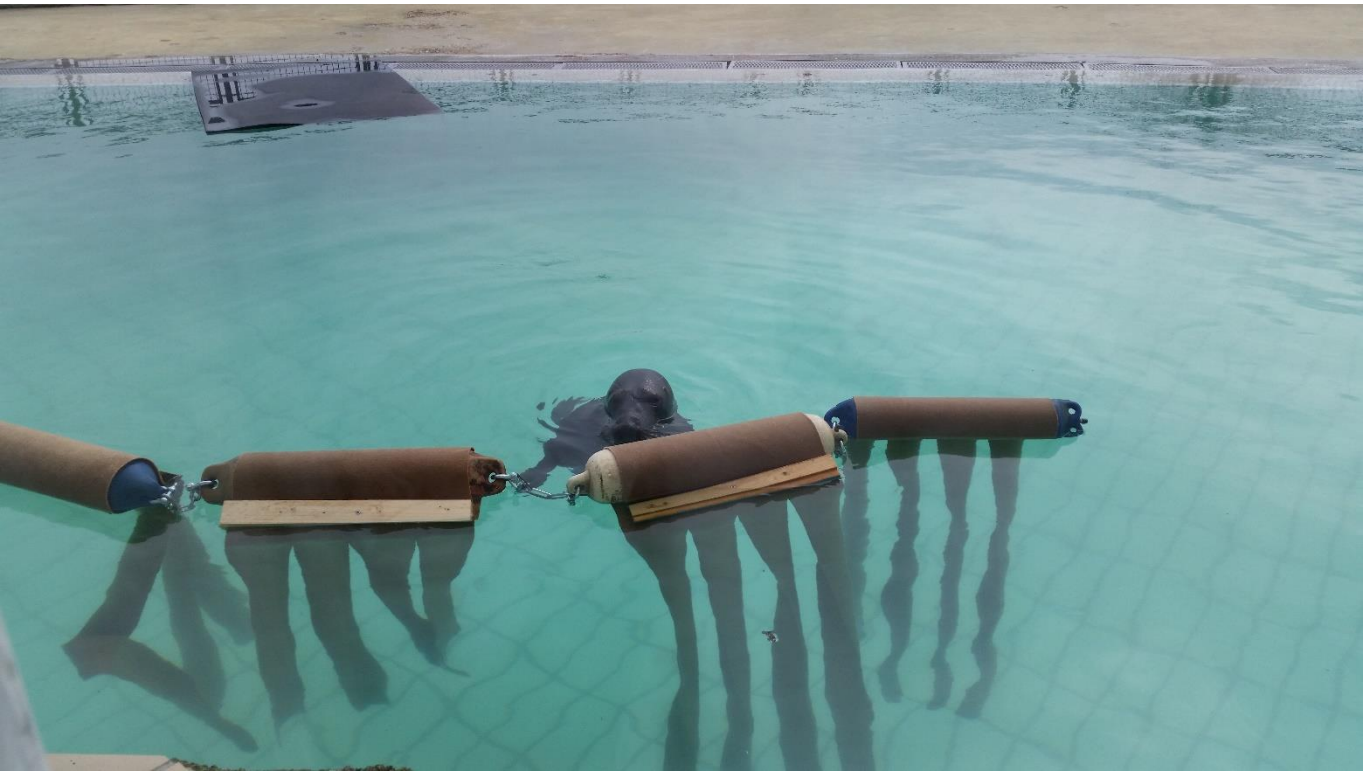
Effects of environmental enrichment on Common Seals (Phoca vitulina)



Michael F. Bakker Paiva

Effects of environmental enrichment on Common Seals (*Phoca vitulina*)

Effects of environmental enrichment on body mass growth and time budget of juvenile and pup Common seals (Phoca vitulina) in the Seal Rehabilitation and Research Centre (SRRC)

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Michael Bakker Paiva, Pieterburen, 22th of January 2016

Summary

Common seals (Phoca vitulina) are mostly seen from coastal temperate waters to the Polar Regions. High levels of toxic waste that affect the immune system, fisheries, and new outbreaks of viruses consist of the current threats to the seal populations. The Seal Rehabilitation and Research Centre (SRRC) is a specialized hospital for Phocidae that are commonly found stranded along the Dutch coastline. In recent years, there has been an increasing number of admitted seals into the SRRC, mostly because of abandoned pups and seals suffering from lungworm infections. In 2011, the SRRC had 836 seal patients in total; this was the highest number of admitted seals ever recorded at the SRRC. Body mass loss can cause in a longer rehabilitation time in the SRRC, thus resulting in a longer period away from the animal's wild environment. Stereotypic behaviour is relatively common in facilities that house animals, as captive environments are more predictable, sterile and lacking in complexity. Stereotypic behaviour can cause stress and central nervous system dysfunctions. A commonly used attribute that is used to improve animal environments, animal welfare and enhance the animal its behavioural biology is environmental enrichment. During rehabilitation, seals can occasionally show stereotypic behaviour, this can cause a loss of body mass and a reduction of animal welfare. The main focus of this study is the use of felt forest as an environmental enrichment, to find out what effect the enrichment has on the active behaviour and body mass gain of common seals, both pups and juveniles. The study was carried out in an enclosure in the SRRC called "Grote-meeuwenbad". The study consisted of two age classes, juveniles and pups, which were then divided into two enriched and two control groups. At the end of the study a total of 30 seals were observed during this study, 10 juveniles and 20 pups. The enrichment was left for six hours a day, in different periods, and for six days, to avoid the seals becoming habituated to the enrichment. This method resulted in a data collection of 405 hours in total. Using BORIS to analyse the data, showed that all control groups combined were more active than the enriched groups, although it did not show any statistical significant difference ($P = 0.134$). The enriched groups of the juveniles showed a minor higher percentage of active behaviour compared to the juvenile control groups, although this difference was not statistically significant ($P = 0.331$). The control groups of the pups showed a higher percentage of active behaviour when compared to the enriched groups. The enriched pups do show a higher percentage when compared to the enriched juveniles, although this is not statistically significant ($P = 0.089$). When comparing the body mass gain, the enriched pups gained more body mass compared to the enriched juveniles, although this was not statistically significant ($P= 0.670$). The difference in active behaviour, as mentioned above, could be explained because juvenile seals seemed scared of the environmental enrichment for the first two to three days. In these first few days, the juveniles would not enter the pool, but haul out and almost constantly pay attention to the enrichment in the pool, this was considered to be inactive. Another factor that can contribute to the difference in significance is that during observations of juvenile groups, the total number of animals per group was smaller than the groups of the pups. The difference in weight gain can be clarified because all seals, independent of their start weight are released after reaching a certain weight. Until the release the animals usually spend the same amount of time in the pools. Future studies should try to use bigger sampling groups and longer sampling periods to find if there are any significant differences when using higher total numbers. Furthermore, this kind of study has not been performed yet with this sort of environmental enrichment, although there has been a study that would compare a felt forest with food related enrichment. Other studies also prove that food related enrichment has a better effect on the activity of animals than non-food related enrichment.

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1. Introduction

The common seal, *Phoca vitulina* (Linnaeus, 1758), also called harbour seal or spotted seal, is a carnivorous marine mammal that is part of the *Phocidae* family. There are five subspecies, *P.v. vitulina*, *P.v. stejnegeri*, *P.v. mellonae*, *P.v. concolor*, *P.v. richardii*. The current study is focussed on *P.v. vitulina*. Common seals are mostly found in coastal waters from the temperate waters to the Polar Regions (Figure 1.1) and are one of the most widespread pinniped species, the clade of all seal species (Reeves, *et al.*, 2002; Reder, *et al*., 2003; Thompson & Härkönen, 2008). Other than the strong bond between the pup and the mother, studies show that common seals are mostly solitary in the water, but have sometimes been observed swimming in groups. On land, common seals gather on beaches or sandbanks, called haul out spots. This is an anti-predator strategy, as hauled out animals frequently scan the surroundings for danger (Godsell, 1988; Silva & Terhune, 1988; Reeves, *et al.*, 2002).

