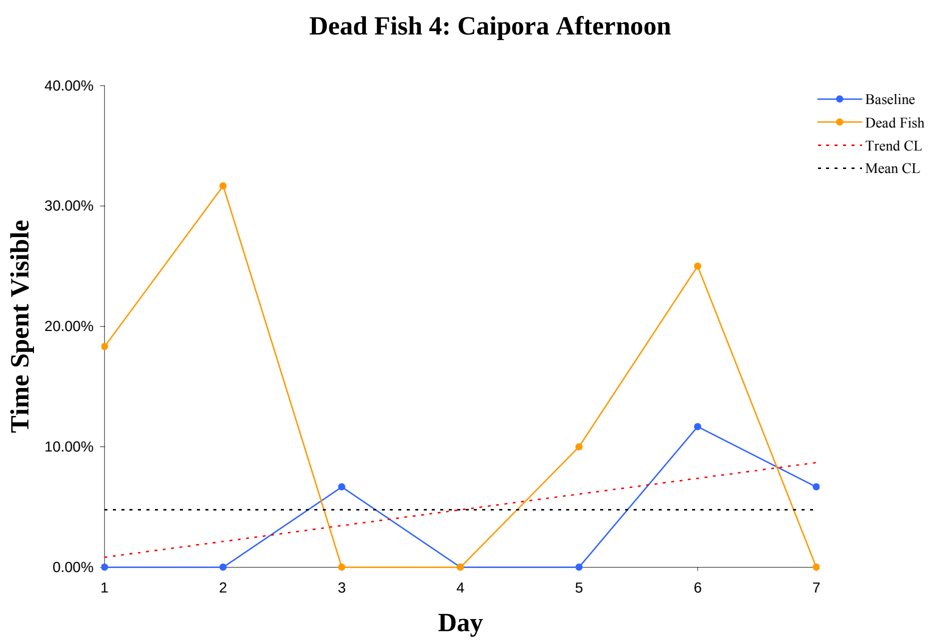

Figure E.22: Percentage of time spent visible for Caipora in the afternoon of dead fish four. The results are not significant.

Dead Fish 4: Izel Morning

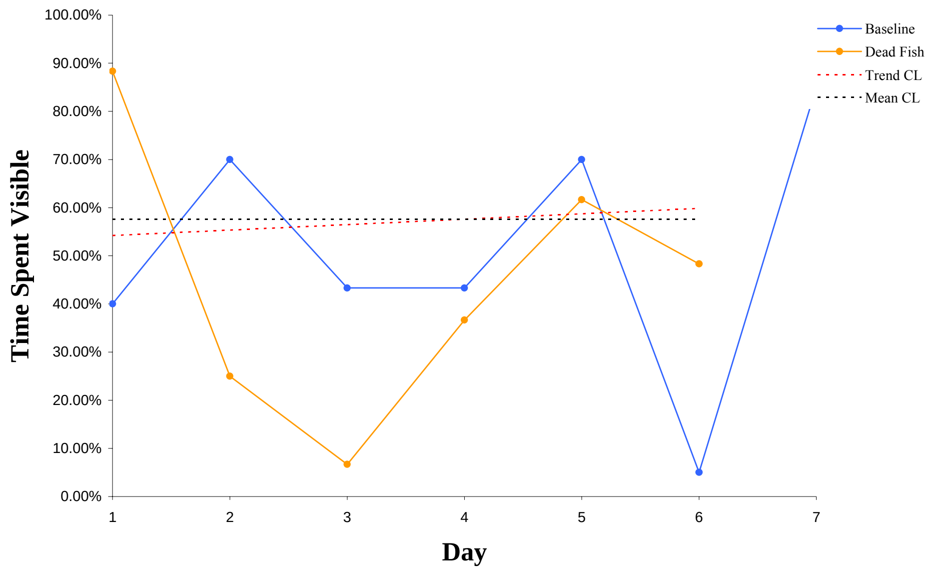

Figure E.23: Percentage of time spent visible for Izel in the morning of dead fish four. The results are not significant.

Dead Fish 4: Izel Afternoon

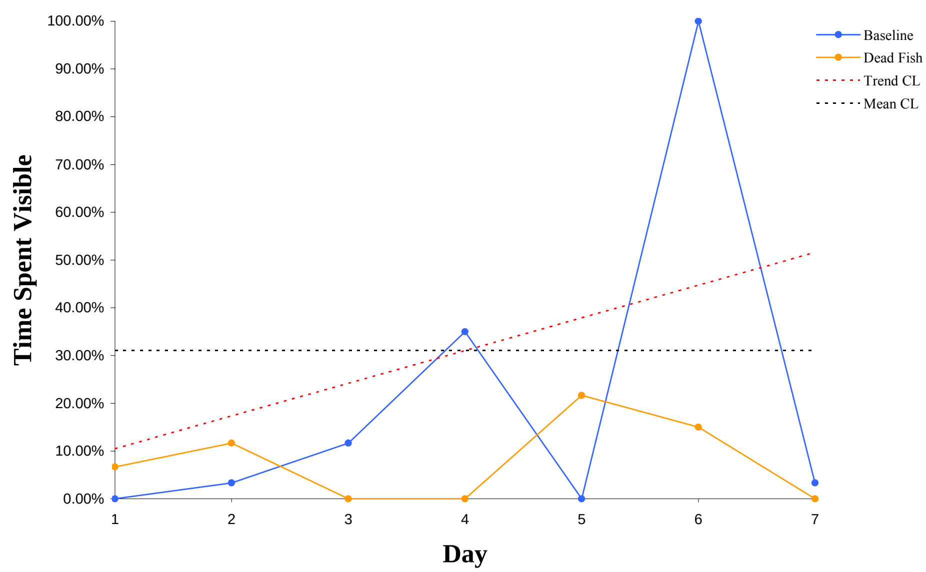

Figure E.24: Percentage of time spent visible for Izel in the afternoon of dead fish four. The results are not significant.

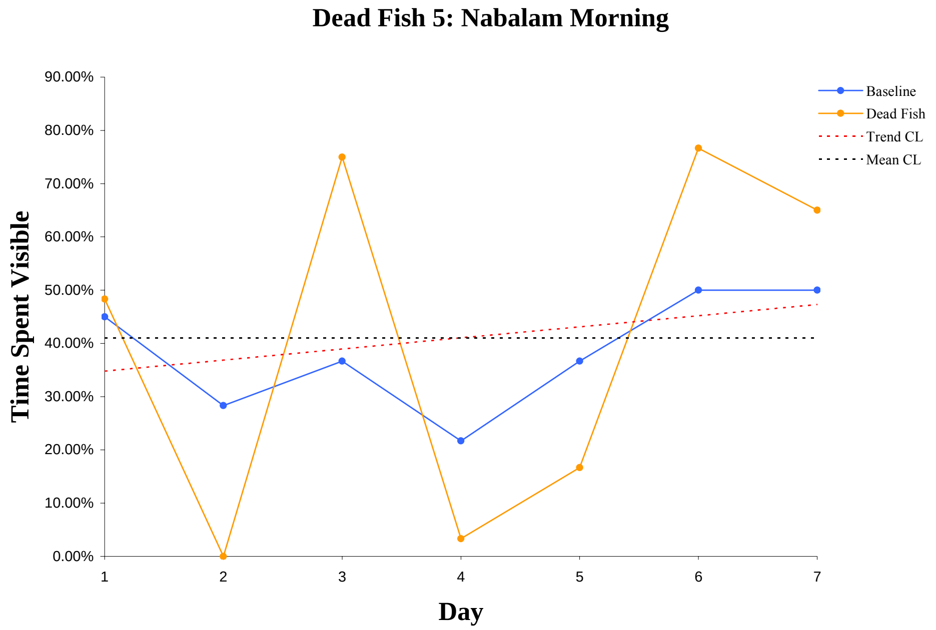

Figure E.25: Percentage of time spent visible for Nabalam in the morning of dead fish five. The results are not significant.

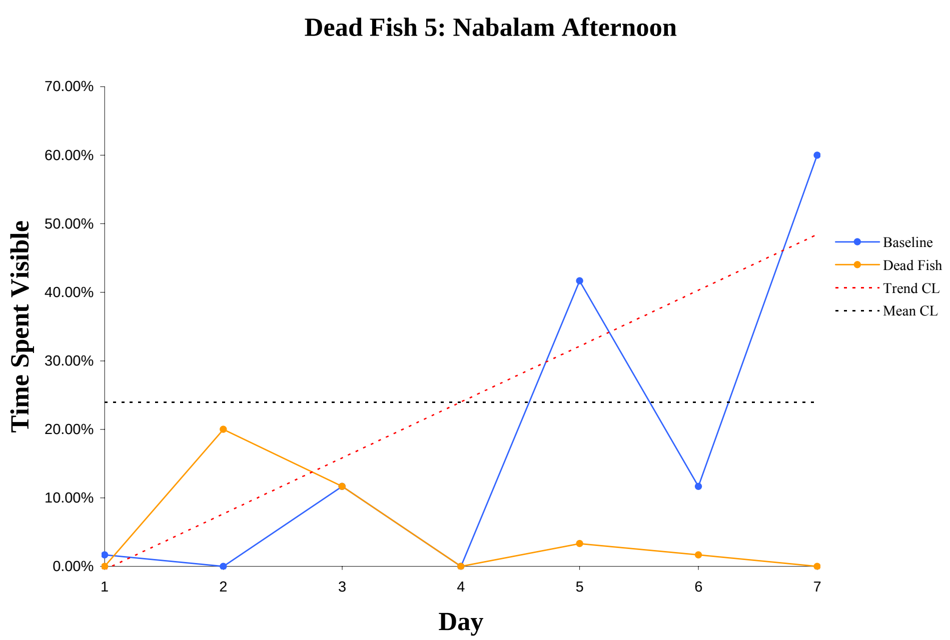

Figure E.26: Percentage of time spent visible for Nabalam in the afternoon of dead fish five. The results are not significant.

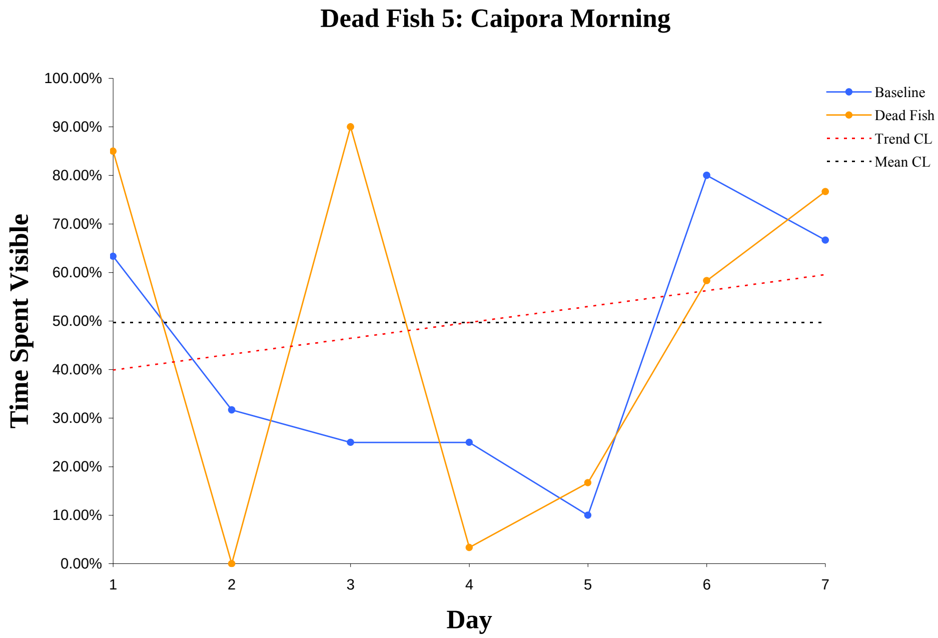

Figure E.27: Percentage of time spent visible for Caipora in the morning of dead fish five. The results are not significant.

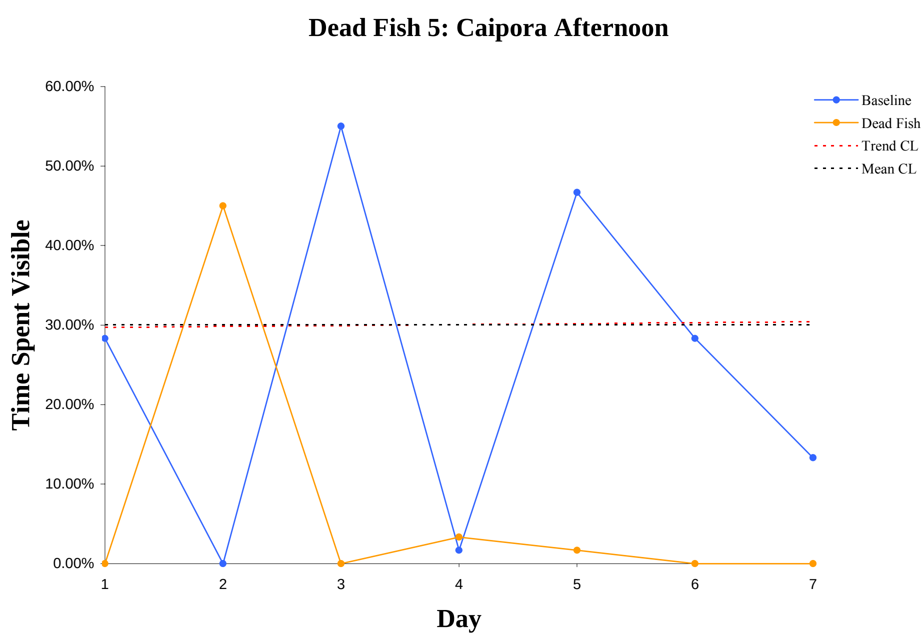

Figure E.28: Percentage of time spent visible for Caipora in the afternoon of dead fish five. The results are not significant.

