Master thesis in Biology

Social contact and proximity of free-living grey seal (*Halichoerus grypus*) pre-weaning pups with comparative notes on 'orphan' pups in rehabilitation

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Abstract

Pre-weaning seal pups sometimes happen to be found stranded and can be accepted in a rehabilitation centre. Even though pups of different species have different ecological and biological needs, rehabilitation centres use the same husbandry technics for all seal species. This can be compromise the write development of pups. This study focuses on the needs of grey seal pups (*Halichoeurs grypus*) and will be included in a project comparing grey seal and harbour seal pups both in wild and in rehabilitation centres. The aim of this study is to provide scientific based recommendations for rehabilitation centres. The thesis first describes wild grey seal pups' behaviours and their interactions with their mother. In a second time, I compared behaviours of 7 rehab grey seal pups with the ones I studied in the wild. Behaviours were analysed from 5 min video clips. In the case of grey seal pups, there were no obvious differences between wild and rehab pups. Nevertheless, rehab pups housed in isolated cells shows social behaviours that pups usually do only with its mother in the wild. We conclude that social contacts are important for the welfare of the pup.

Introduction

Pre-weaning seal pups are sometimes found stranded. Strandings occur when pups are separated from their mother and are caused by several reasons: failure to bond with and follow the mother, inadequate maternal care, low birth weight, storms or human disturbance [1, 2]. Human disturbance continues to be an important factor for seal mortality [3]. For grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*), human disturbance usually results in the colony fleeing and leaving behind all pre-weaning infants unable to follow [4, 5]. If this happens shortly after birth, it can compromise the bonding between a mother and her pup and, therefore, result in her abandoning her pup, possibly because she is unable to recognise it. Stranded pups are unable to survive on their own and are likely to die if they are not rescued. Even though grey seals and harbour seals are not considered as endangered [3], rehabilitation centres have been set up for the purpose of pup welfare [6].

There are no scientifically based protocols or guidelines for raising stranded seal pups in biologically adequate ways. Rehabilitation centres often keep seal pups in isolation and restrict access to water [7], usually for practical reasons. It allows keepers an easy access to the pups for hand-feeding and medical treatments, but it is possible that this compromises two of the Five Freedoms established by the Animal Welfare Act, 1999, i.e. freedom from discomfort and freedom to express normal behaviour [8].

There are several important biological and ecological differences between seal species [9]. Rehabilitation centres use the same methods to rehabilitate harbour and grey seal pups [7], despite the fact that needs of these two species are most likely different, suggesting that rehabilitation methods should be adapted in species-specific ways. In the case of orphan

harbour seals, wild pre-weaning pups spend all their time beside either their mother or other seals [10] [Wilson and Jones, in preparation*] and about 50% of their time in the water [11]. Most of their social interaction with their mother occurs at the water's edge or in the water. Even though some rehabilitation centres, following an initial period of isolation, pups are housed with other pups or adults, while unlimited access to water is provided, this happens much later than the natural pup's weaning age. Grey seal pups are most of the time alone on the beach and usually do not interact with individuals other than their mother [12]. Grey seals have evolved as so called 'ice breeders' [13, 14], giving birth to their pup on ice. Since the last ice age, several populations have further evolved to also breed on land, typically beaches or ledges [15, 16], but their ancestral traits are still widely visible. For instance, as typical for ice breeding species, pups are born with a white and long hair coat, the lanugo, to protect them from the cold. At birth, pups do not yet have sufficient amounts of fat blubber to keep them warm on the ice but the lanugo provides additional insulation until the pups have enough fat [17]. They weigh about 13.5 kg and increase their body mass at a rate of more than 1 kg per day. However, the lanugo is not water-proof such that pups born on ice cannot follow their mothers into the water [17]. Nevertheless, pups born on shore follow in some occasions their mother into water [12, 18]. Even though mothers do not need to feed during the lactation period [19], they often return to the water after having fed their pups and leave them by themselves much of the time [20]. After an average of 17 days, pups are weaned and weigh between 38 and 40 kg [21]. Therefore, I would predict that the difference in the physical and social environment of grey seal pups between those in rehab and those in the wild would be much less than for harbour seals.