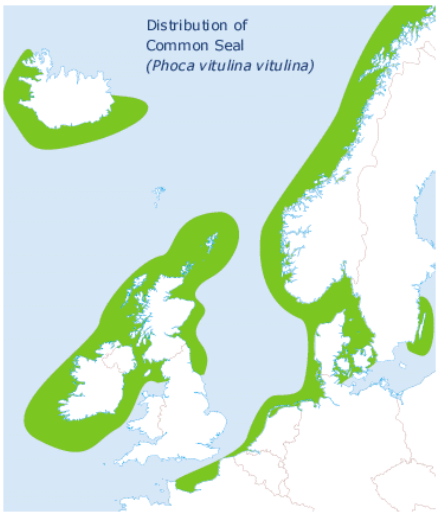


Figure 1.1 Distribution map of the Common seal (*Phoca vitulina vitulina*) (Kustgids, 2015)

Common seals have a small and compact head with large eyes, large whiskers, ears with no external pinna, and relatively short flippers with strong claws on the front flippers. They are spotted and commonly brown, tan or grey coloured. The average life expectancy in the wild is 20 years. Common seals can become up to 1.7 to 2m long and can weigh between 80 to 150kg; there is a slight sexual dimorphism with the males becoming slightly larger than females. Common seals in the Wadden Sea are born in late May, June and July, with the pup's fur resembling adult seals. Pups lose their lanugo fur in utero, although pups born too early will hold their coat for a couple of days. Minutes after being born pups are able to swim and dive, while swimming they may be seen traveling on the back of the mother holding on to them with their front flippers. After a nursing period of about three to four weeks the mothers wean the pup and abandon them to care for themselves. The mating occurs at the time of weaning in the water, without any overt competition between males (Wilson, 1974; Reeves, et al., 2002; Hawker, 2006).
Seals forage, mate and rest in the water, nevertheless they also haul-out to sleep, rest, give birth, females nurture their pups, sunbath and moult. The number of seals that will join a haul out spot depends on weather conditions, temperature, wind force and solar radiation (Lelli & Harris, 2001; Reeves, et al., 2002; Reder, et al., 2003; Norris, 2007).
Grey seals (*Halichoerus grypus*), the second species of pinniped in the Wadden Sea can be differentiated from the Common seal by the size of the body (up to 3m and 250-300kg) and grey seals have more of a cone shaped head and separated nostrils.
Common seals are considered opportunistic feeders. They prey on a wide variety of fish, cephalopods (e.g. squids) and crustaceans (Pierce & Santos 2003; Thompson & Härkönen, 2008; Kavanagh, et al., 2010).

Monitoring of the seal populations in the Wadden Sea is done by aerial surveys during different seasons in the entire Wadden Sea. The surveys are synchronized and standardized in the Seal Agreement under the Bonn Convention. This is needed because seals can only be counted when they are on haul out spots during low tides. Authorities of each of the four areas of the Wadden Sea; the Netherlands, Lower Saxony (DE), Schleswig-Holstein (DE), and Denmark, publish the numbers of their maximum counts in the Wadden Sea. Counts that are used to sum up the numbers of seals in these regions are not done in the same month, which can lead to a less reliable counting. Currently, there are approximately 39,100 common seals in the Wadden Sea (Reijnders, et al., 2003; Galatius, et al., 2014).

A major threat to the seal population of the Wadden Sea in the early 20th century was hunting. Seals were killed and given bounties for, because they were believed to affect the numbers of fish found in European waters. After the 1960's, the hunting of seals was forbidden and population numbers grew. In 1988 and 2002, there were mass mortality events, linked to the Phocine distemper virus (PDV). During the virus outbreak in 1988, more than 18,000 animals are estimated to have died. During the 2002 outbreak an estimated number of 30,000 animals have died. At this time, it was estimated that approximately 60% of the whole population present in the Wadden Sea was decimated. The decrease in population numbers of 1988 and 2002 can be seen in the total number of seals (red bars) (Figure 1.2).

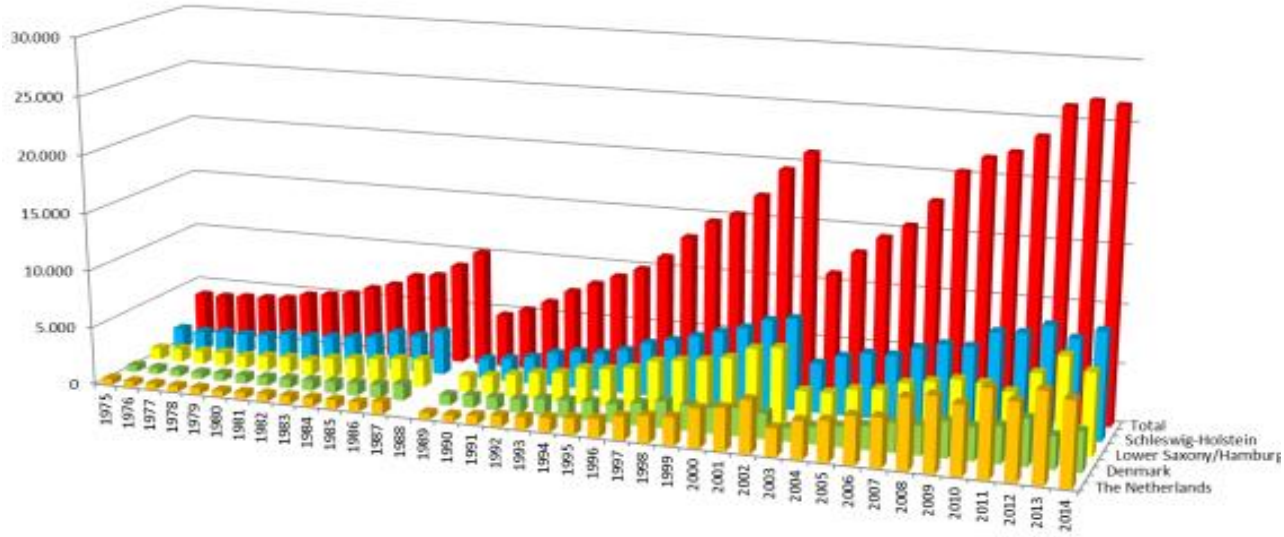


Figure 1.2 Total numbers of seals that can be found in the total Wadden Sea and the countries/regions that have a shoreline to the Wadden Sea. (Galatius, et al., 2014)

Current threats to the population are immune-suppressions, due to the exposure to high level toxic waste, fisheries, and new outbreaks of viruses, such as the avian influenza H10N7. This influenza discovered in late 2014, caused an increased mortality in the Northern European waters. (Reeves, *et al.*, 2002; Rijks, *et al*., 2005; Thompson & Härkönen, 2008; Galatius, *et al*., 2014)

The Seal Rehabilitation and Research Centre (SRRC) is a specialized hospital for Phocidae species that strand on the shores of the Netherlands. Strandings occur for different reasons, including orphaned pups ("huilers"), parasitic pneumonia (lungworm infection), bycatch, net entanglements, and boat collisions. The SRRC was founded in 1971 as a small rescue centre for pups. Since then it has grown into a full size rehabilitation and research facility that is recognized around the world. The mission of the SRRC is to help and rehabilitate every seal that has a condition caused, directly or indirectly, by human interaction. The SRRC releases every single animal; no animals are placed in captivity.
During the past years, the number of seals in rehabilitation has increased because of pups losing mothers and seals being admitted due to lungworm infections. In 2011, the highest number of admitted seals was recorded, with 836 in total, most of which had lungworm infections (Appendix I). Most seals that are admitted to the SRRC are emaciated, since the pups are dependent of their mothers on feeding. Older animals (such as juveniles) cannot

spend long periods of time under water to forage, often due to lungworm infections causing problems with breathing. After the seals have been treated for the reason they have been admitted to the SRRC, the seals are released back into the wild.