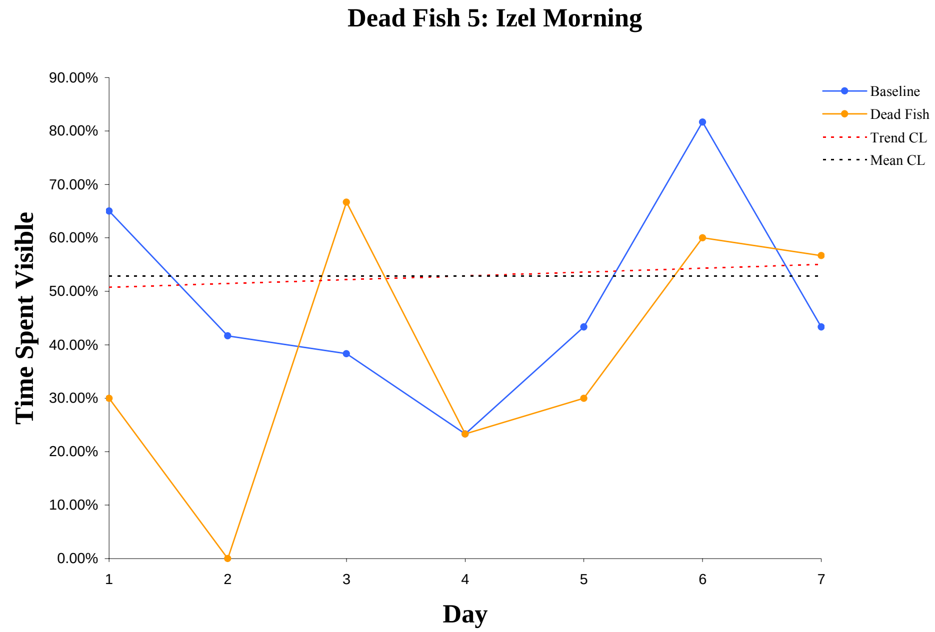

Figure E.29: Percentage of time spent visible for Izel in the morning of dead fish five. The results are not significant.

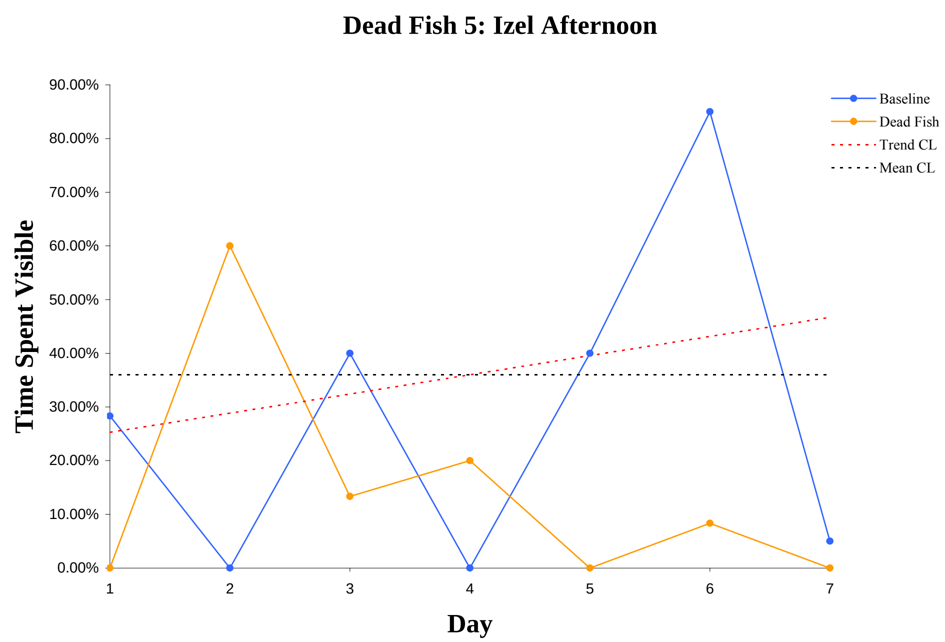

Figure E.30: Percentage of time spent visible for Izel in the afternoon of dead fish five. The results are not significant.

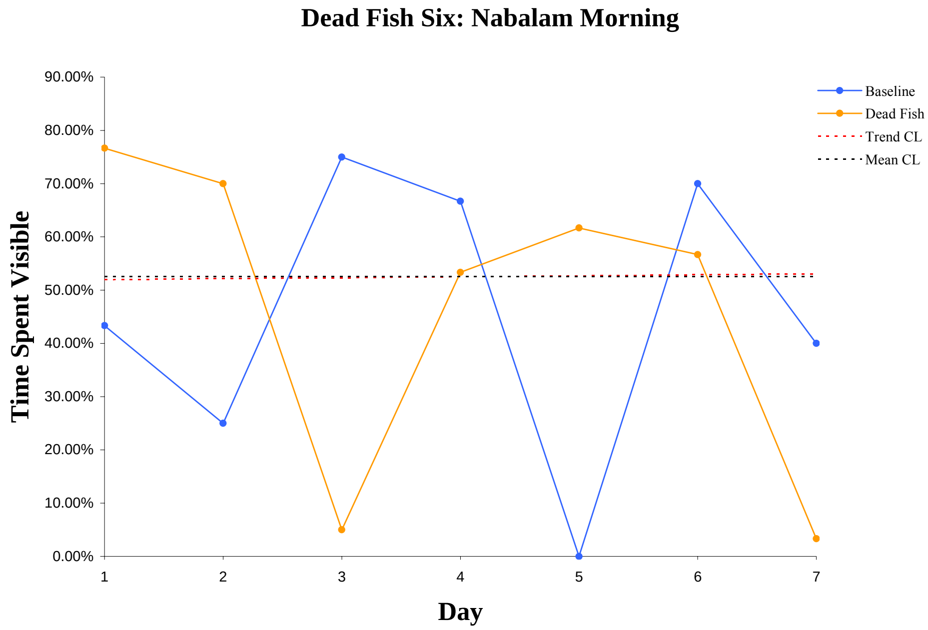

Figure E.31: Percentage of time spent visible for Nabalam in the morning of dead fish six. The results are not significant.

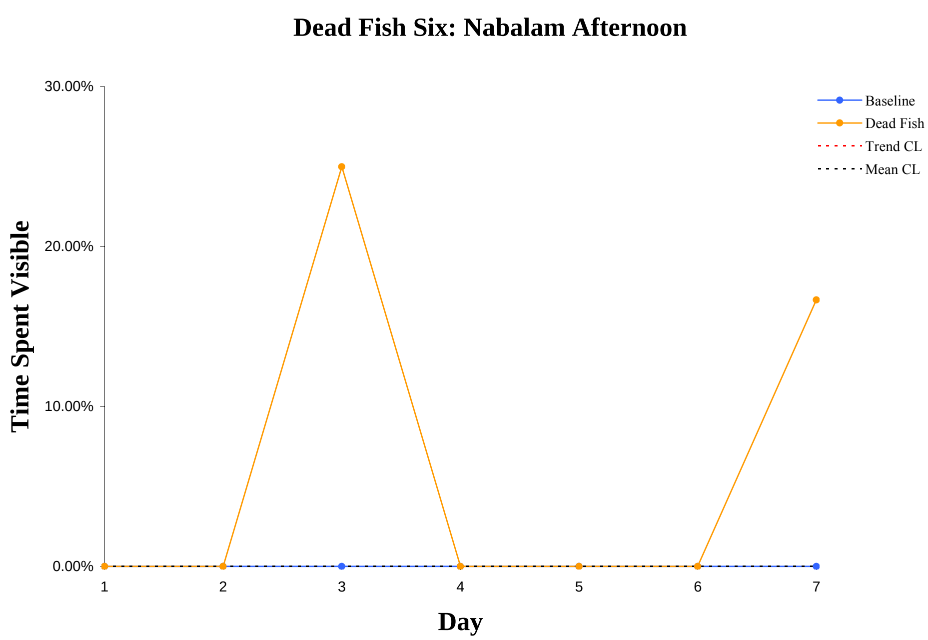

Figure E.32: Percentage of time spent visible for Nabalam in the afternoon of dead fish six. The results are not significant.

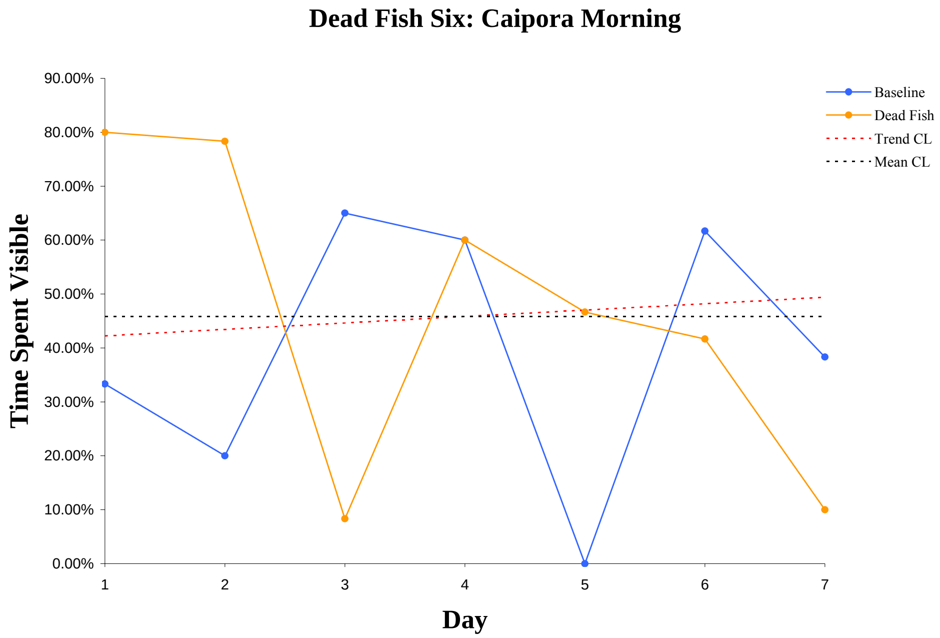

Figure E.33: Percentage of time spent visible for Caipora in the morning of dead fish six. The results are not significant.

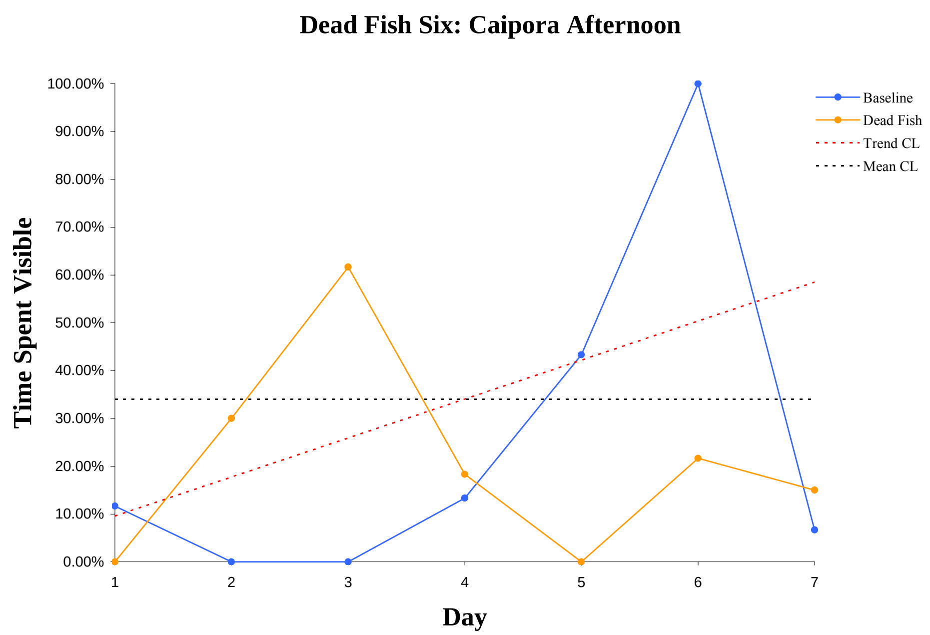

Figure E.34: Percentage of time spent visible for Caipora in the afternoon of dead fish six. The results are not significant.

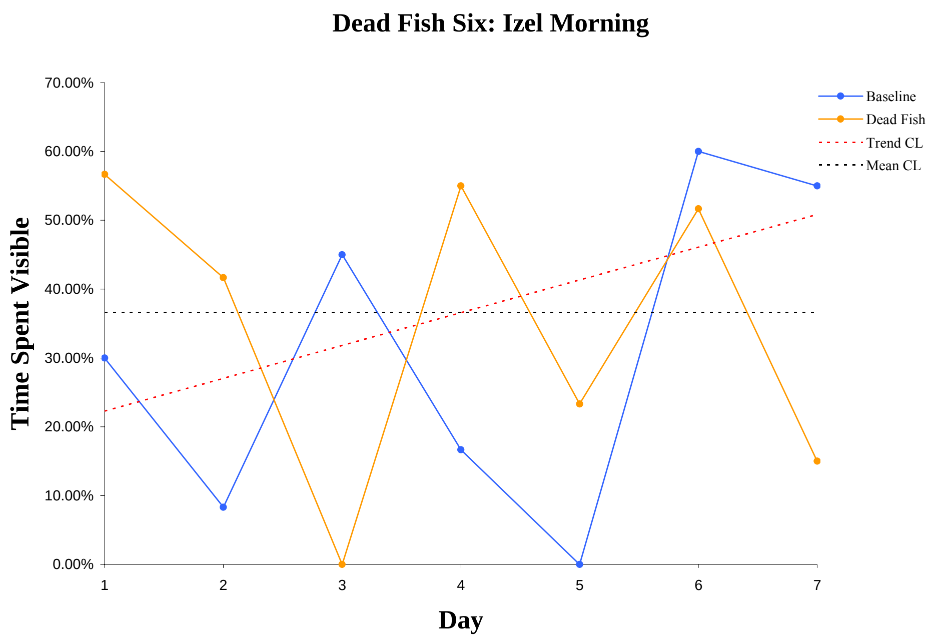

Figure E.35: Percentage of time spent visible for Izel in the morning of dead fish six. The results are not significant.