However, the current literature on infant grey seal behaviour is very weak and most studies focus on the behaviour of grey seal mothers. One finding has been that grey seal mothers'

behaviour differs between locations, beach topographies and personalities [4, 22]. Other studies have documented growth rate differences between male and female pups [22-24]. Male pups are usually more active and interact more with their mother than females [24] and they have a higher birth and weaning weight, and higher growth rate than female pups [22, 24]. This is most likely the result of sexual selection, which has produced a large sexual dimorphism in different seal species giving bigger males a reproductive advantage over smaller males. The first study about social development of grey seal pup was a case study of a female in a rehabilitation [25]. Later, Kit Kovacs [12] described wild grey seal pups' behaviour during first weeks of their life and the development through time of these behaviours. To my knowledge, no further published information is available on the developmental patterns of grey or harbour seals.

The goal of this thesis is to describe quantitatively and compare the behaviour of pre-weaning grey seal pups in the wild, and 'orphan' pups in rehabilitation facilities to suggest evidence-based guidelines for seal pup husbandry in rehabilitation centres. These results will be compared with results of the studies of Sue Wilson on development of harbour seal pups [Wilson and Jones, in preparation*].

Material and methods

Studied animals

Wild and rehabilitated grey seal pups were studied in Cornwall, United Kingdom. They were aged between 0 and 22 days. Wild pups' age was estimated by the observer, based on the developmental stage when first observed (Table 1). Pups were considered weaned when they were fully moulted. The oldest pup non-fully moulted was 22 days old, thus I chose this

age as a threshold. They were visually identified according to their estimated age, their position on the beach and by their mother if she was present. The age of rehab pups was determined by the centre. Each pup could be individually identified by the name attributed in the rehabilitation centre.

Table 1: Description of the five age classes of seal pups from birth to weaning and moulting [11, 22].

Stage	Description	Estimated age (days)
I	Skinny skin and bones, body with rolls, possible umbilicus, no neck and chip like	1 to 5
II	Quite fat	5 to 10
III	Barrel white	10 to 15
IV	Barrel moulting	15 to 20
V	Barrel moulted	> 20

Natural beaches

Four natural beaches used by grey seals were studied in West Cornwall (Figures 1 to 4). All beaches were characterised by steep cliffs backed with coves. Cliffs were between 45 and 60 metres high. I was laying at the top of the cliff to observe the seals without being noticed. The beaches were mostly composed by a mix of sand and shingle with some rockery parts. One of the beaches large boulders were present on the beach (Figure 2). Beach 1 (Figure 1) was used by grey seals for pupping and visited all year round. Tourists were frequently present at the top of the cliff to observe the seals. The three other beaches were pupping beaches and only used during the pupping season by mother pup pairs and one adult male. All four beaches were visited 5 days a week from 8 September to 28 November 2016. Visits occurred either from mid- to low-tide or from low- to mid-tide for a period of 3 hours between 08:00 and 18:30 GMT depending on the tide schedule and daylight. During observations, each pup was filmed for 5 minutes each. If important changes occurred near

105 the pup (arrival or departure of the mother, changing of zone), a second video was taken for
106 the same pup on the same day. A total of 22 pups were observed and 93 video clips were
107 analysed (beach 1: N=27; beach 2: N=35; beach 3: N=26; beach 4: N=5). The number of video
108 clips per pup ranges from 1 to 13. The number of pup filmed at each stage is stage I = 12
109 pup, stage II = 11 stage, III = 13 and stage IV = 9 (Table 1). Pups could be filmed at different
110 stages.


111

112 *Figure 1: Picture of beach 1. Mix of sand and shingle. Rockery parts*

Figure 2: Picture of beach 2.Mix of sand and rocks with presence of large boulders

Figure 3: Picture of beach 3. Beach of sand and shingle. Large boulders appear at low tide

Figure 4: Picture of beach 4. Mix of sand and shingle, rockery parts

Table 2: Stage when pups were filmed.

		Pup ID																				
		B1P1	B1P2	B1P3	B1P4	B1P5	B2P3	B2P4	B2P5	B2P6	B2P7	B2P8	B2P10	B2P11	B3P1	B3P2	B3P3	B3P4	B3P5	B3P6	B3P7	B4P1	B4P2
Stage	I	X	X	X			X	X	X	X	X	X							X			X	X
	II	X		X	X		X						X	X	X		X	X	X				X
	III	X		X	X	X	X		X		X		X				X	X	X	X	X		
	IV	X			X	X	X				X					X		X	X		X		

Rehabilitation centre

Rehabilitated grey seal pups were studied at the Cornish Seal Sanctuary of Gweek, Cornwall, United Kingdom. The sanctuary is composed of a “Hospital” and several outdoor pools. In most of the pools, resident harbour and grey seals as well as sealions are housed. The sanctuary is open to visitors all year round 7 days a week from 10:00 to 16:00.