Stereotypical behaviour is relatively common in facilities that house and/or rehabilitate animals, as captive facilities are often predictable, sterile and lacking in complexity. Stereotypical behaviours are usually considered repetitive behaviours, which seem to have no apparent function, and unchanging patterns. Stereotypic behaviour could be caused by the following three non-mutual reasons: 1) induced by the captive environment that triggers or motivates a specific behaviour, 2) the environment that creates a state of sustained stress, or 3) an early rearing environment that affects development; resulting in abnormal behavioural sequencing. The first one is considered 'frustration-induced stereotypic behaviour, while the latter two causes are considered 'malfunction-induced stereotypic behaviour' (Grindrod & Cleaver, 2001; Mason, *et al.*, 2006; Hosey, *et al.*, 2009).
Mason & Rushen (2006) formulates and summarizes different studies that suggest that animal welfare decreases with stereotypic behaviour. One commonly accepted definition is that welfare decreases when 5% of the population shows this behaviour, or when the individual animal spends over 10% of the time on stereotypic behaviour (Mason & Latham, 2004). Stereotypic behaviour can cause stress and Central Nervous System (CNS) dysfunctions (Mason, *et al.*, 2006). During the rehabilitation process seals in the SRRC also occasionally show stereotypic behaviour, mostly shown as swimming in circles. This has been associated with a loss in body mass because of spending more time on stereotypic behaviour and less on foraging (Sánchez, pers. comm.[1]).

Environmental enrichment is used to improve animal environments, captive animal welfare, and to enhance the inhabitant's behavioural biology. Enrichment has been included into programs for the past decades for the primary reason to reduce undesirable or stereotypic behaviour, and to encourage animals to engage more into their natural behavioural repertoire, regardless of the species, type of stereotypic behaviour or kind of enrichment. It is a process in which changes to captive environments are made with the goal of increasing behavioural choices (Hunter, *et al.*, 2002; Mitchell & Wilson, 2006; Shyne, 2006). Hosey *et al.* (2009) speak of three aims of behavioural enrichment, preserving and conserving wild behaviour, promoting desirable behaviours over undesirable ones, and to increase activity levels.
Smith & Litchfield (2010) and Brando (2010) have shown that environmental enrichment, such as exercise and mental stimulation, results in a reduction of stress and stereotypic behaviour in different pinniped species. Furthermore, Smith & Litchfield (2010) show that changes in behaviour, due to introduction of enrichment, can be seen by an increase of active behaviour and a decline of stereotypic behaviour, though it was not statistically significant. Also other marine mammal species have shown an increase of their behavioural repertoire when manipulable objects and enrichment devices are exposed (Hunter, *et al.*, 2002). Grindrod & Cleaver (2001) have shown significant differences in time spending of circling behaviour in common seals when exposed to enrichment.

At Kolmarden Zoo (Sweden), felt was used to create an underwater felt forest as enrichment for captive pinnipeds (South African fur seals (*Arctocephalus pusillus*), common seals and grey seals) and bottlenose dolphins (*Tursiops truncatus*). Ruotimaa (2007) has studied how much energy a Baltic grey seal would be willing to pay to enter a cage with the underwater felt forest, comparing it to the willingness when food is offered in the cage. The willingness was tested with a door that had to be pushed down by the seal with a set amount of kilograms to hold the door closed. Ruotimaa found that the seal was only willing to pay 17% (10kg) of the energy to enter the cage with the enrichment, compared to the price (60kg) the seal was willing to pay for food.

[1] Guillermo Sánchez, 2015, personal comment Veterinary department SRRC.

The effect of this type of environmental enrichment on time budget and body mass growth, however, has not been studied yet (Edberg, 2010). The problems that stereotypic behaviour cause, decrease of animal welfare, stress, loss in body mass, and CNS dysfunctions, are the main reason for performing this study and to see if environmental enrichment using an underwater felt forest could help reducing stereotypy. The goal of this behavioural study is to assess the influence of environmental enrichment (i.e. an underwater felt forest) on the time budget[1] and body mass growth of common seals in captivity.

Therefore, the following research question is formulated:
What is the effect of the underwater felt forest on time budget and body mass of pups and juvenile common seals?
These sub questions are formulated to answer the research question.

- What is the effect of environmental enrichment on the active behaviour of pups[2] and juvenile[3] common seals?
- What is the effect of environmental enrichment on the body mass of pups and juvenile common seals?
- Is there a difference between the effect of environmental enrichment in active behaviour and body mass gain between pups and juvenile common seals?

1. Time budget activity patterns i.e. how a species utilises its time (feeding, grooming, interacting, etc.) (Mitchell & Wilson, 2006)
2. Individuals are considered pups when they are admitted to the SRRC less than four weeks old. The first ten days this can be seen by the presence of the umbilical cord, and the period of the pupping season.
3. Individuals are considered juveniles when they are four weeks to two years.

2. Material and Methods

2.1 Grote-meeuwenbad, SRRC Pieterburen

The study was conducted in the “Grote-meeuwenbad”, an enclosure in the third, and last, rehabilitation phase of the SRRC. The enclosure includes two pools, where the plateaus are attached to each other, but separated by a removable fence (Appendix II). Both the plateau and the pool surfaces are covered with tiles. The water in the pools circulates constantly as part of the life support system. As part of the medical procedures, the pools are drained once a week in order to measure the weight of the seals and for cleaning purposes.
The human interaction, such as force-feeding, handfeeding or, body restriction, with the animals is brought back to a minimum at this stage of the rehabilitation process. Interactions with the animals in this phase are only the daily removal of left over fish, the weekly sanitation of the enclosure, and weighing of the animals. Since these are outdoor enclosures both biotic (e.g. gulls and herons) and abiotic (e.g. temperature, rain and sunlight) factors influence these pools.

2.2 Common seals, juveniles and pups

Common seals of two different age classes; juveniles (>4 weeks; <2 years old) and pups (<4 weeks old), were the study subjects. A total of 30 seals were included in the study; 10 juveniles and 20 pups (appendix III). The number of seals used in this study was dependent on the seals that were admitted before the study, so the number of individuals could not be predicted beforehand.

During the study the individuals were fed twice a day, with a standardized amount of 5kg of defrosted North Atlantic herring (*Clupea harengus*) per indivudial.

For both the juvenile and pup age classes, four different groups were defined: two enriched groups, where the environmental enrichment was introduced; and two control groups where no environmental enrichment device were introduced (table 2.1).

Table 2.1 Enriched and Control group numbers of juvenile and pups

Group	Juveniles	Pups
Enriched groups*	1 + 3	5 + 7
Control groups*	2 + 4	6 + 8

*see Appendix III for the individuals per group.

Commonly the seals in the centre are weighed once a week. For the study the seals are weighed at the first day and at the last day of the observations. Further information about the observations is found in 2.4.1.

2.3 Required equipment

The construction used to make the environmental enrichment is based on enrichment devices used for the marine mammal collection at Kolmarden Zoo (Sweden). The felt forest used in this study was made by cutting up a material described as felt into small long strokes and mounting them on a buoy of 60cm long. This felt is usually used for the production of paper (Routimaa, 2007), and was donated by Kolmarden Zoo.

Four buoys were attached to each other with short chains to make the construction collapsible and bigger (see Appendix IV for the blueprint). Before the environmental enrichment could be introduced to the enclosure, the veterinary department revised the construction of the enrichment, in order to make sure it was safe for the seals and no parts of the enrichment could harm the individuals.