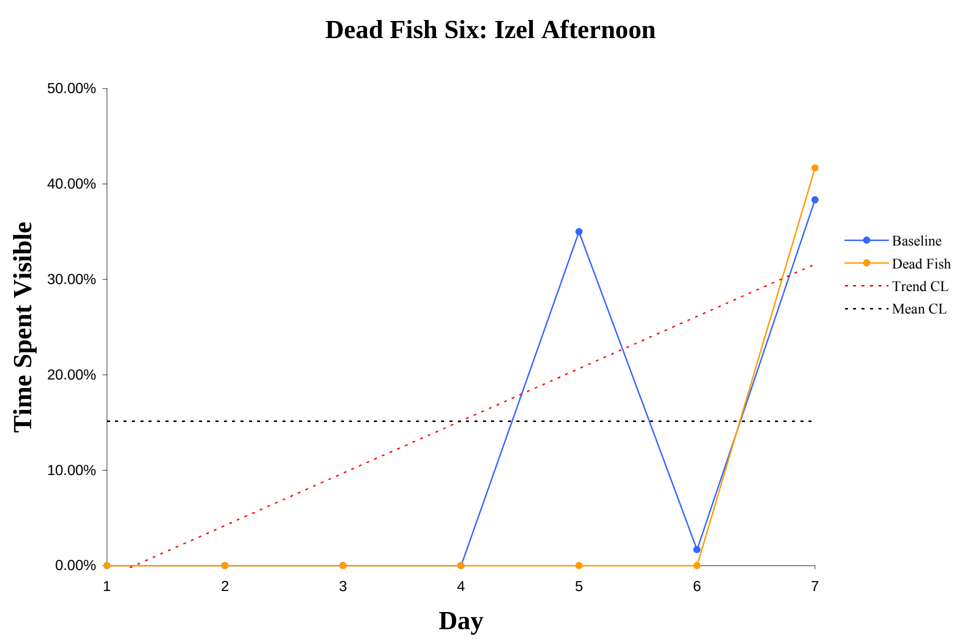

Figure E.36: Percentage of time spent visible for Izel in the afternoon of dead fish six. The results are not significant.

APPENDIX F: PERCENTAGE OF TIME SPENT IN WATER

Dead Fish One: Nabalam Morning

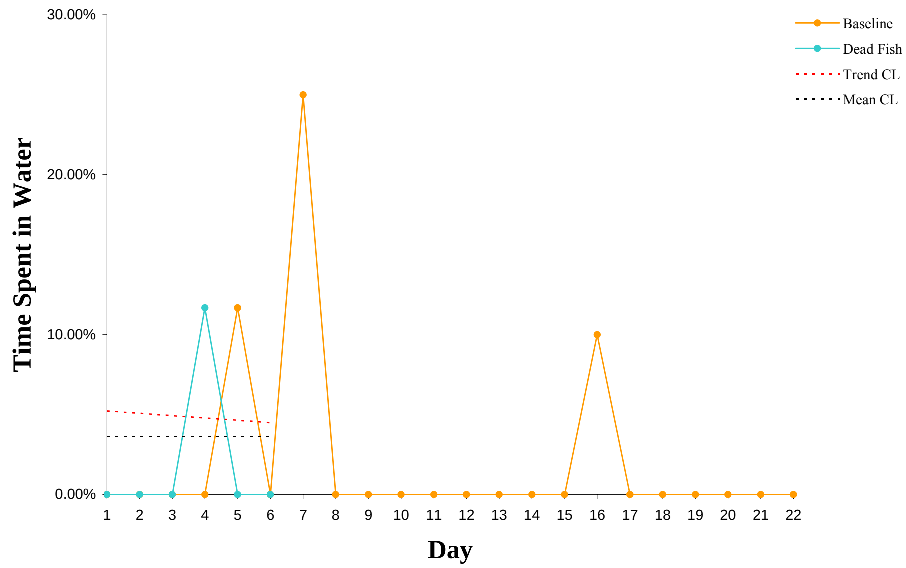

Figure F.1: Percentage of time spent in water for Nabalam in the morning of dead fish one. The results are not significant.

Dead Fish One: Nabalam Afternoon

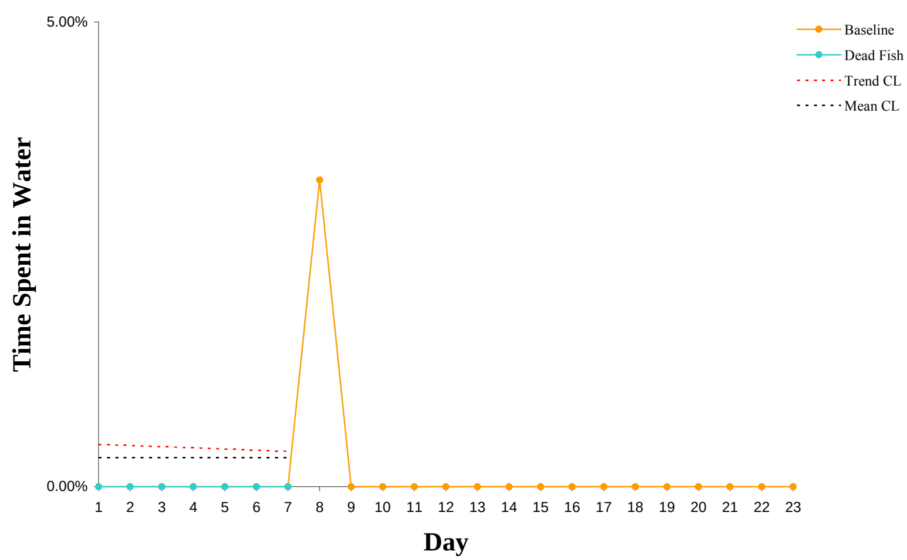

Figure F.2: Percentage of time spent in water for Nabalam in the afternoon of dead fish one. The results are not significant.

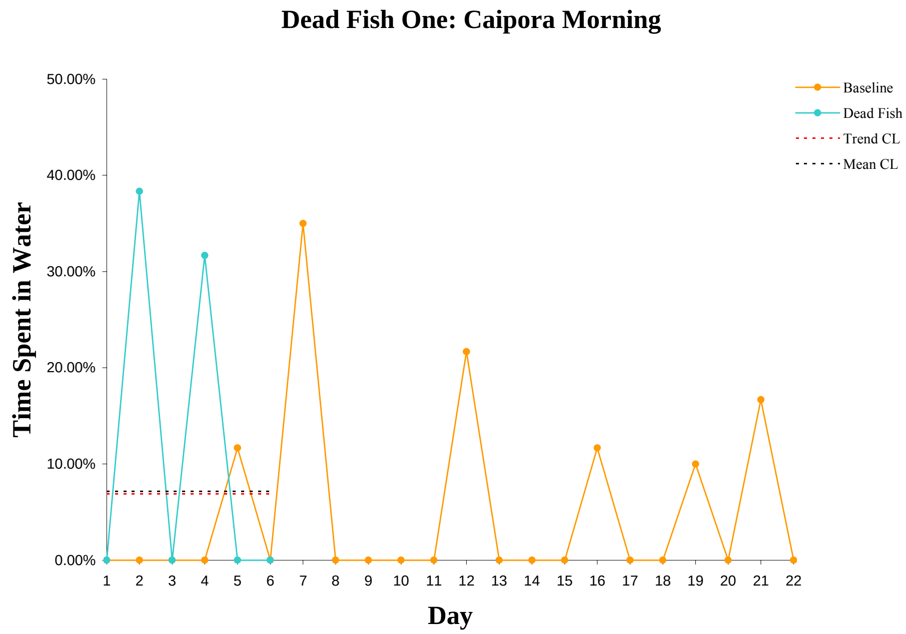

Figure F.3: Percentage of time spent in water for Caipora in the morning of dead fish one. The results are not significant.

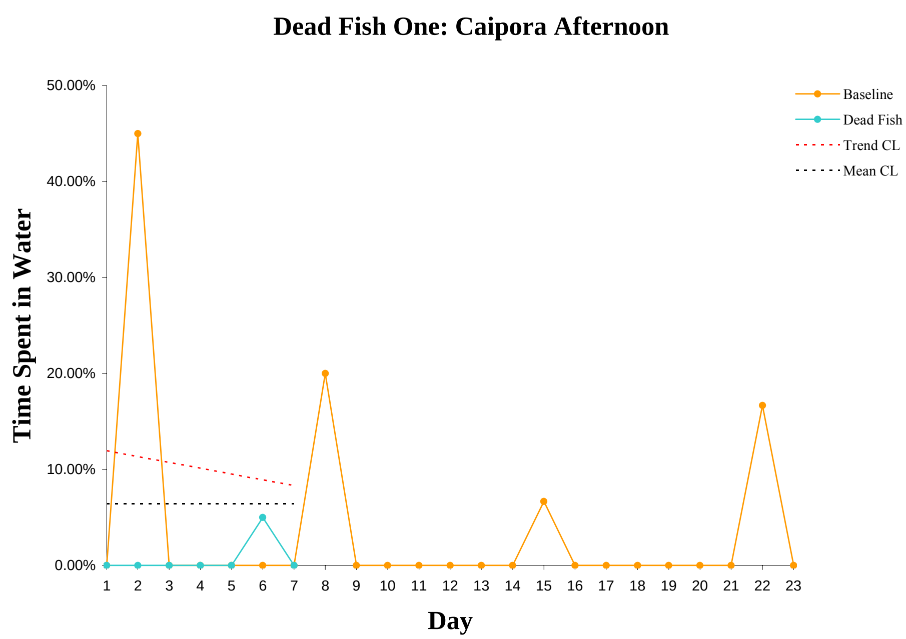

Figure F.4: Percentage of time spent in water for Caipora in the afternoon of dead fish one. The results are not significant.

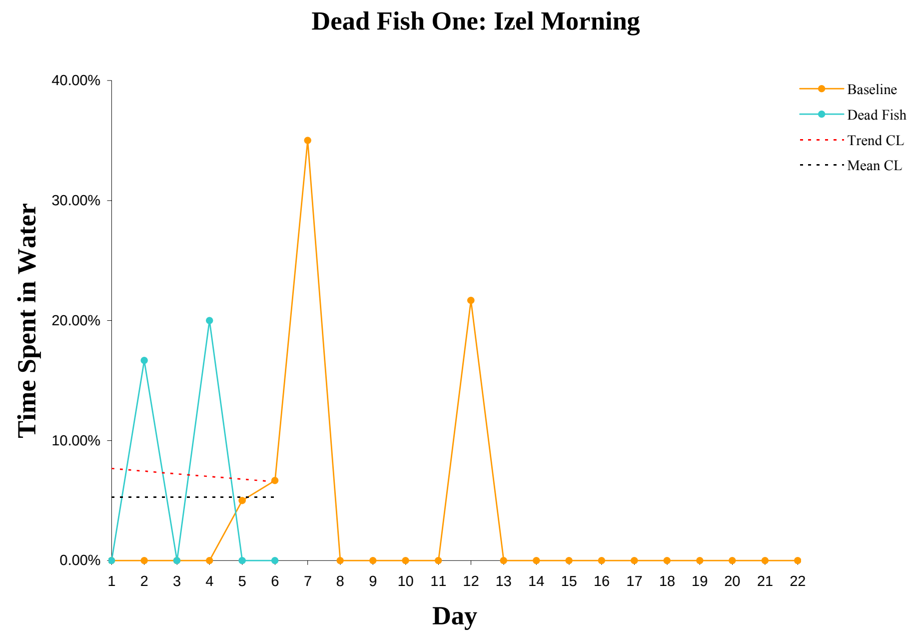

Figure F.5: Percentage of time spent in water for Izel in the morning of dead fish one. The results are not significant.

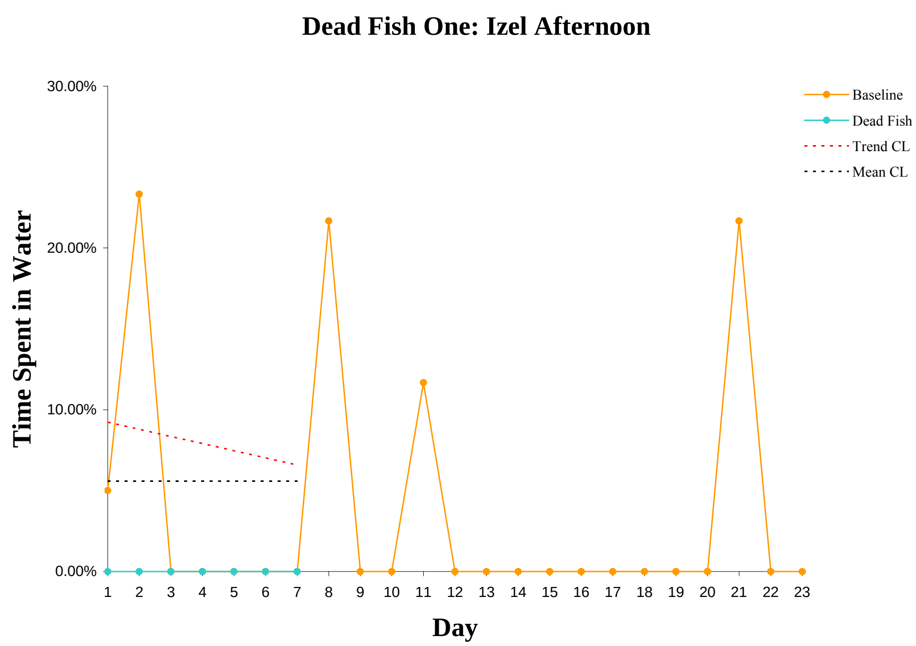

Figure F.6: Percentage of time spent in water for Izel in the afternoon of dead fish one. The results are not significant.