During their stay in the sanctuary rehabilitated pups are moved in different pools before being released in the wild. As soon as they arrive, pups are put into quarantine cells, only accessible for the animal care team, to receive medical care and to have a hidden place to rest for a few minutes or few days before being moved to the “Hospital” accessible to visitors. These cells consist of individual cells divided into two parts (Figure 5). The lower part (~1.5 m x ~2.0 m) can be filled with water during the day if the pup is in good conditions (i.e. if medical treatment does not require that the pup remain dry). The upper part (~ 0.5 m x 0.5-2.0 m) serves as a haul-out place when the lower part is filled with water. They are tube-fed with fish soup or force-fed with whole fish while they are learning to eat dead fish. Pups stay in the ‘hospital’ until they are fully off-treatment and when they can eat fish without being hand-fed. Depending on the pup, this can happen before they are fully moulted or up to several week later. They are then moved to the “Nursery pool”, permanently filled with water, where they are housed with up to two other pups. Pools dimensions are 6.6 m x 3.0

m with a depth of 0.8-1.3 m. There is a haul out place big enough for all pups and places where they can hide from visitors. They are fed three times a day with dead fish.

Figure 5: Individual cell. Cornish Seal Sanctuary, Gweek, Cornwall, UK

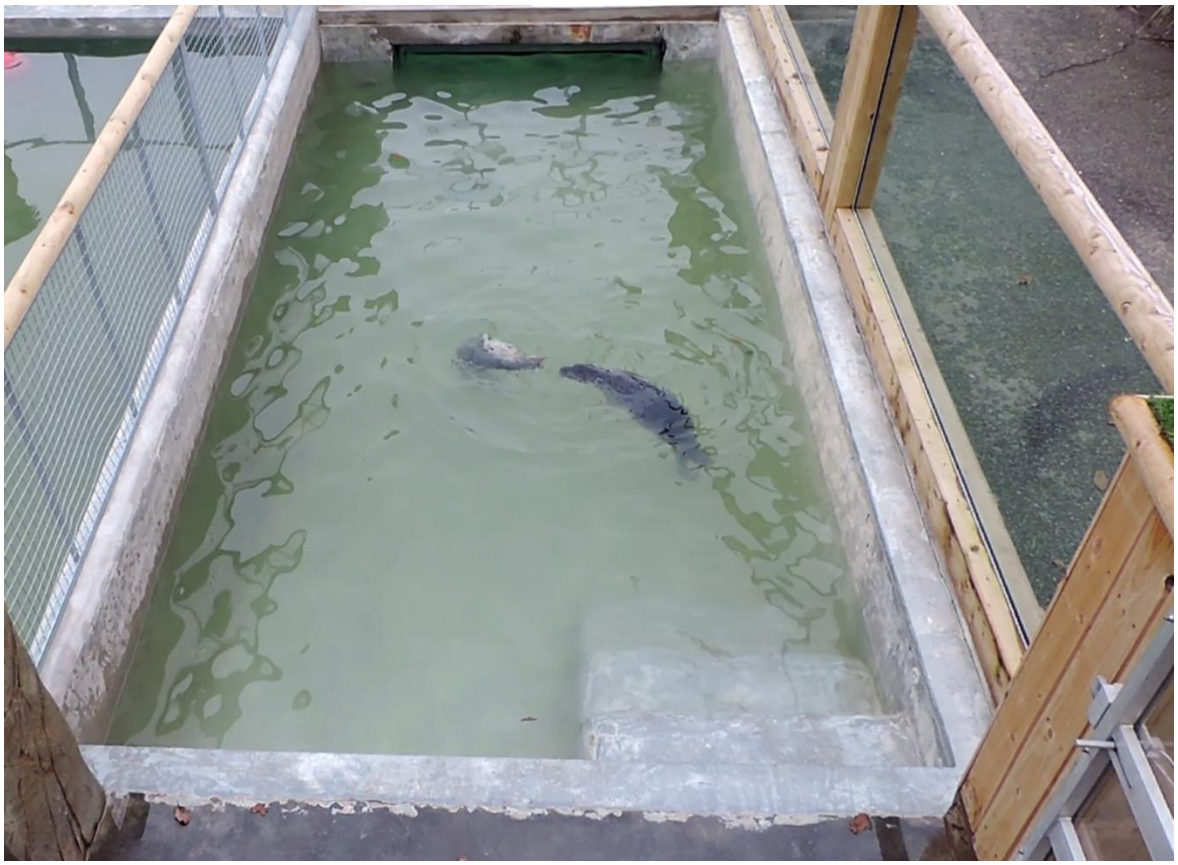


Figure 6: Nursery pool. Cornish Seal Sanctuary, Gweek, Cornwall, UK

The rehabilitation centre was visited once a week from 14 September to 29 November 2016 between 09:00 and 16:30 GMT. Each pup was filmed for 5 min 1-3 times per visit. No data collection took place during feeding times. Four pups from this rehabilitation centre were filmed for a total of 15 video clips (between 3 and 6 video clips per pup) (Table 3). In addition to these clips, 3 video clips of 3 different pup from the rehabilitation centre Exploris (N. Ireland, United Kingdom) were included in the analysis (Table 3).