In order to avoid disturbances produced by the observer, observations were done by using Axis dome cameras, one for each pool (Appendix II) to monitor the behaviour. Furthermore, to store all camera images, a server (QNAP TS 459Pro) at the SRRC was used.

The scales used to measure the weight of the seals during the whole study, were made by WEDA B.V. Avery Berkel. These scales measure a minimum of 1kg to a maximum of 150kg, with an accuracy of 0.05kg.

2.4 Data sampling and collection

2.4.1 Behavioural observations

The total length of the observations lasted 24 days. This was divided into four observation periods of six days. During each six-day period, one enriched group and one control group of the same age class were present.

To get an overview of the animal's behaviour, states were recorded using focal animal sampling and continuous recording as described by Lehner (1996). To give an overview of the time budget of the seals, a combined ethogram of Hunter *et al.* (2002) and Hawker (2006) was used (Appendix VI).

In order to determine the active hours of the seals, images were recorded for 24 hours during the two weeks prior to the data collection. The analysis of these images showed that the seals did not engage in any to almost no active behaviour; with or without enrichment, for the period of 0.00 am to 6.00 am. Therefore, these hours were not included in the data collection. A day was divided into three periods, each containing six hours in total for the collection of data, excluding the period between 0.00 am to 6.00 am as mentioned above.

The enrichment was left in the pool only for six hours a day to avoid the seals becoming habituated to the presence of the structure (Smith & Litchfield, 2010). The periods of six hours when the enrichment was in the pool were randomly chosen by the observer at the beginning of the study, and have been used for all four observation periods. An overview of when the enrichment was present in the pool can be seen in table 2.2. Each six-hour period was organized as follows:

- 45 minutes data collection
- 60 minutes pause, no data collection
- 45 minutes data collection
- 60 minutes pause, no data collection
- 45 minutes data collection,

resulting in a data collection of 810 minutes per seal in the six data collection days. The remaining 105 minutes were used for basic husbandry tasks in the pool done by animal keepers.

Table 2.2 Three sampling periods that the environmental enrichment was present in the enclosure, X marks when it was present.

Day\period	A 6.00 AM to 12.00 PM	B 12.00 PM to 6.00 PM	C 6.00 PM to 12.00 AM
1			X
2		X	
3		X	
4	X		
5			X
6	X		

As on the camera images individual seals could not be recognized from one another, before the 45 minutes of data collection started, the positions of all the seals were noted on a form (Appendix V) while standing next to the pool.

As daylight was not sufficient, during C observations, a large light in the middle of the seal rehabilitation centre was turned on to make sure that the seals in the enclosures were visible on the camera image (table 2.2).

2.4.2 Body mass

Weights of the seals were measured on the first day of the observation period and after the last day of observations. A reed basket was used to catch and transport the seal to a scale that was placed in the enclosure. The basket was placed on the scale to weigh the seal, noting the weights on a weighing list with 0,1kg accuracy. After weighing, the seal is released from the basket back into the enclosure.

2.5 Data preparation and analysis

2.5.1 Behavioural observations

The raw video data was imported into the behavioural observational program “Boris” (Penelope, 2015) that can be used on any computer. In Boris, states are measured over time, including the beginning and end of each behaviour. Later, the analysed time budget was imported into SPSS for statistical testing. The variables that were used in SPSS can be found in Appendix VII.

To see if the enrichment had a significant effect on the time budget and body mass the Linear Mixed Model (LMM) (Beaumont, 2012) was used. The behaviour category “out of sight” was divided over the observed behaviours of the specific seal for use in LMM.

In order to analyse possible significant differences in active behaviour, the behaviour percentage of grooming, aggression, movement, playing, interaction with enrichment, and stereotypic behaviour were combined to represent active behaviour. The statistical test used in LMM was generalized LMM. The variables “group” and “seal” were selected as the subjects of the data structure. Besides, the variable “date” was used as repeated measures of the data structure. In Fields and Effects, “active behaviour” considered as the target; and “enriched” was the fixed effects (Appendix VII).

2.5.2 Body mass

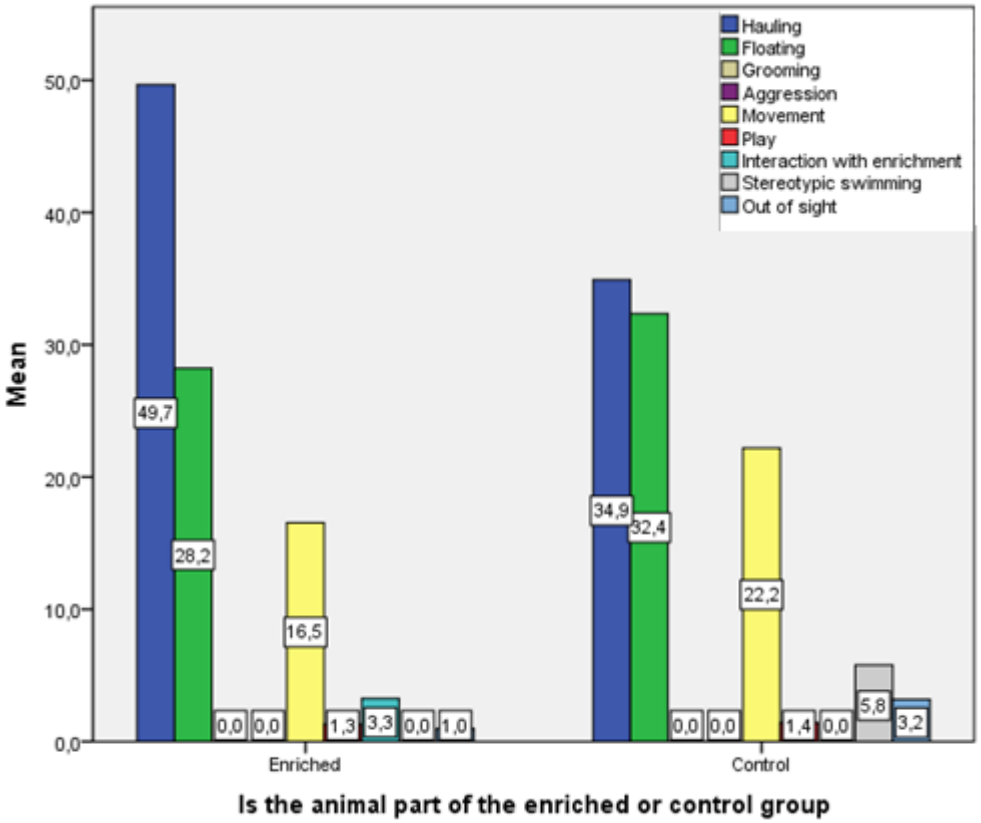
Body mass measurements from the weighing list were added to the SPSS sheet (Appendix VII). In order to analyse possible correlations in body mass growth among the control and the enriched groups, LMM was used. The field subjects, repeated measures, and fixed effects were kept as described before in 2.5.1 behavioural observations. However, the target was changed to “change in body mass”.

3. Results

During this study, a total of 30 seals have been observed for 13.5 hours per seal, resulting in a total of 405 hours of raw video data.