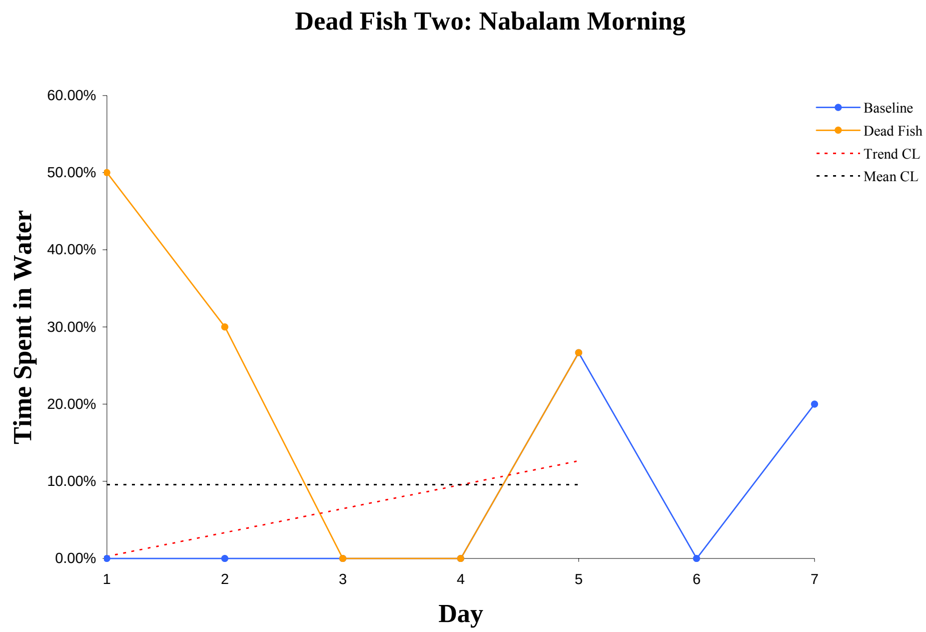

Figure F.7: Percentage of time spent in water for Nabalam in the morning of dead fish two. The results are not significant.

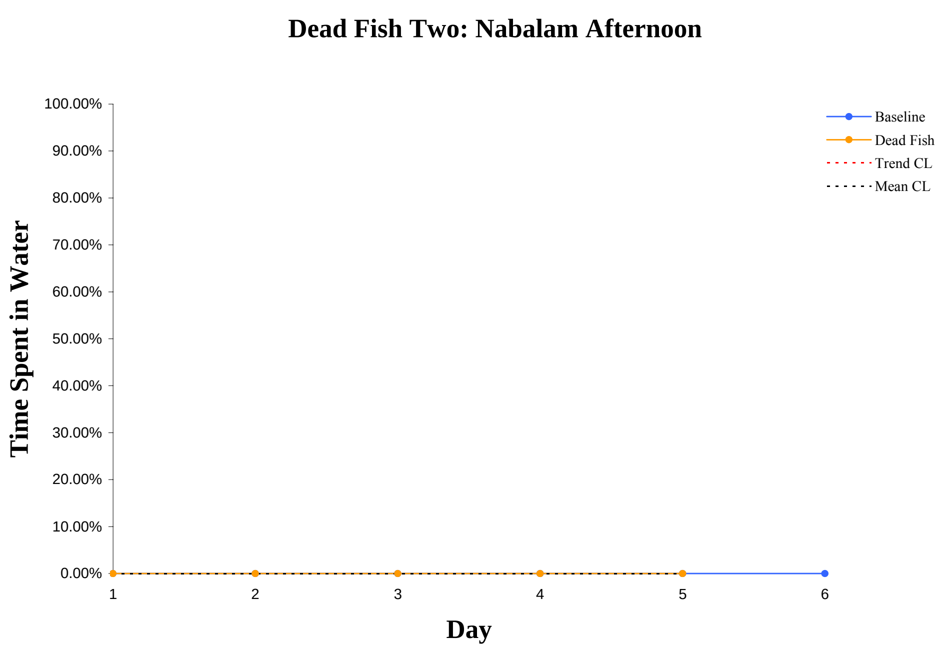

Figure F.8: Percentage of time spent in water for Nabalam in the afternoon of dead fish two. The results are not significant.

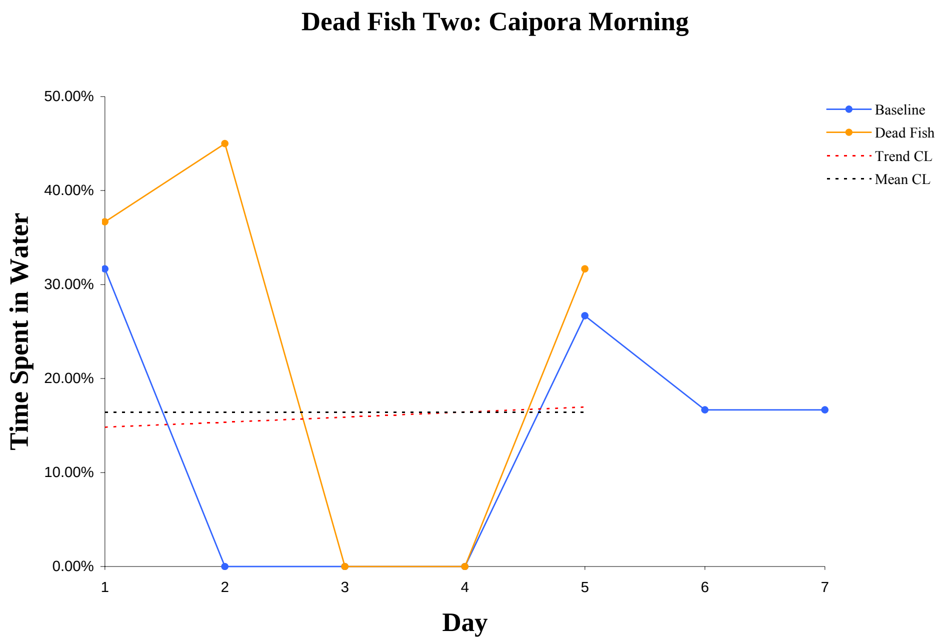

Figure F.9: Percentage of time spent in water for Caipora in the morning of dead fish two. The results are not significant.

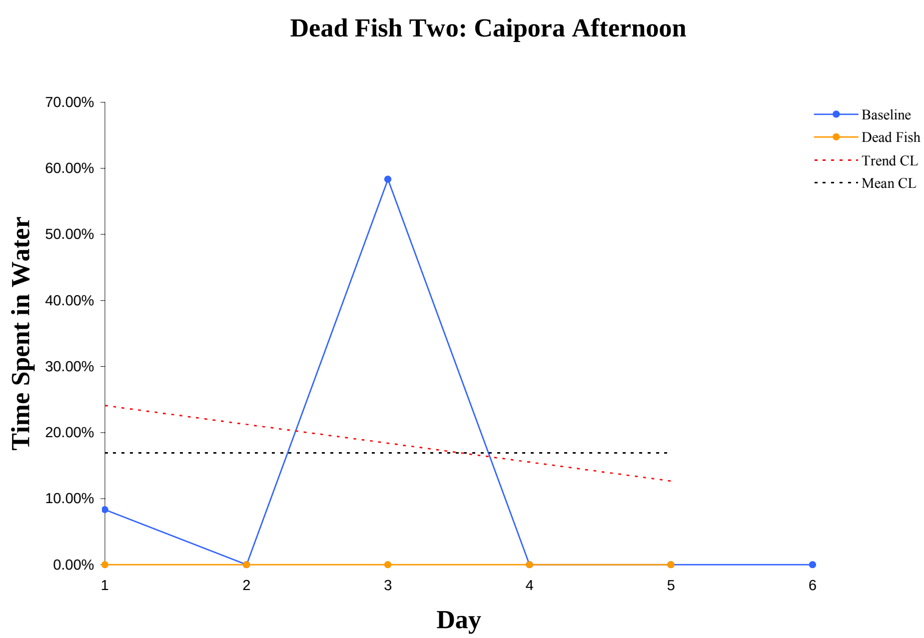

Figure F.10: Percentage of time spent in water for Caipora in the afternoon of dead fish two. The results are not significant.

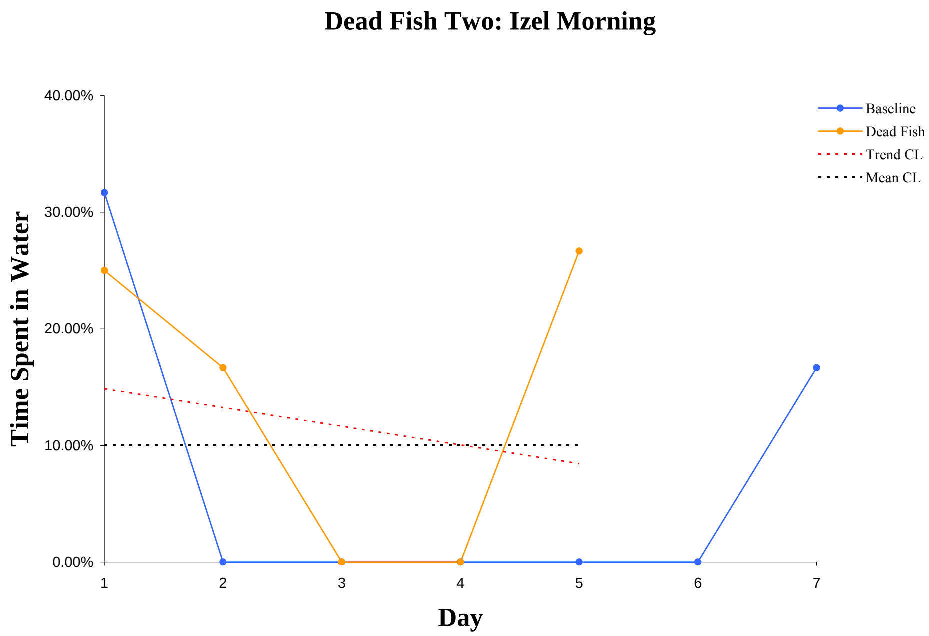

Figure F.11: Percentage of time spent in water for Izel in the morning of dead fish two. The results are not significant.

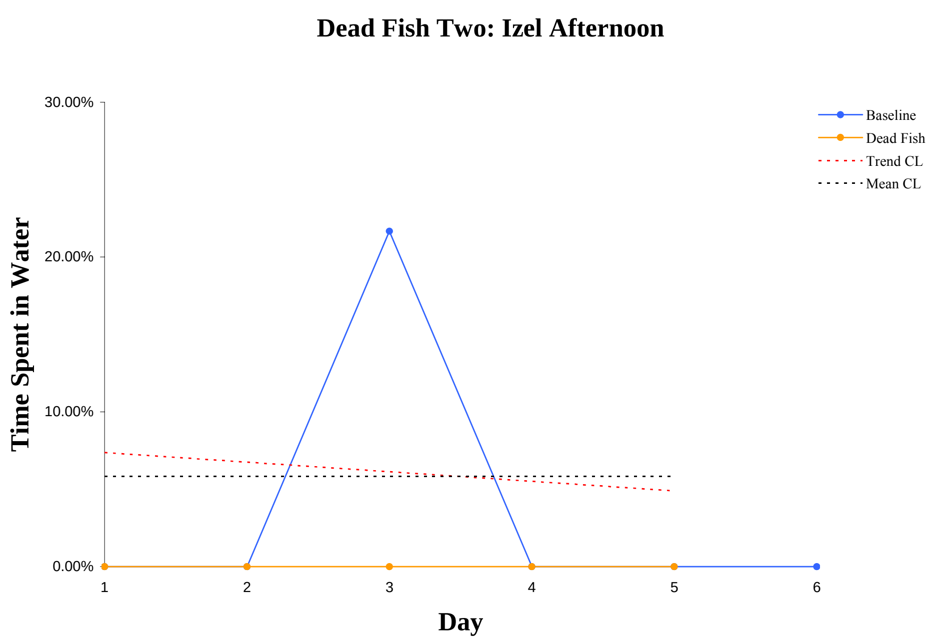

Figure F.12: Percentage of time spent in water for Izel in the afternoon of dead fish two. The results are not significant.

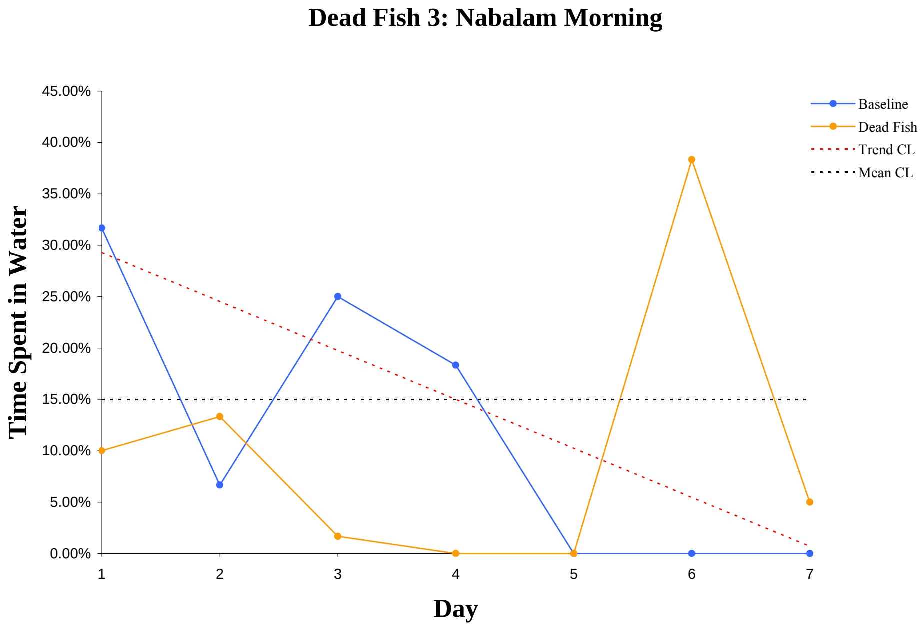

Figure F.13: Percentage of time spent in water for Nabalam in the morning of dead fish three. The results are not significant.

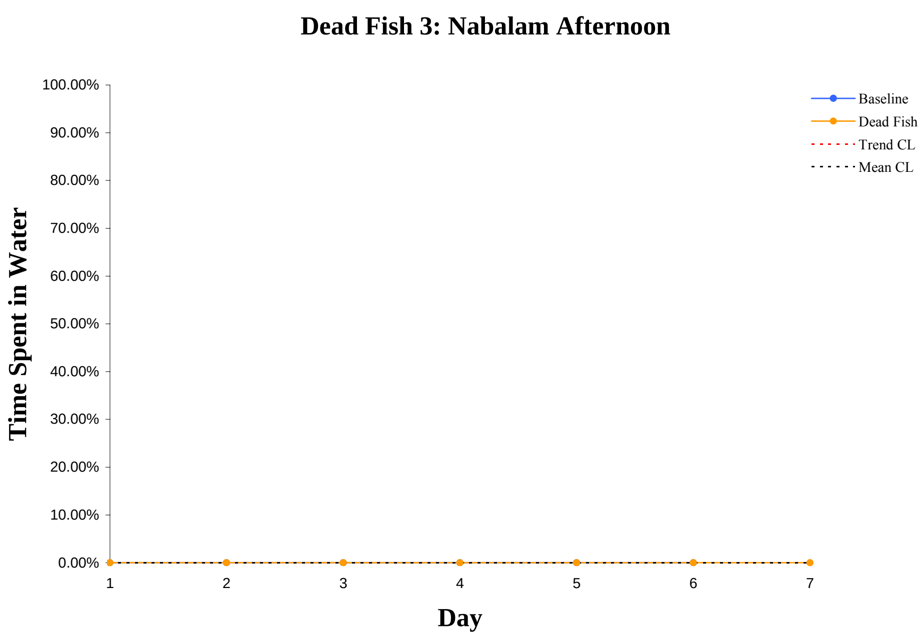

Figure F.14: Percentage of time spent in water for Nabalam in the afternoon of dead fish three. The results are not significant.