Table 3: Video clips of pups in the different facilities and pools. Celery, Cauliflower and Curly Kale were rehabilitated at Exploris (Portaferry, N. Ireland, UK)

	Pup names						
	Seal	**Sheep**	**Platypus**	**Grizzly Bear**	**Celery**	**Cauliflower**	**Curly Kale**
Total	**3**	**3**	**6**	**3**	**1**	**1**	**1**
Dry cell	3	3	3	1	1	1	1
Cell filled with water	0	0	3	1	0	0	0
Nursery pool	0	0	0	1	0	0	0

Video processing

Each 5-min video clip was divided in 15s segments. For each segment, behaviours were recorded as present or not. Thus, several behaviours could be present in a same segment. In addition, the zone where the pup was filmed (dry zone of the beach, water's edge, in the water), body position (prone, on side, supine), the identity and distance to the nearest neighbour, as well as the presence and distance of the mother were recorded. For wild pups, the behaviours of the mother were also recorded in the same way. Detailed behavioural descriptions were made for each 15s segment, according to a standardised ethogram adapted from the one established by Kovacs [12] (Table 4). This data processing was adapted from Sue Wilson's harbour seal study [Wilson and Jones, in preparation*] in order to compare later the two species.

Behaviour description

Table 4: Description of the behaviours recorded

Behaviour	Description
Alert	Awake
Rest	Eyes closed, not moving
Comfort movement	Stretching, yawning, scratching, face wiping
Directed movement	Movements to change location
Scan	Looking around with head up, with upper body sometimes turned in the same direction
Look at	Turning head toward another seal
Directed movement	Changing location without aiming to get or stay close to another individual
Follow/approach	Directed movements toward another seal
Cry	Vocalising
Play	Exaggerated body movements and loose body tone
Body contact	Body part in contact with another individual, including nosing and nursing
Nose	Nose contact with another individual excluding searching nipples
Nurse	Searching or suckling on nipples

Statistical analysis

To test whether the behaviours' proportion of pup change with the age of the pup, mixed effect models and log likelihood ratio tests were used with the glmer() function with binomial family. Pup identity and clip number were entered as random factors. The age of the pup was the fix factor. The lme4 package was required. Th test whether behaviours' proportion changed when the mother of the pup was present or absent the glmer() function was also used with the social factor (presence/absence of the mother) as the fixed factor. All analyses were carried out in RStudio (RStudio Team (2015). RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL http://www.rstudio.com/).

Results

Natural behaviour

I investigated the behaviours of pre-weaned grey seal pups. For each behaviour, proportion were calculated as the proportion of 15s segments were the behaviour was present on the total of the 15s segments. This gave a proportion between 0 and 1. I studied in which zones the different behaviours occurred, the proportion of time pups were observed in the different zones, whether the age of the pup has an influence on the behaviour frequencies during the first three weeks of their life, and which activities occurred more often when pups were alone or with their mother.

Most of the time, pups were observed on the dry zone (85% of 15s segments) of the beach but sometimes, they could be found at water's edge (12% of 15 s segments) or in water (3% of 15s segments) (Figure 7).