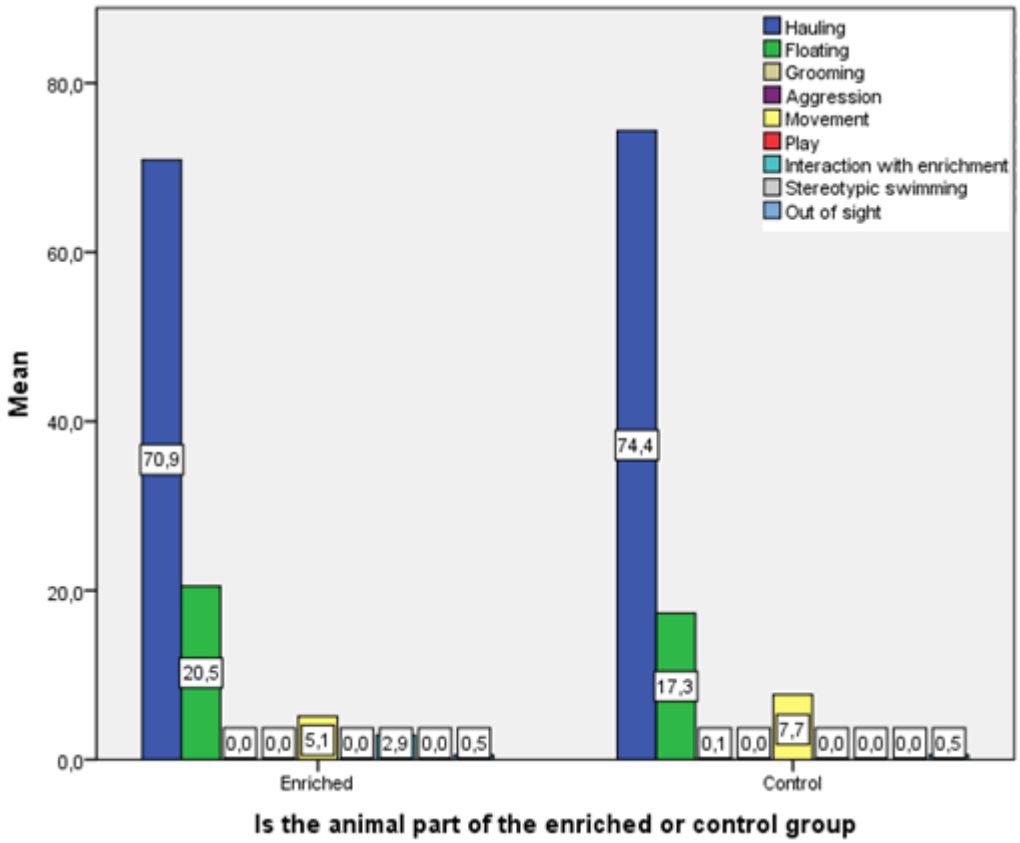
3.1 Effect of environmental enrichment on the active behaviour of pups and juveniles

Both enriched groups of the pups showed more hauling behaviour (49.7%) than any other behaviour, this is also the case with the control groups of the pups (34.9%). The control groups showed a higher sum of active behaviours then the enriched. The control groups were active for 31.1% of the time, of which 5.8% was stereotypic behaviour, however the enriched were only active for 21.6%. Although a difference in percentage of active behaviour can be seen (Graph 3.1), LMM showed no significant difference (P = 0.134) between the active behaviour of the enriched and the control groups of the pups.



Graph 3.1 Behaviour overview of enriched and control groups of the pup age class. Percentage of behaviours of the Enriched/Control groups (N =20)

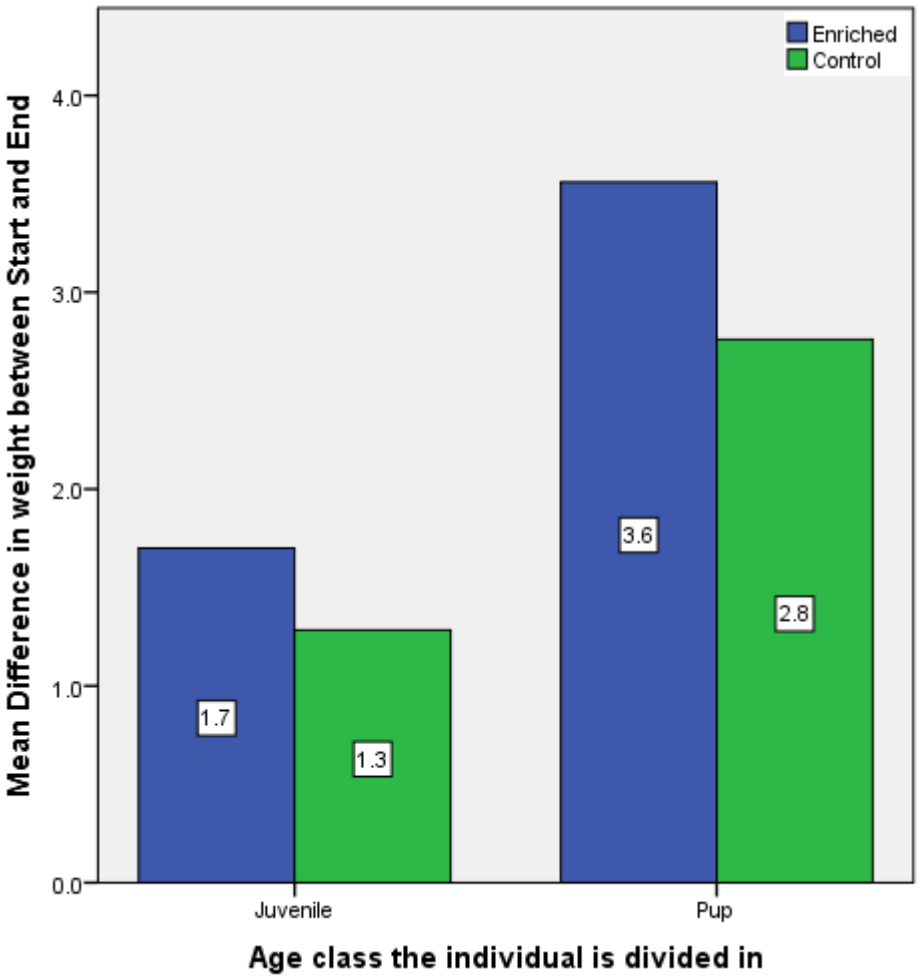
Likewise, both enriched groups of the juveniles showed more hauling behaviour (70.9%) than any other behaviour, this is also the case with the control group (74.4%). The enriched groups showed hardly a higher sum of active behaviours than the control. The enriched groups were active for 8.3% of the time, the control were active for 8%. Although a small difference in percentage of active behaviour can be seen (Graph 3.2), LMM showed no significant difference (P = 0.331) between the active behaviour of the enriched and the control groups of the juveniles.



Graph 3.2 Behaviour overview of enriched and control groups of the juvenile age class. Percentage of behaviours of the Enriched/Control groups (N = 10)

3.2 Effect of environmental enrichment on the body mass of pups and juveniles

The enriched pups showed an average body mass gain per seal of 3.6kg compared to the control groups which gained 2.8kg (Graph 3.3). Although the body mass gain is higher in the enriched group, LMM showed that this difference is not statistically different (P = 0.595).
The enriched juveniles showed a higher average of body mass gain per seal (1.7kg) compared to the control groups (1.3kg) (Graph 3.3). LMM showed no significant difference between the weights of the enriched and the control groups of the juveniles (P = 0.533).