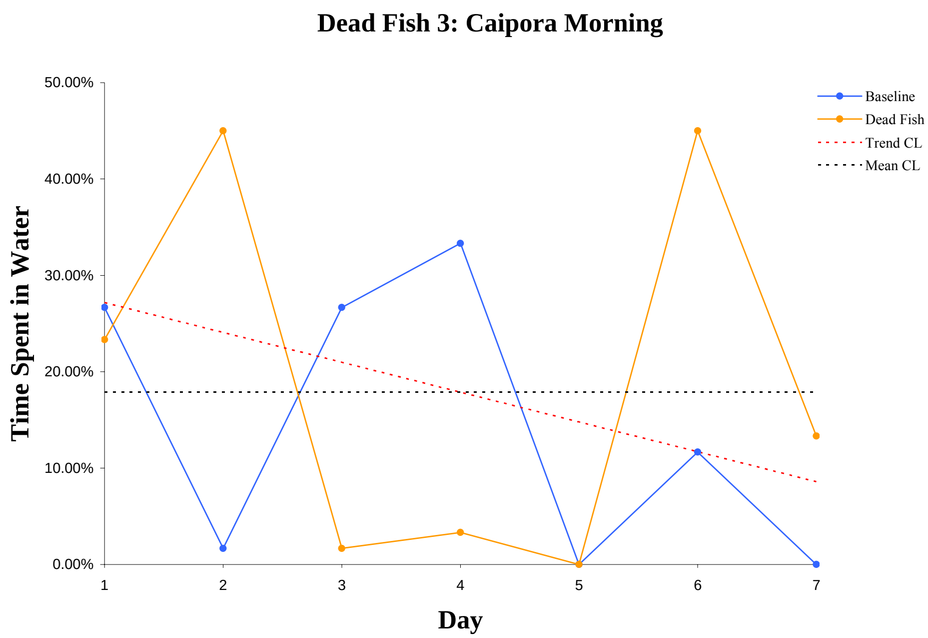

Figure F.15: Percentage of time spent in water for Caipora in the morning of dead fish three. The results are not significant.

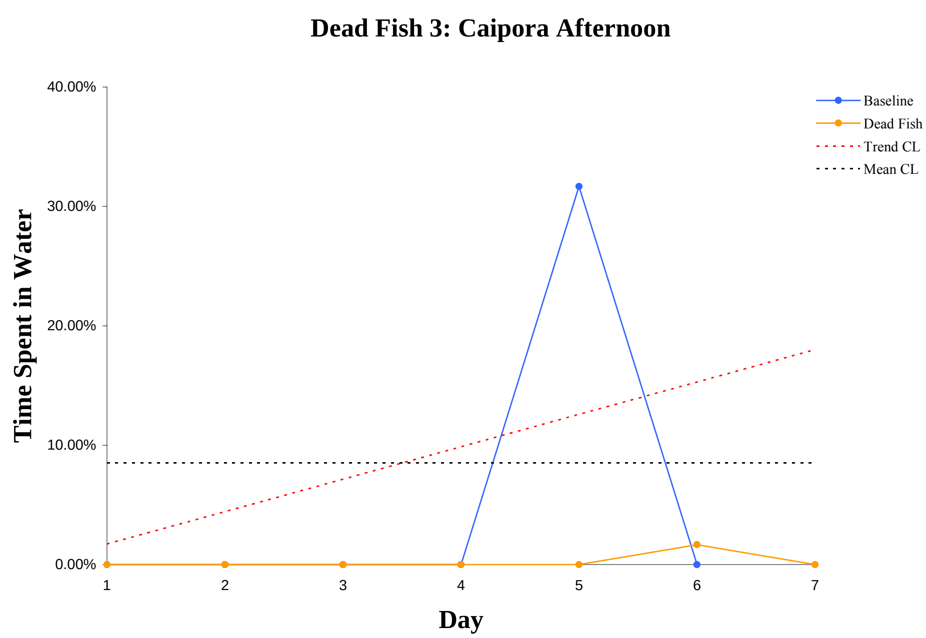

Figure F.16: Percentage of time spent in water for Caipora in the afternoon of dead fish three. The results are not significant.

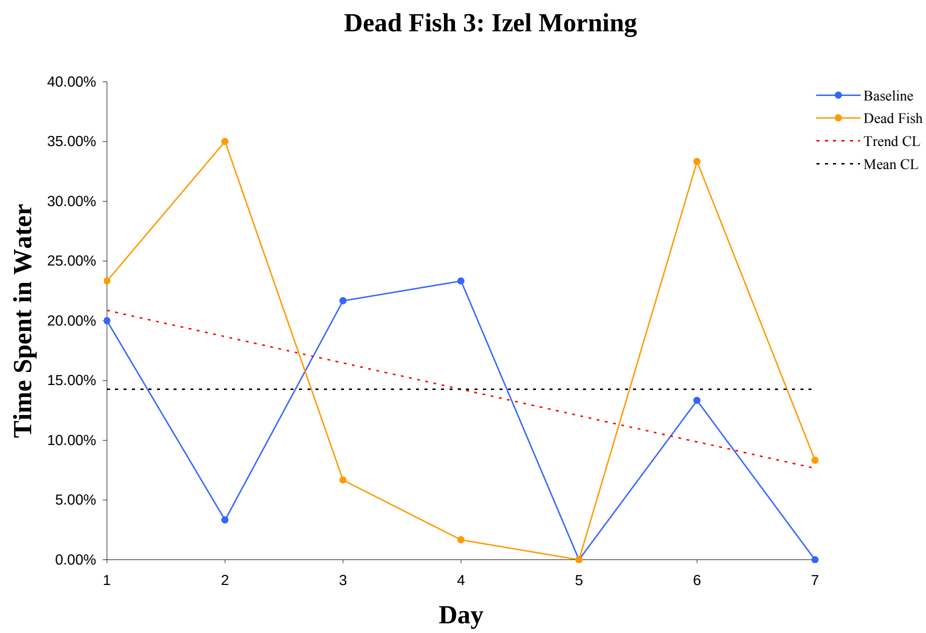

Figure F.17: Percentage of time spent in water for Izel in the morning of dead fish three. The results are not significant.

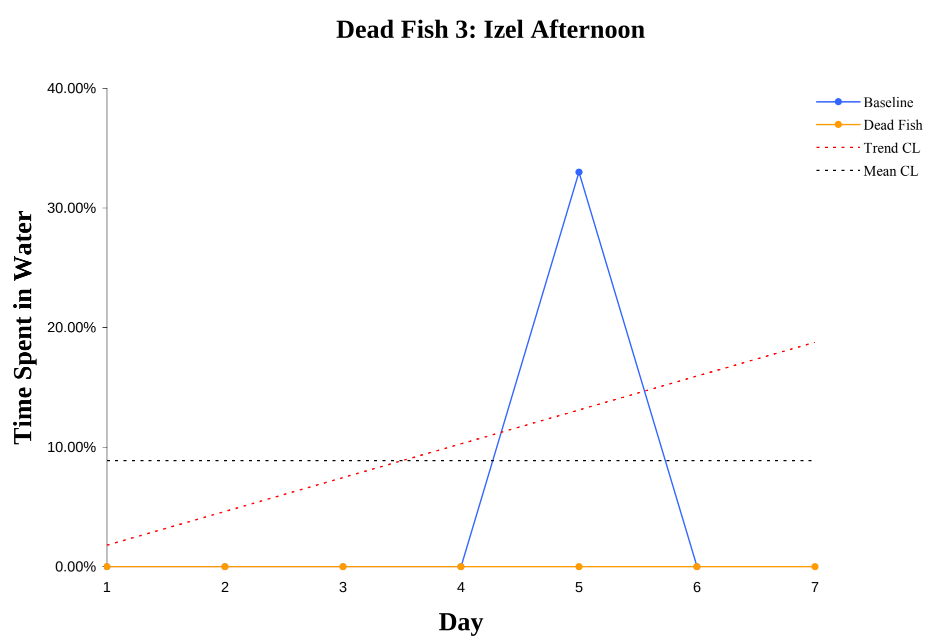

Figure F.18: Percentage of time spent in water for Izel in the afternoon of dead fish three. The results are not significant.

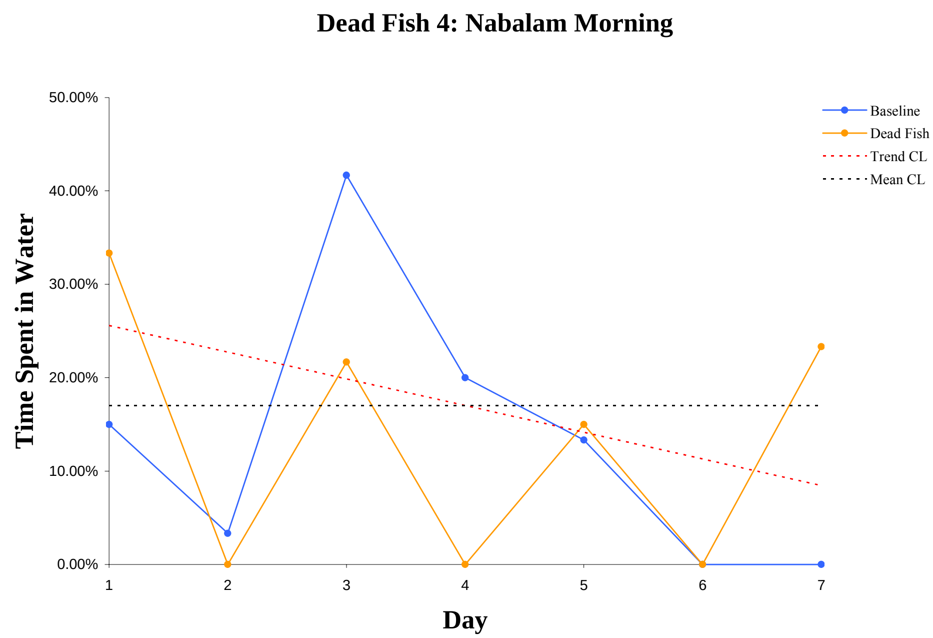

Figure F.19: Percentage of time spent in water for Nabalam in the morning of dead fish four. The results are not significant.

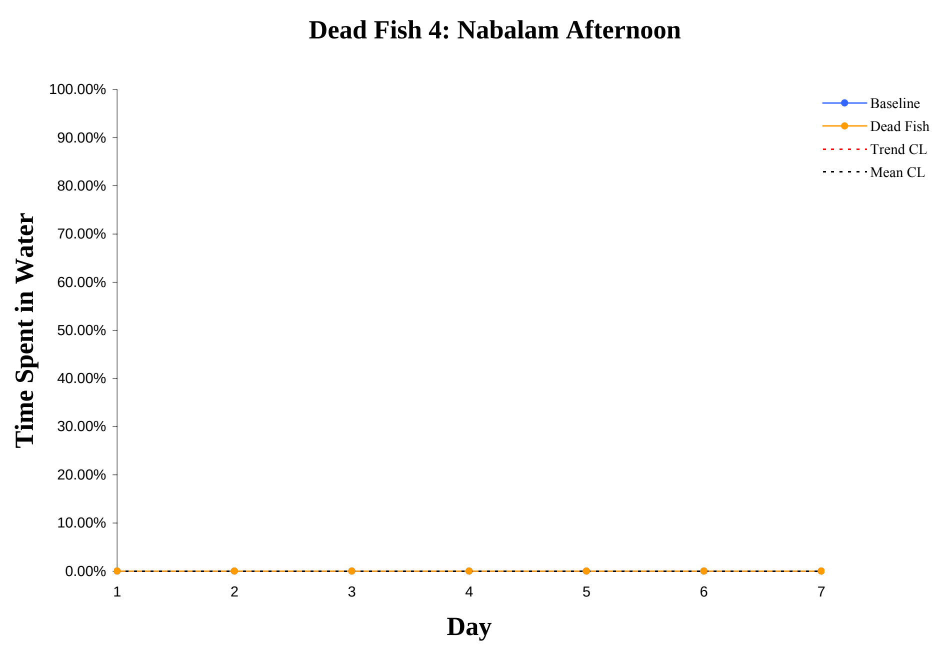

Figure F.20: Percentage of time spent in water for Nabalam in the afternoon of dead fish four. The results are not significant.

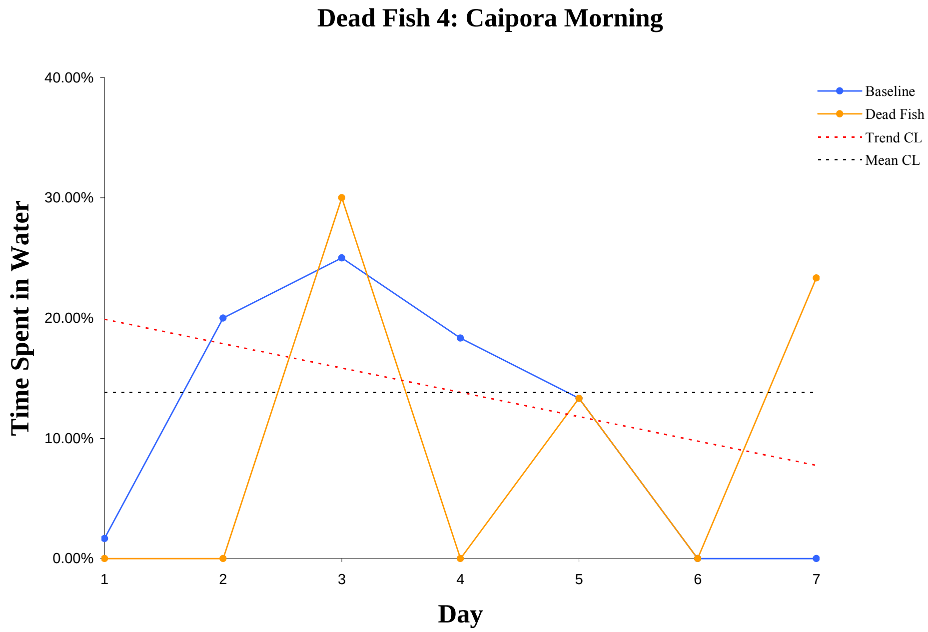

Figure F.21: Percentage of time spent in water for Caipora in the morning of dead fish four. The results are not significant.