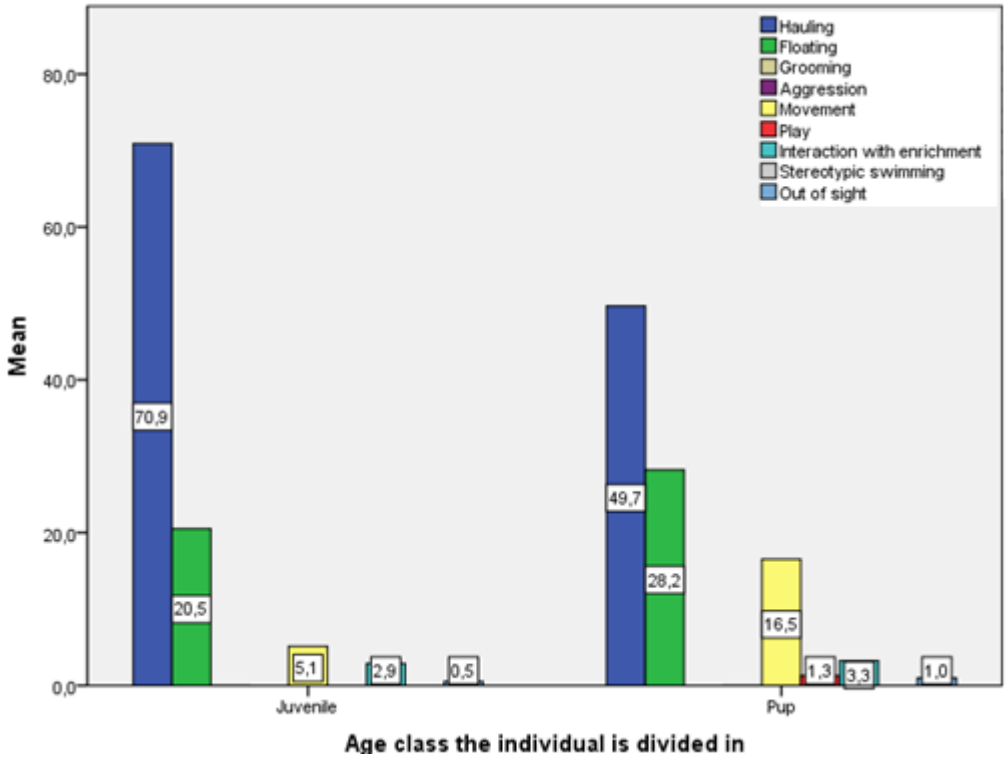


Graph 3.3 Average difference in weight between the start and end of the six-day period per group compared to the enriched and control groups of juveniles; and enriched and control groups of pups separated (N = 30)

3.3 Comparison of the effect of environmental enrichment on active behaviour and body mass between juveniles and pups

3.3.1 Difference in active behaviour between pups and juveniles

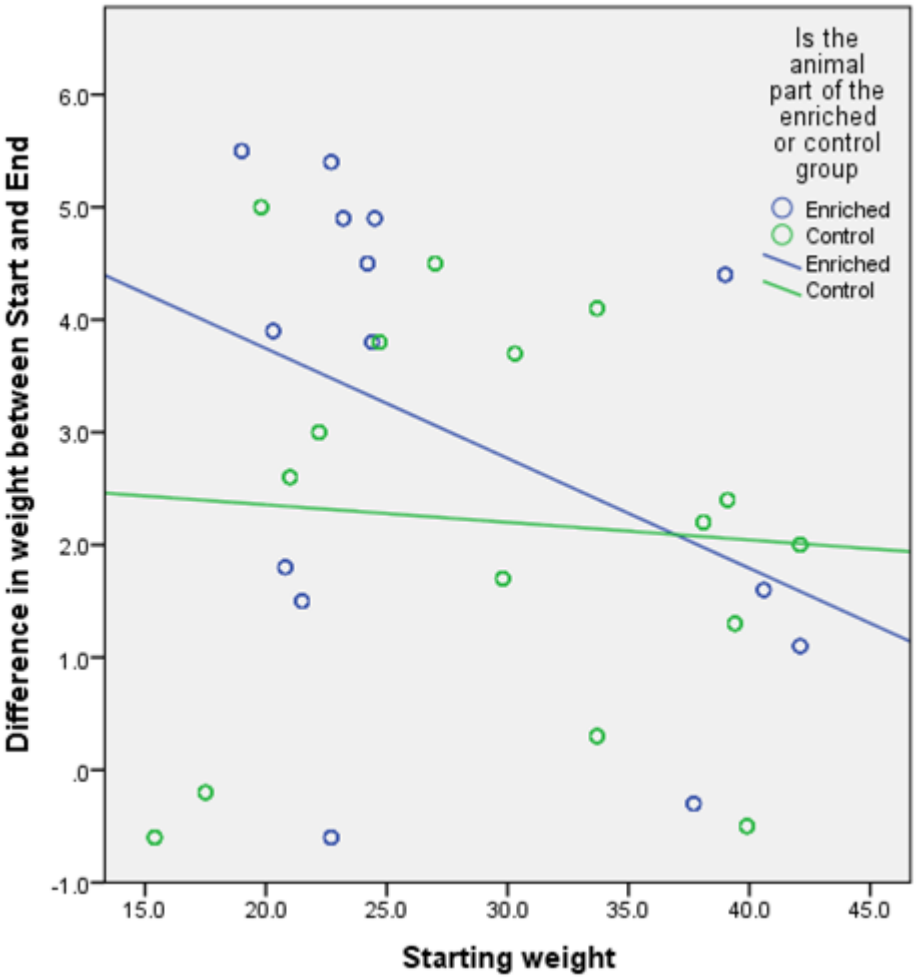
Although the enriched individuals of the pups did show a higher percentage of active behaviour (21.6%) compared to percentage of active behaviour of the juvenile enriched groups (8.3%) (Graph 3.4), LMM showed that this difference is not statistically different (P = 0.089) between the active behaviour of the enriched juveniles and the enriched of the pups.



Graph 3.4 Behaviour overview of enriched juvenile and enriched pup age classes. Percentage of behaviours of the Enriched groups (N = 14)

3.3.2 Difference in body mass gain between pups and juveniles

When the enriched and the control groups are separated, of both age classes, enriched seals that were lower in weight, show a higher weight gain compared to the ones that were higher in weight, whereas the control individuals gain more or less a stable amount of body mass independent of their starting weight (Graph 3.4). Graph 3.3 shows that the enriched groups of the pups gained an average of 3.6kg, while the enriched groups of the juveniles gained an average of 1.7kg. Although a difference can be seen LMM showed no statistical significant difference (P = 0.670) between the weight gain of the enriched groups of the juveniles and the enriched groups of the pups.



Graph 3.4 Scatterplot comparing of the difference in weight at the start and at the end of the six-day period between the enriched and the control groups (N = 30)

4. Discussion and conclusion

For the pup age class, even though for both groups LMM showed no statistically significant difference, the overall percentage of time spend on active behaviour for the control group was higher than for the enriched group. The overall percentage difference was smaller when comparing the active behaviour of the enriched and the control groups of the juvenile age class, which LMM also showed no statistical significant difference. For the first two days when the environmental enrichment was present in the enclosure, the seals seemed scared of it. This could explain why there is a no statistical difference. In these first few days, the juveniles would not enter the pool and haul out and almost constantly pay attention to the enrichment in the pool. Animal keepers reported that the morning after the first observation period of six hours (C period), the plateau of Grotebad, where the enriched group was present, was covered in faeces which could indicate that the animals did not enter the pool that night. Instead, the pups in the first hours stayed on a distance from the enrichment, but then continued with their business and some started interacting with the enrichment. Another factor that can contribute to the difference in significance is that during observations of juvenile groups, the total number of animals per group was smaller than the groups of the pups (Appendix III). When comparing the active behaviour of both the enriched and control groups, groups of three to five animals showed a significantly higher active behaviour than a group of one, two or six animals (Appendix VIII).

As stated before in the material and methods, a large light post that is present in the middle of the SRRC was used to light the enclosures during the C observations, between 6.00 pm and 12.00 am (Table 2.2), which could have affected the activity of the seals during this period. However, LMM showed that when periods were compared, period A showed significantly more active behaviour than the other periods (Appendix VIII). As Acevedo-Gutierrez and Cendejas-Zarelli (2011) mention, common seals are commonly hauled out throughout the night, this could mean that seals are not disturbed by the light post and continue sleeping during the night.