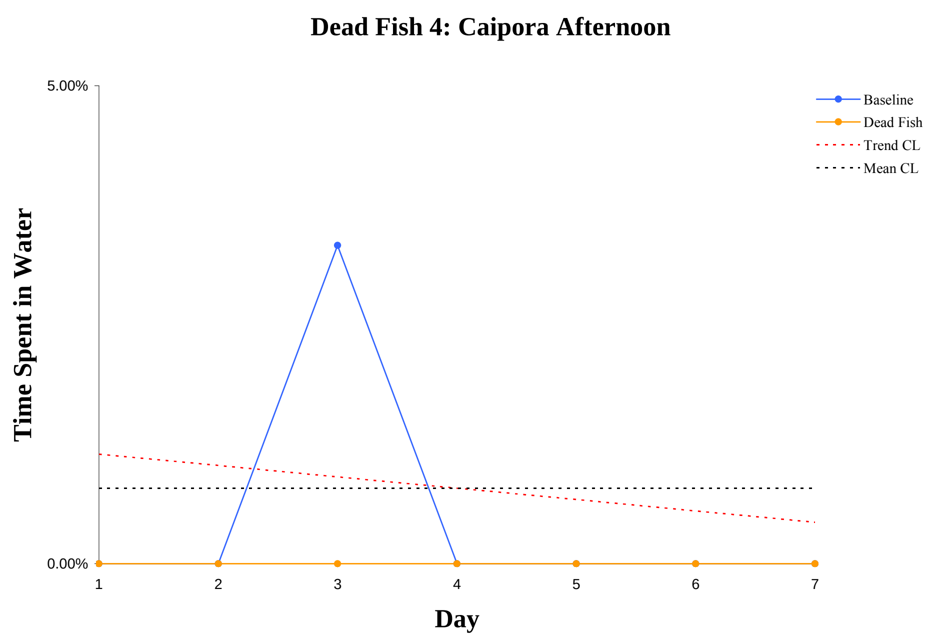

Figure F.22: Percentage of time spent in water for Caipora in the afternoon of dead fish four. The results are not significant.

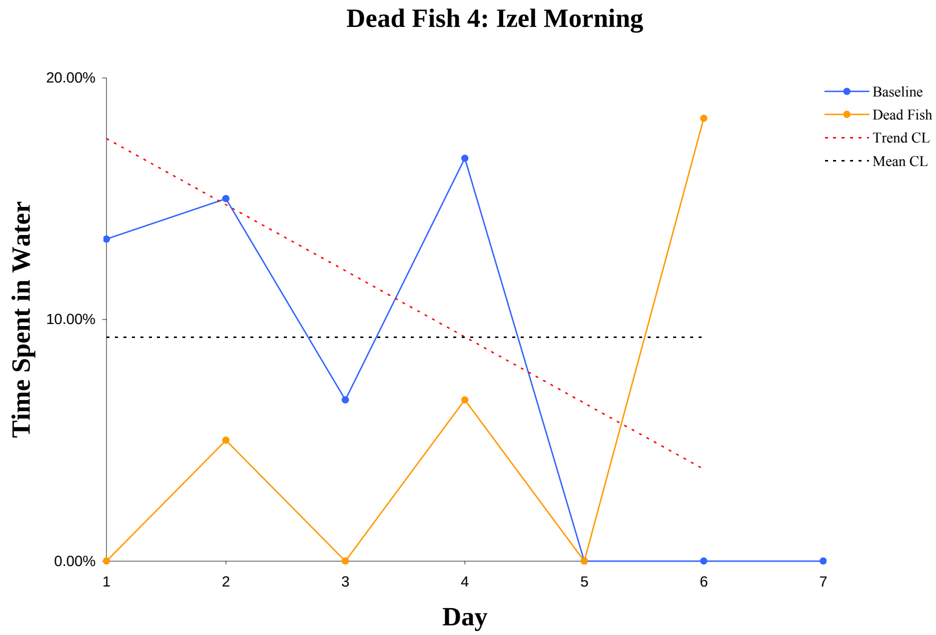

Figure F.23: Percentage of time spent in water for Izel in the morning of dead fish four. The results are not significant.

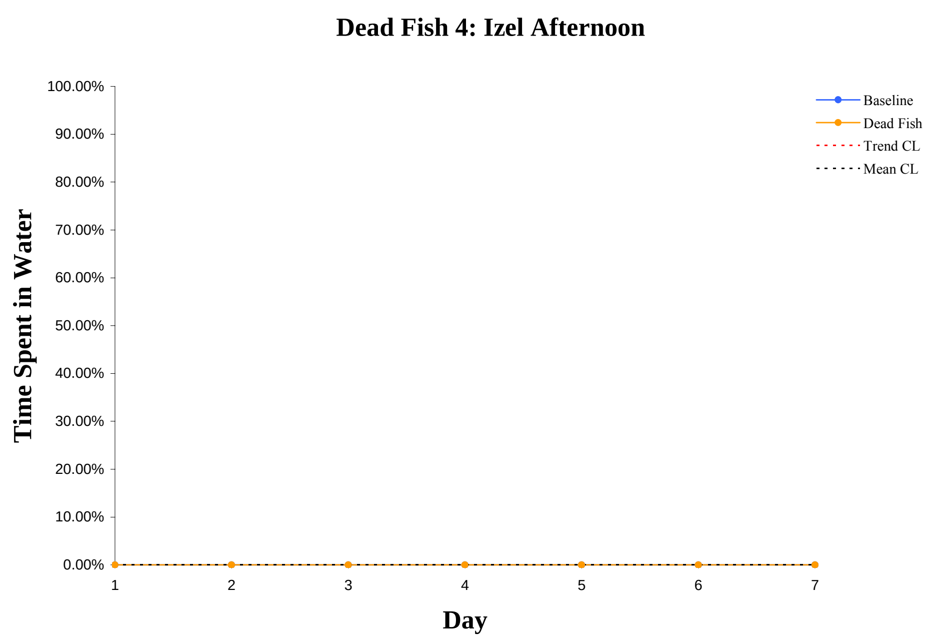

Figure F.24: Percentage of time spent in water for Izel in the afternoon of dead fish four. The results are not significant.

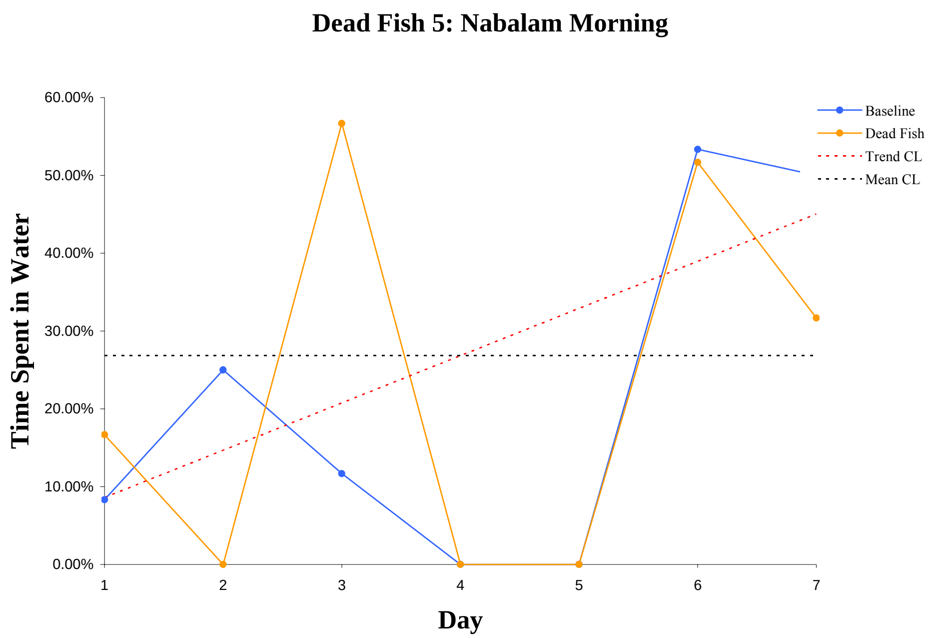

Figure F.25: Percentage of time spent in water for Nabalam in the morning of dead fish five. The results are not significant.

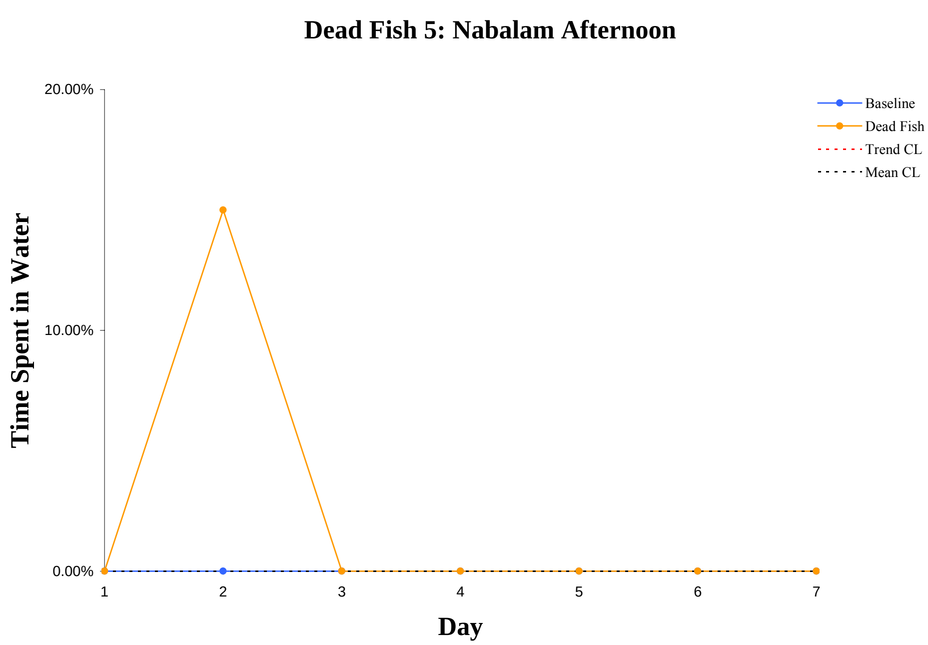

Figure F.26: Percentage of time spent in water for Nabalam in the afternoon of dead fish five. The results are not significant.

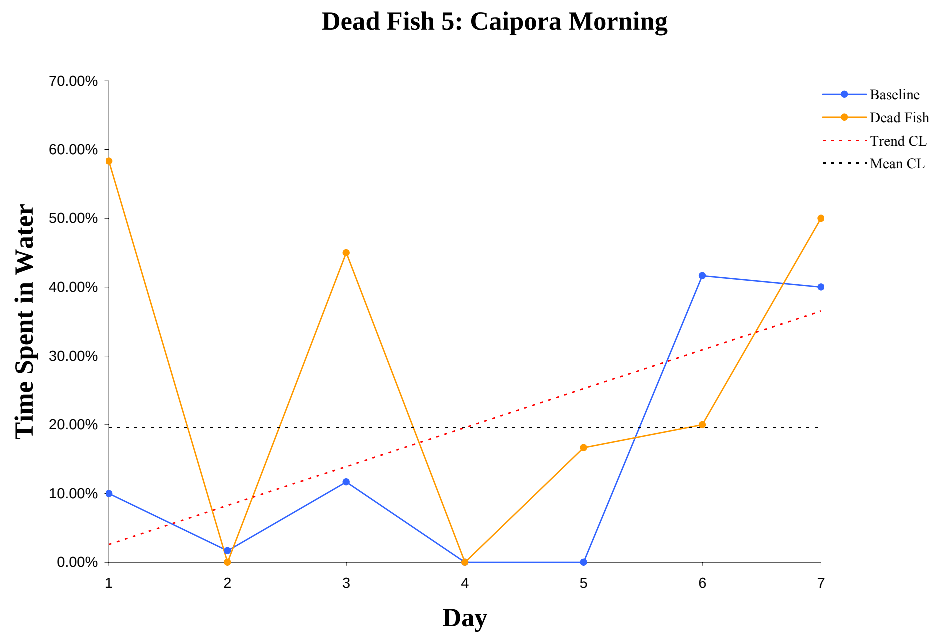

Figure F.27: Percentage of time spent in water for Caipora in the morning of dead fish five. The results are not significant.

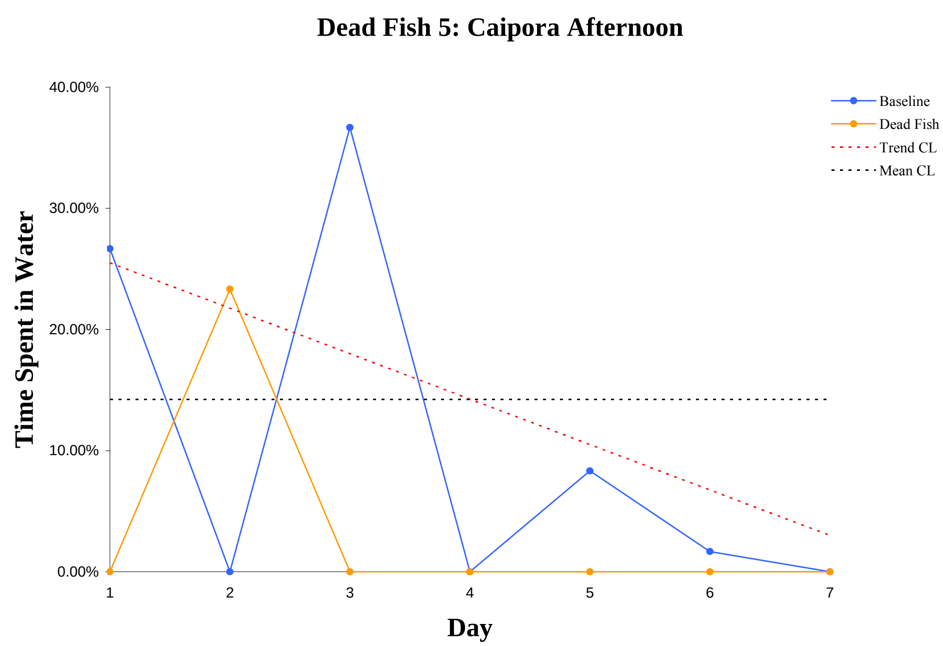

Figure F.28: Percentage of time spent in water for Caipora in the afternoon of dead fish five. The results are not significant.

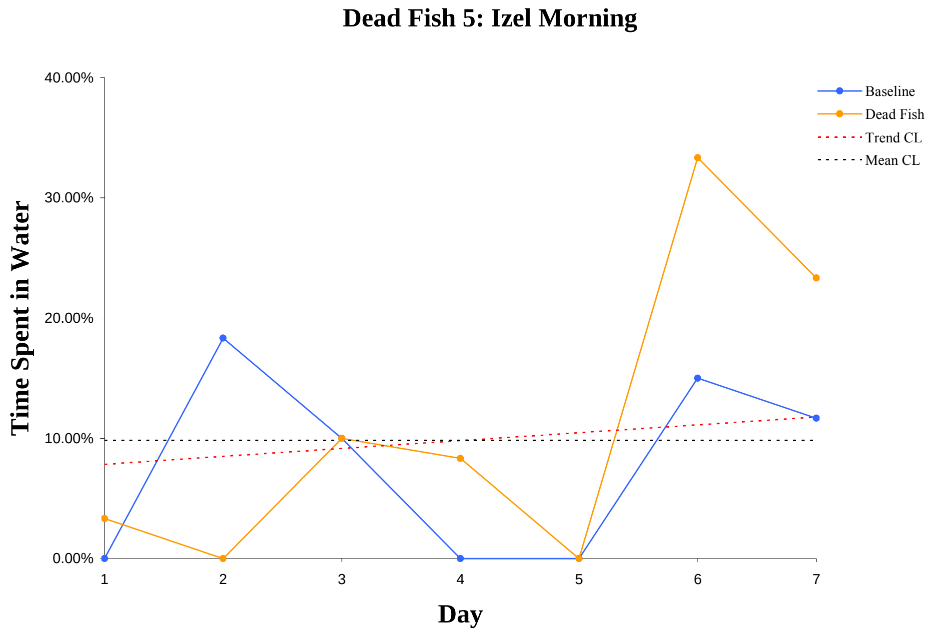

Figure F.29: Percentage of time spent in water for Izel in the morning of dead fish five. The results are not significant.

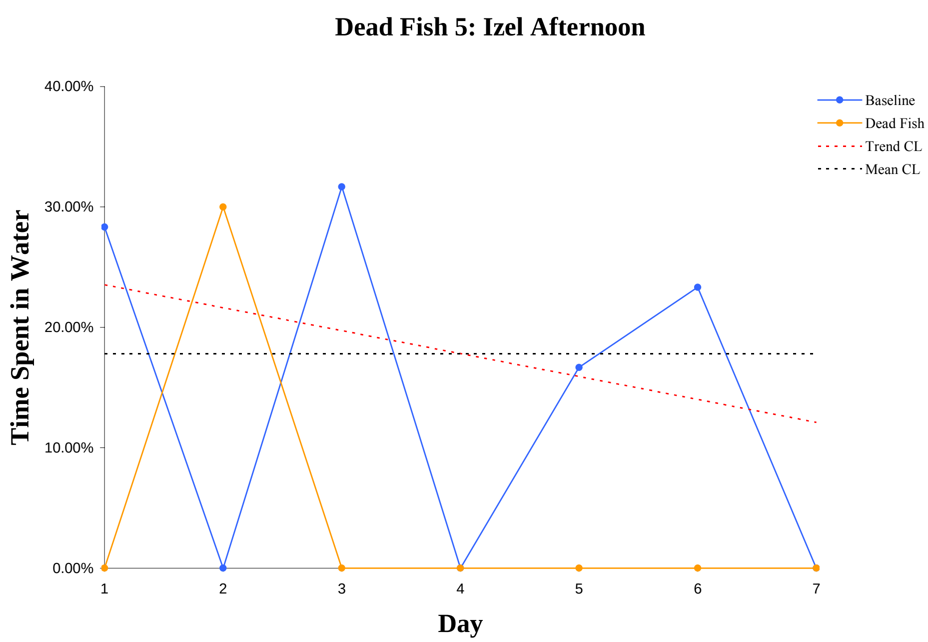

Figure F.30: Percentage of time spent in water for Izel in the afternoon of dead fish five. The results are not significant.

Dead Fish Six: Nabalam Morning

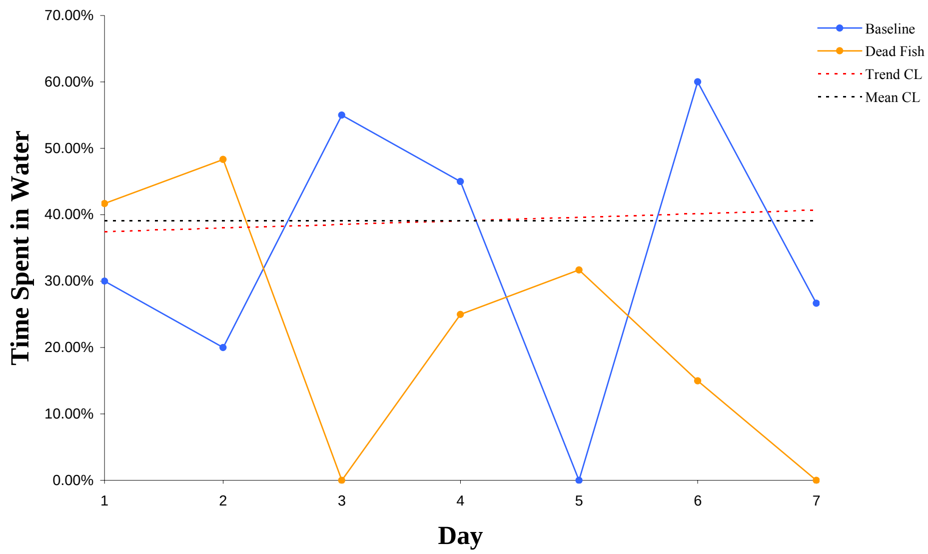

Figure F.31: Percentage of time spent in water for Nabalam in the morning of dead fish six. The results are not significant.

Dead Fish Six: Nabalam Afternoon

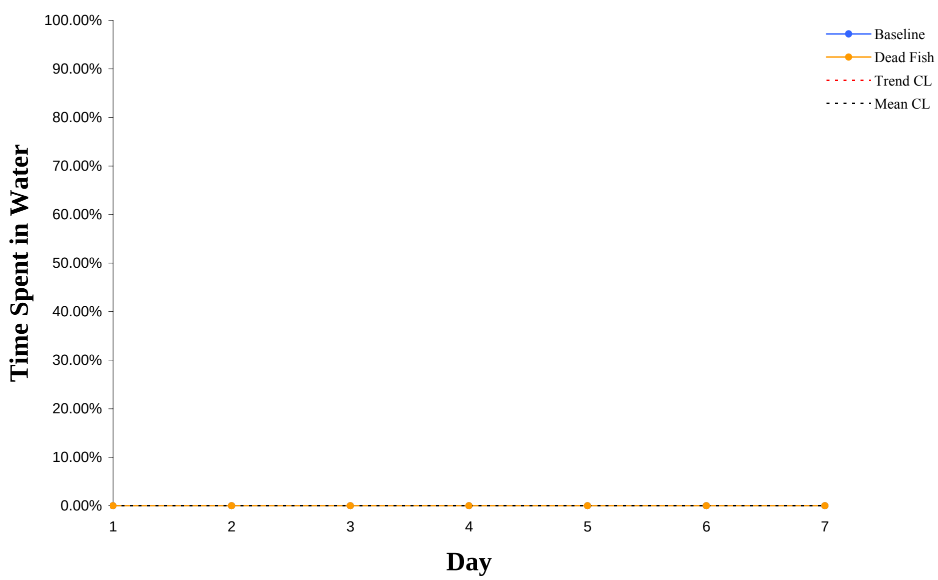

Figure F.32: Percentage of time spent in water for Nabalam in the afternoon of dead fish six. The results are not significant.

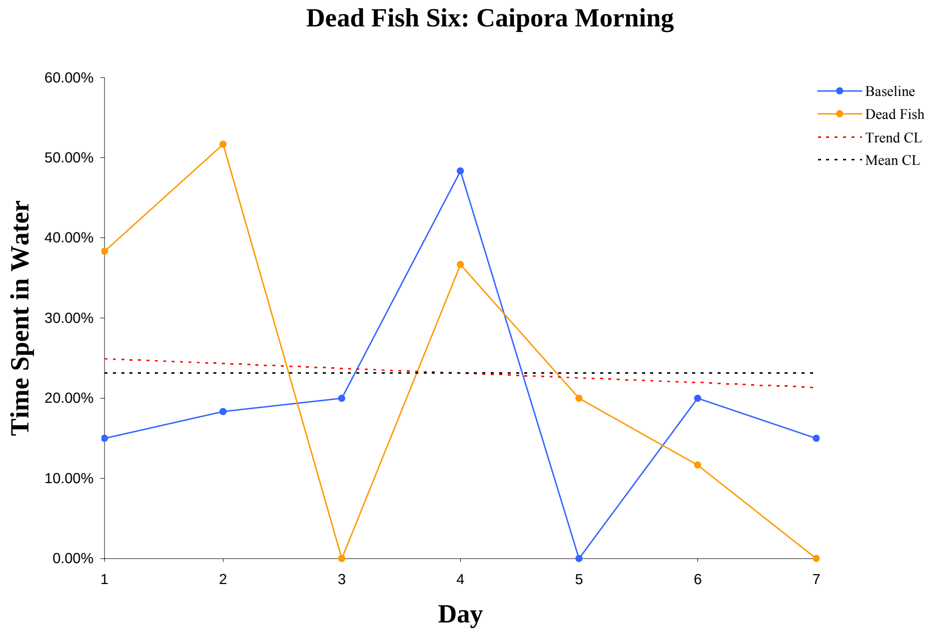

Figure F.33: Percentage of time spent in water for Caipora in the morning of dead fish six. The results are not significant.

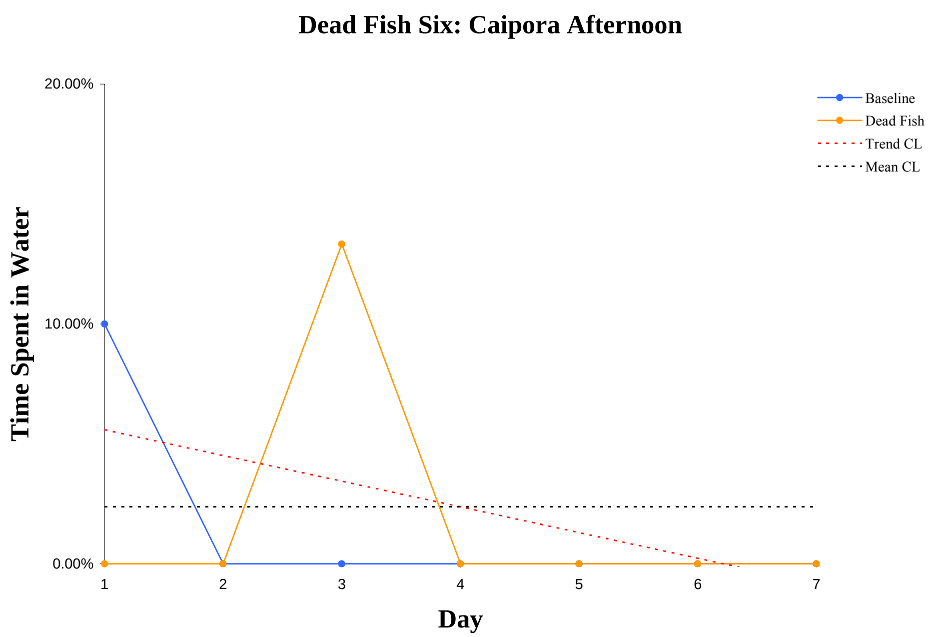

Figure F.34: Percentage of time spent in water for Caipora in the afternoon of dead fish six. The results are not significant.

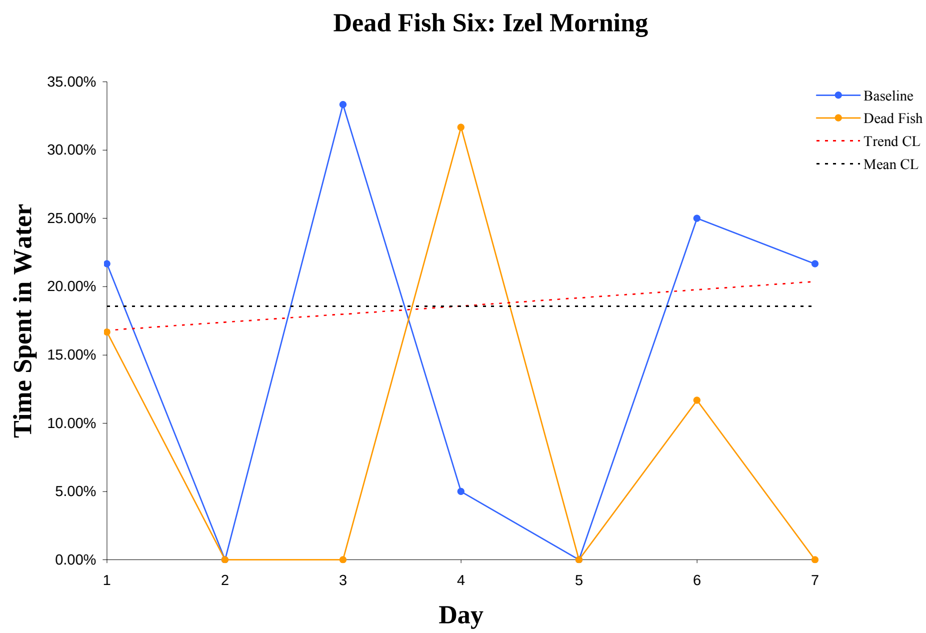

Figure F.35: Percentage of time spent in water for Izel in the morning of dead fish six. The results are not significant.