Stereotypic behaviour was only seen in two individuals of the control groups of the pups, the individual with rehab number 15139 spend 24.7% of its time on stereotypic behaviour, and the individual 15158 spend 33.1% of the total time on stereotypic behaviour. The stereotypic behaviour contributed to 5.8% of the total active behaviour in the results of the control groups of the pups. For both individuals the stereotypic behaviour consisted of swimming circles in the pool. As stated before, this behaviour was considered to be active behaviour as well.
As mentioned earlier a commonly accepted definition by Mason & Latham (2004), is that welfare decreases when 5% of the population shows stereotypic behaviour, or when an individual animal spends more than 10% of its time on stereotypic behaviour. Grindrod & Cleaver (2001) used random feeding methods, instead of the routinely three times a day feedings. In their feeding methods they used ice blocks and buoys to hide food. They found that environmental enrichment reduces the stereotypic behaviour in common seals, the seals spend less than half of the original time on stereotypic behaviour after environmental enrichment was introduced. As in this study the animals that show stereotypic behaviour were in the control groups, the effects of the environmental enrichment on stereotypic behaviour reduction could not be tested.

A higher average weight gain has been seen in the enriched pups compared to the enriched juveniles, although LMM statistical testing did not show any significant difference. Seals with lower body mass, that were in the enriched groups of all age classes, showed a higher gain of kilograms over the six days, when compared to the animals with higher body mass of the enriched group (Graph 3.4). Pups, are overall lighter than the juveniles when moved to the last phase pools, but are normally released with more or less the same weight, and are present in this phase for almost the same amount of time. This could explain why the pups show a higher average weight gain compared to the juveniles.

Using LMM for statistical analysis, comparing the active behaviour of the enriched pups against the enriched juveniles, showed no significant difference in active behaviour. This could be explained, as stated before, that the juvenile enriched groups showed less active behaviour, as they were scared of the enrichment.

When comparing the body mass gained during the six-day periods between the enriched groups of the pups and the juveniles, showed no statistical significance. This could be because most of the animals at the last phase of the rehabilitation process, even though most pups are lower in body mass, are mostly the same weight when they arrive to this pool.

This study did have its limitations. It had a short sampling period for each observation group, which is caused by limited time that was available during this bachelor thesis. Furthermore, seals in this stage of rehabilitation normally stay in these pools for two to three weeks to gain body mass and then being released back into the wild. Also, the sampling groups of juvenile animals were small compared to the sampling groups of the pups. The small sampling groups are caused by the number of seals that are admitted to the SRRC in the previous period before the study. The number of seals that will be admitted cannot be determined beforehand. Furthermore, the number of seals that can be present in one pool is also limited to around five seals at a time.

Overall, the environmental enrichment did show differences in percentages, although it did not show any significant differences between the enriched and control groups of both age classes, and between age classes. This can be caused because the seals are scared of the construction in the first few hours or days. Also, the fact that the enrichment is a non-food related object can cause the seals not to be interested in the object. Routimaa (2007) used a similar constructed felt forest to test how much effort grey seals are willing to put to gain access to a cage with food or when the food is replaced by a felt forest. Routimaa (2007) found that the seals were willing to use more energy to access the cage with food rather than the one with the felt forest. This is in line with Gringrod and Cleaver (2001), they stated that food based enrichment is more popular with seals. Food related environmental enrichment studies could be carried out in the SRRC as well, to test differences in active time budget when using food related enrichment against non-food related enrichment.

5. Recommendations

Future studies are recommended to see if there would be differences when studies are carried out observing this type of environmental enrichment, longer observation periods should be held, such as using the whole period an animal is present in the last (third) phase of the rehabilitation process. In that case the observations time of three times 45 minutes per six-hour period, could be transformed to a shorter observation time so that an overflow of data is avoided. Doing this, could also help to provide more information on the body mass gained over this time in the third phase pool.

Although some interesting variables were found that had a significant difference for active behaviour, such as group size and day period (Appendix VIII), further studies should provide more information on whether this will stay significant with bigger sampling groups and longer sampling periods.

Comparable studies could be carried out comparing the use of the felt forest as environmental enrichment against the use of environmental enrichment based on food related objects in order to find what differences there are on active behaviour.

Furthermore, studies could be done studying different pinniped species to see if there are any differences in active behaviour when using a felt forest construction. Routimaa (2007) used grey seals in her study; the SRRC receives several grey seal patients during winter. The grey seals could be used for a study on active time budget with felt forest as environmental enrichment to compare against the common seals.

Recommendations to the SRRC, and other rehabilitation centre, are to keep using environmental enrichment for the animals, as this has been proven before to help reduce stress and enhance welfare of the animals. This enrichment itself needs to be studied further, studying more individual to see if the enrichment needs alterations. An alteration could be by combining the enrichment with food.

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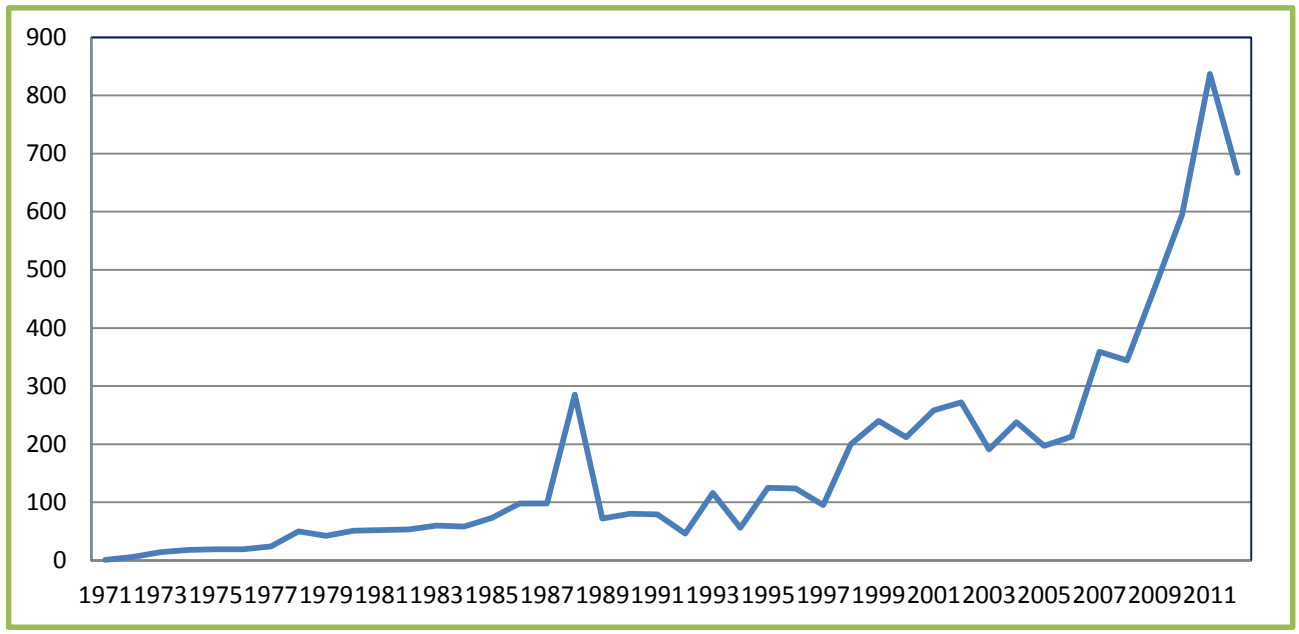
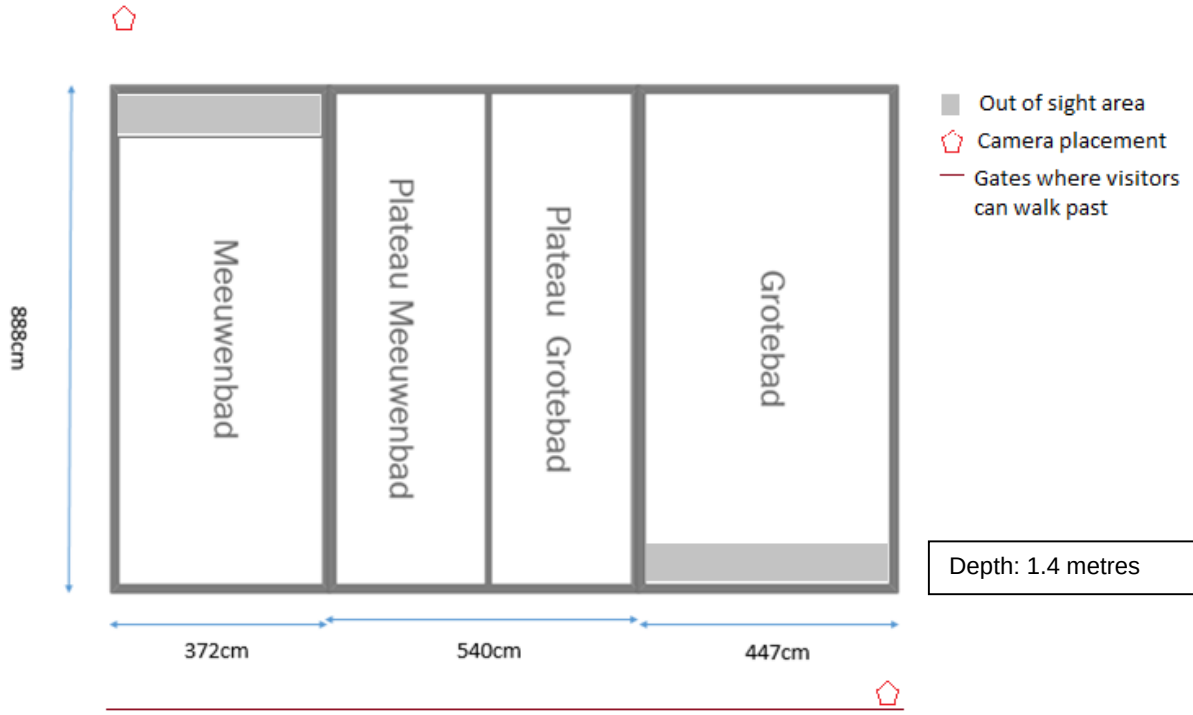
Appendices