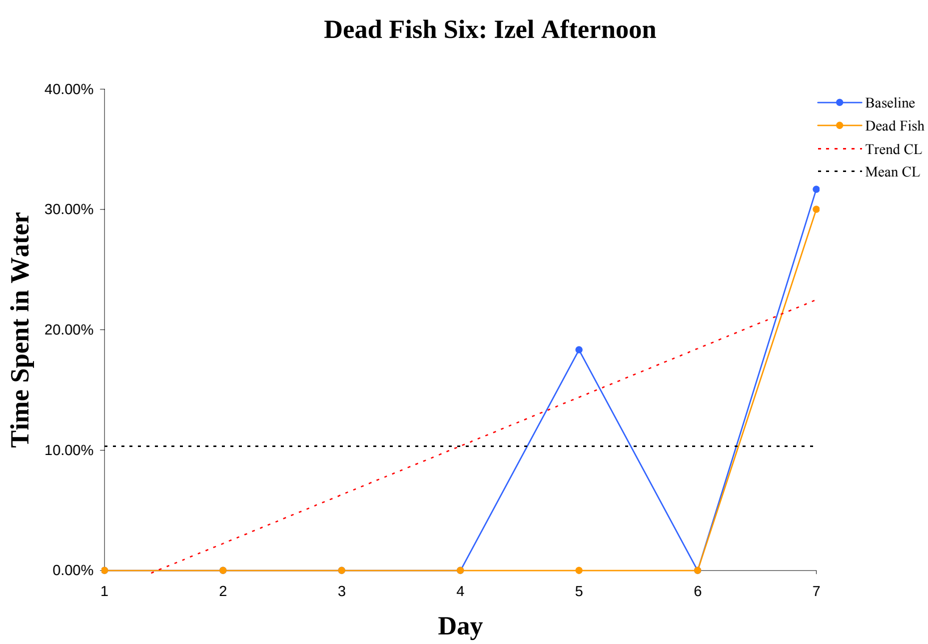

Figure F.36: Percentage of time spent in water for Izel in the afternoon of dead fish six. The results are not significant.

APPENDIX G: NO PREY SURVEY

Please circle your:

Age: 18-25 26-38 39-50 51-65 65+ **Sex:** Male Female

Choose one answer for each of the following questions:

1. Do you agree with feeding live insects to lizards in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

2. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

3. Do you agree with feeding live fish to penguins in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

4. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

5. Do you agree with feeding live fish to jaguars in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

6. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

7. Do you agree with feeding live mice to hawks in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

8. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

9. Prior to today, have you ever seen a predator hunt and eat a prey animal, such as on TV or in a zoo?

Yes No

10. If yes, where? (circle any that apply):

Zoo/Aquarium Feeding a pet TV In the wild Other ______________

APPENDIX H: FISH INTRODUCTION SURVEY

Please circle your:

Age: 18-25 26-38 39-50 51-65 65+ **Sex:** Male Female

Choose one answer for each of the following questions:

1. Do you agree with feeding live insects to lizards in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

2. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

3. Do you agree with feeding live fish to penguins in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

4. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

5. Do you agree with feeding live fish to jaguars in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

6. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

7. Do you agree with feeding live mice to hawks in public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

8. How about out of public view?

Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree

9 Prior to today, have you ever seen a predator hunt and eat a prey animal, such as on TV or in a zoo?

Yes No

10. If yes, where? (circle any that apply):

Zoo/Aquarium Feeding a pet TV In the wild Other _______________

11. Did you see the jaguars interacting with the fish today?

Yes No

12. If yes, is this something you would like to see again? If no, would you like to see it?

Yes No

13. Why?

____

APPENDIX I: ETHOGRAM FOR BEHAVIORAL DATA COLLECTION

	Behavior	Code	Active/ Inactive	Definition
	Climb	CL	Active	Vertical ascent or descent, as into trees or structures. Back of animal is at an angle greater than 45 degrees. Includes only active climbing; if an animal is sitting or lying in a tree, “rest” or “stationary alert” is scored.
GROOM	Groom Self	SG	Active	Includes licking self or licking paw and rubbing it over head, chewing at fur, or shaking water off. Includes pauses of up to 5 seconds.
	Groom Conspecific	GC	Active	Licking a conspecific. Includes pauses of up to 5 seconds. Subscript will denote which conspecific is being groomed.
	Hunt	HN	Active	Any behavior used to obtain prey, including active and visual search, crouching, watching, tail twitching, rushing, swiping, pouncing, wrestling, delivering killing bite, and rolling. Includes consumption of the prey.
	Locomote	LC	Active	Moving around enclosure in no fixed pattern.
	Not Visible	NV	NA	Individual is out of view
	Other	OT	NA	Any other behavior not listed. A subscript will be used to describe behavior. For example, DR for drinking water.
PLAY	Conspecific Play	CP	Active	Playing with part of a conspecific (i.e. tail) or a conspecific. May be reciprocal or not. Subscript will be used to denote which conspecific is being played with.
	Locomotor Play	LP	Active	Solitary, superfluous, apparently purposeless activity such as gamboling, frisking, somersaulting, rolling, and leaping.
	Object Play	OP	Active	Dragging, batting, chewing, carrying, or tossing objects. Subscript will be used to denote object type.
	Rest	RS	Inactive	Individual is lying or sitting, either awake or asleep, and not attending to the surrounding environment.
	Olfactory Investigate	OI	Active	Olfactory investigation of an object, plant, substrate, etc, either by sniffing or flehmen. Does not include sniffing the air (that is scored

				as Stationary Alert). Subscript will be used to denote what is being sniffed.
	Stationary Alert	SA	Inactive	Alert, standing quadrupedally, sitting or lying quietly, but remaining attentive. Individual may movie head side to side and/or sniff air, perhaps attending to external stimuli. Subscript will be used to denote whether individual is stationary alert on land or in water.
	Stereotypic Pace	SP	NA	Moving around enclosure on a set path (at least two repetitions are required to score this behavior)
	Swim	SW	Active	Moving through water in no fixed pattern.

REFERENCES

Bashaw, M. J., Bloomsmith, M. A., Marr, M. J., & Maple, T. L. (2003). To hunt or not to hunt? A feeding enrichment experiment with captive large felids. *Zoo Biology, 22*(2), 189-198.

Boinski, S., Swing, S. P., Gross, T. S., & Davis, J. K. (1999). Environmental enrichment of brown capuchins (*Cebus apella*): Behavioral and plasma and fecal cortisol measures of effectiveness. *American Journal of Primatology, 48*(1), 49-68.

Box, H. O., & Gibson, K. R. (Eds.). (1999). *Mammalian Social Learning: Comparative and Ecological Perspectives*. Cambridge: Cambridge University Press.

Broom, D. M., & Johnson, K. G. (1993). *Stress and animal welfare*. London: Chapman and Hall.

Brown, J. L., Wasser, S. K., Wildt, D. E., & Graham, L. H. (1994). Comparative aspects of steroid hormone metabolism and ovarian actvity in felids measured noninvasively in feces. *Biology of Reproduction, 51*, 776-786.

Carlstead, K., Brown, J. L., & Seidensticker, J. (1993). Behavioral and adrenocortical responses to environmental changes in leopard cats (*Felis bengalensis*). *Zoo Biology, 12*(4), 321-331.

Crosbie, J. (1993). Interrupted time-series analysis with brief single-subject data. *Journal of Consulting and Clinical Psychology, 61*(6), 966-974.

Dembiec, D. P., Snider, R. J., & Zanella, A. J. (2004). The effects of transport stress on tiger physiology and behavior. *Zoo Biology, 23*(4), 335-346.

Fisher, W. W., Kelley, M. E., & Lomas, J. E. (2003). Visual aids and structured criteria for improving visual inspection and interpretation of single-case designs. *Journal Of Applied Behavior Analysis, 36*(3), 387-406.

Forthman, D.L., Elder, S.D., Bakeman, R., Kurkowski, T.W., Noble, C.C., and Winslow, S.W. (1992). Effects of feeding enrichment on behavior of three species of captive bears. *Zoo Biology*, **11**(3), 187-195.

Foster-Turley, P., & Markowitz, H. (1982). A captive behavioral enrichment study with Asian small-clawed river otters *Aonyx cinerea*. *Zoo Biology, 1*(1), 29-43.

Graham, L. H., & Brown, J. L. (1996). Cortisol metabolism in the domestic cat and implications for non-invasive monitoring of adrenocortical function in endangered felids. *Zoo Biology, 15*(1), 71-82.

Griffin, A. S., & Evans, C. S. (2003). Social learning of antipredator behaviour in a marsupial. *Animal Behaviour, 66*(3), 485-492.

Griffin, A. S., Evans, C. S., & Blumstein, D. T. (2001). Learning specificity in acquired predator recognition. *Animal Behaviour, 62*(3), 577-589.

Huitema, B. E. (2004). Analysis of interrupted time-series experiments using ITSE: A critique. *Understanding Statistics, 3* (1), 27-46.

Ings, R., Waran, N. K., & Young, R. J. (1997). Attitude of zoo visitors to the idea of feeding live prey to zoo animals. *Zoo Biology, 16*(4), 343-347.

IUCN. (1987a). Captive breeding, *IUCN policy statement*. Gland, Switzerland: IUCN.

IUCN. (1987b). Translocations of living organisms: introduction, re-introductions, and re-stocking, *IUCN Position Statement*. Gland, Switzerland: IUCN.

IUCN. (1995). IUCN/SSC guidelines for re-introductions.

Kitchener, A. C. (1999). Watch with mother: a review of social learning in the Felidae. In H. O. Box & K. R. Gibson (Eds.), *Mammalian Social Learning: Comparative and Ecological Perspectives* (pp. 236-258). Cambridge: Cambridge University Press.

Law, G. (1991). Behavioural enrichment for cats. In J. Partridge (Ed.), *Management Guidelines for Exotic Cats* (pp. 108-112). Bristol: Association of British Wild Animal Keepers.

Leyhausen, P. (1979). *Cat Behavior*. New York: Garland Publishing, Inc.

Margulis, S. W., Hoyos, C., & Anderson, M. (2003). Effect of felid activity on zoo visitor interest. *Zoo Biology, 22*(6), 587-599.

Markowitz, H. (1997). The conservation of species-typical behaviors. *Zoo Biology, 16*(1), 1-2.

May, R. M. (1991). The role of ecological theory in planning re-introduction of endangered species. In J. H. W. Gipps (Ed.), *Beyond Captive Breeding: Re-introducing Endangered Mammals to the Wild* (pp. 145-163). New York: Oxford University Press.

Mellen, J., & MacPhee, M. S. (2001). Philosophy of environmental enrichment: Past, present, and future. *Zoo Biology, 20*(3), 211-226.

Miller, B., Biggins, D., Hanebury, L., & Vargas, A. (1994). Reintroduction of the black-footed ferret (*Mustela nigripes*). In P. J. S. Olney, G. M. Mace & A. T. C. Feistner (Eds.), *Creative Conservation: Interactive Management of Wild and Captive Animals* (pp. 455-464). London: Chapman and Hall.

Nowell, K., & Jackson, P. (Eds.). (1996). *Wildcats: Status, Survey, and Conservation Action Plan*. Switzerland: IUCN.

Piper, R.G., McElwain, I.B., Orme, L.E., McCraren, J.P., Fowler, L.G., & Leonard, J.R. (1982). Fish Hatchery Management. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Rabin, L. A. (2003). Maintaining behavioural diversity in captivity for conservation: Natural behaviour management. *Animal Welfare, 12*(1), 85-94.

Rendell, L., & Whitehead, H. (2001). Culture in whales and dolphins. *Behavioral and Brain Sciences, 24*, 309-324.

Roberts, L.S., Janovy, J., & Schmidt, P. (2004). Foundations of Parasitology. McGraw-Hill, Chicago.

Schapiro, S.J., Bloomsmith, M.A., Porter, L.M., & Suarez, S.A. (1995). Long-term effects of inanimate environmental enrichment on young rhesus monkeys. *American Journal of Primatology, 36*, 154.

Schapiro, S.J., Bloomsmith, M.A., Porter, L.M., & Suarez, S.A. (1995). Enrichment effects on rhesus monkeys successively housed singly, in pairs, and in groups. *Applied Animal Behavior Science, 48*, 159-172.

Seal, U. S. (1991). Life after extinction. In J. H. W. Gipps (Ed.), *Beyond Captive Breeding: Reintroducing Endangered Mammals to the Wild* (pp. 39-55). New York: Oxford University Press.

Shepherdson, D. (1994). The role of environmental enrichment in the captive breeding and reintroduction of endangered species. In P. J. S. Olney, G. M. Mace & A. T. C. Feistner (Eds.), *Creative Conservation: Interactive Management of Wild and Captive Animals*. London: Chapman and Hall.

Shepherdson, D., Carlstead, K., Mellen, J., & Seidensticker, J. (1993). The influence of food presentation on the behavior of small cats in confined environments. *Zoo Biology, 12*(2), 203-216.

Stoskopf, M. K., & Gibbons, E. F. J. (1994). Quantitative evaluation of the effects of environmental parameters on the physiology, behavior, and health of animals in naturalistic captive environments. In E. F. J. Gibbons, E. J. Wyers, E. Waters & E. W. J. Menzel (Eds.), *Naturalistic environments in captivity for animal behavior research* (pp. 140-160). Albany: State University of New York Press.

Vargas, A., & Anderson, S. H. (1998). Ontogeny of black-footed ferret predatory behavior towards prairie dogs. *Canadian Journal of Zoology, 76*(9), 1696-1704.

Wilson, E. O. (1992). *The Diversity of Life*. New York: W.W. Norton and Company.