Appendix I Admitted seals to the SRRC



Overview of the yearly total amount of admitted seals to the SRRC.

Appendix II Schematics of the Grote-meeuwenbad



Depth: 1.4 metres

Schematics of the measurements of the “Grote-meeuwenbad” at the SRRC.

Appendix III Information of the observed seals

Juvenile 16-04-2015 to 21-04-2015

Enriched (1[3])	Est. age*	Weight at start[1]	Weight at end[2]
15-044	7 months	39	43.4
Control (2[3])			
15-008	6 months	39.4	40.7
15-036	7 months	39.1	41.5

Juvenile 15-05-2015 to 20-05-2015

Enriched (3[3])	Est. age*	Weight at start[1]	Weight at end[2]
15-028	7 months	40.6	42.2
15-019	6 months	37.7	37.4
14-362	4 months	42.1	43.2
Control (4[3])			
15-047	8 months	38.1	40.3
15-045	8 months	39.9	39.4
15-051	8 months	42.1	44.1
15-052	8 months	33.7	34.0

Pups 24-07-2015 to 29-07-2015

Enriched (5[3])	Est. age*	Weight at start[1]	Weight at end[2]
15-116	7-10 days	23.2	28.1
15-099	2-4 days	22.7	22.1
15-115	7-10 days	20.3	24.2
15-103	5-6 days	20.8	22.6
Control (6[3])			
15-109	7-10 days	17.5	17.3
15-122	10 days	15.4	14.8
15-104	10+ days	22.2	25.2
15-093	2-4 days	21	23.6
15-098	2-4 days	19.8	24.8

* = This is the estimated age of the seal at arrival in the SRRC

[1] = The weight of the seal at the start of the 6 day observing period.

[2] = The weight of the seal at the end of the 6 day observing period.

[3] = Group number that has been assigned, this is in relation to table 2.1

Pups 17-09-2015 to 22-09-2015

Enriched (7[3])	**Est. age***	**Weight at start[1]**	**Weight at end[2]**
15-157	7-10 days	19.0	24.5
15-155	10 days	24.4	28.2
15-156	10 days	21.5	23.0
15-154	10 days	24.5	29.4
15-151	10 days	24.2	28.7
15-160	10 days	22.7	28.1
Control (8[3])			
15-158	10 days	27.0	31.5
15-152	10 days	24.7	28.5
15-138	5-6 days	29.8	31.5
15-139	10 days	33.7	37.8
15-149	10 days	30.3	34.0

* = This is the estimated age of the seal at arrival in the SRRC

[1] = The weight of the seal at the start of the 6 day observing period.

[2] = The weight of the seal at the end of the 6 day observing period.

[3] = Group number that has been assigned, this is in relation to table 2.1

Appendix IV Blueprint for making algae

Buoys are used to make the construction float. Two pieces of wood 40cm long are secured together with screws to hold the felt around buoy, with the felt squeezed in between. As seen in the blueprint the felt is cut in four strokes of 120cm long and 10cm wide each and leaving on top a long enough sheet of felt to wrap around the buoy. Later the buoys can be attached to each other to make the forest bigger using an extra chain between the buoys (see the pictures to the left). The felt is 2mm thick. The algae “tentacles” are cut out by hand with a knife.

Appendix V Form for the position of the seals

Camera

Camera

Appendix VI Ethogram behaviours listed

Behaviour	Key-code Boris[1]	Active behaviour Y/N	Description
Hauling	1	N	Out of water, inactive.
Floating	2	N	In water, inactive.
Grooming	3	Y	Scratching itself, rubbing body on any kind of material.
Aggression	4	Y	Directed to another individual, such as threatening movements with head (fast movement with the head towards approaching seal), scratching other seal, hitting own belly with one of the front flippers, biting, wrestling.
Movement	5	Y	Locomotion while in and out of water.
Play	6	Y	Interactions with other individuals, which are not aggressive.
Interaction with enrichment	7	Y	Any interaction that is directed to the enrichment or touching.
Stereotypic swimming	8	Y	Swimming in repetitive patterns.
Out of sight	9		The seal is out of sight.

Ethogram of behaviours that will be used to make up the time budget overview. (Hawker, 2006; Hunter, *et al.*,2002)

Appendix VII overview of the variables entered in SPSS

Seal	Date	Day period	Age class	Group	Group size	enriched	1	2	3	4	5	6	7	8	9	Starting weight	End weight
Number that has been assigned to the seal, E.g. 1	The date that the samples has been taken	The period of the day that the samples have been taken. E.g. 2 (6.00am to 12.00pm)	The age class the individual is divided in (1 = juvenile, 2 = pups)	Which group did the seal belong to (1-8)	How many seals were present in the group.	Is the animal part of the enriched (1) or the control (2)	*	*	*	*	*	*	*	*	*	The weight of the animal at the start of the observations	The weight of the animal at the end of the observations

Variables to be entered during the study in SPSS.
*The % that this seal has spent on each behaviour during this day period (Appendix VI). This data is imported from the analysis of the computer program BORIS.

Appendix VIII Effects of environmental enrichment on active behaviour

Model Term	P
Group_size = 1	0.474
Group_size = 2	0.066
Group_size = 3	0.026
Group_size = 4	0.003
Group_size = 5	0.000
Group_size = 6	-*
Period = A	0.001
Period = B	0.155
Period = C	-*

*This coefficient is set to zero because it is redundant