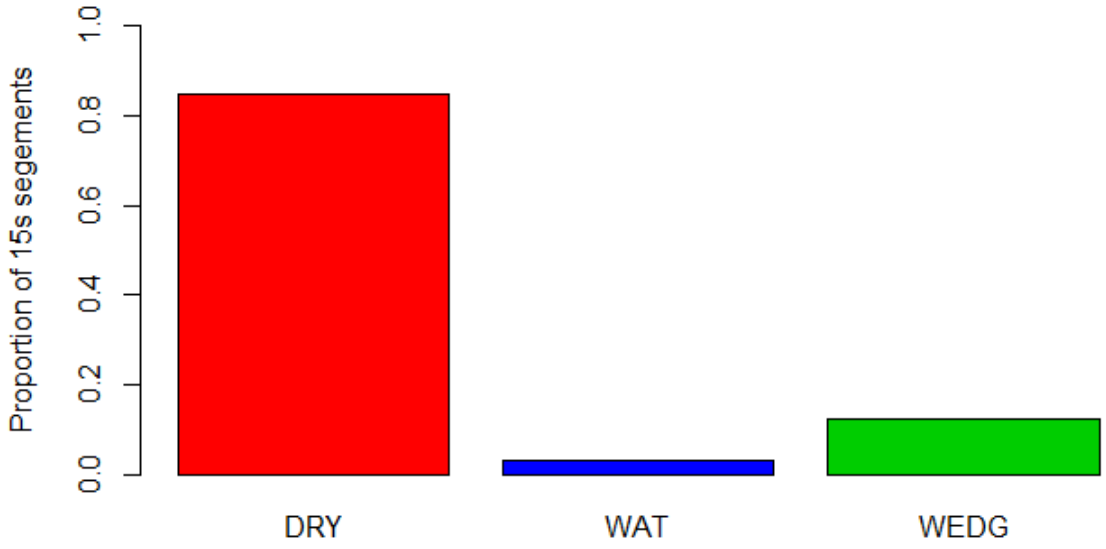


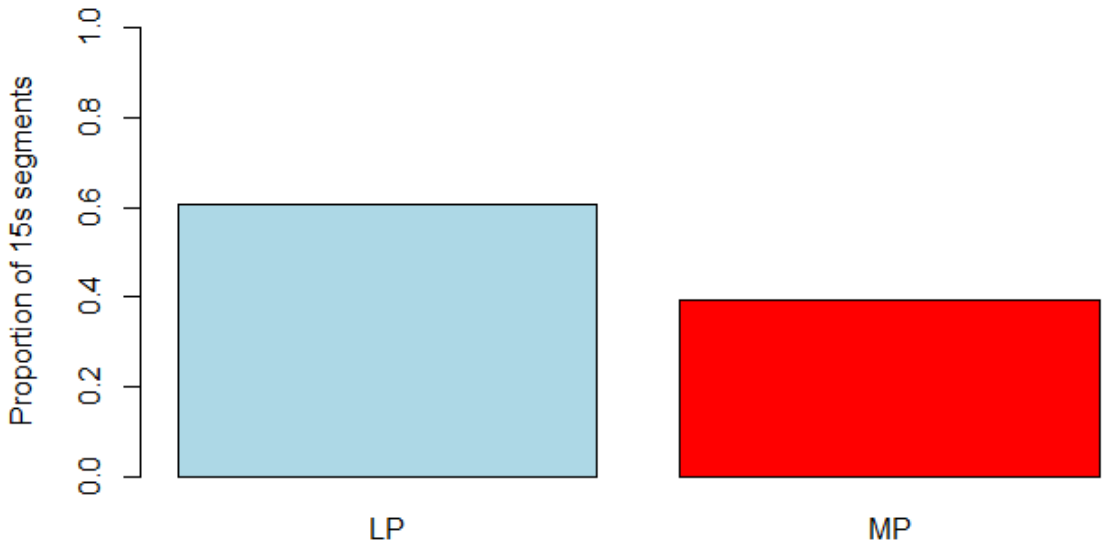
Figure 7: Proportion of 15s segments pups were observed in the different zones. Red: pups were on the dry zone of the beach (DRY); blue: pups were in the water (WAT); green: pups were at the water's edge (WEDG).

Most of the behaviours were observed in the three zones (Table 5). All were observed on the dry zone of the beach. Sleeping and nursing were never observed in the water. Play was never observed at the water's edge.

Table 5: Frequencies of behaviours in the three different zones. XX: proportion > 0.05; X: proportion <0.05; 0: absent

	Zones		
Behaviour	Dry	Wedg	Wat
Alert	XX	XX	XX
Rest	XX	XX	0
Comfort movements	XX	XX	X
Diriected movements	XX	XX	XX
Scan	XX	XX	XX
Look at	X	X	XX
Cry	X	X	X
Follow/approach	X	XX	XX
Body contact	XX	XX	XX
Play	X	0	X
Nose	X	XX	XX
Nurse	XX	XX	0

Pup were observed more often alone (60%) than with their mother (40%) (Figure 8). When they are alone, they are usually far from their nearest neighbour (mean = 11,5 m; range from 0 m to 35 m). When they are with their mother the mean distance between pups and mother is about 1 meter (range from 0 m to 12 m).



204

205 *Figure 8: Proportion of 15s segments when pups were observed alone (LP = lone pup) or with*

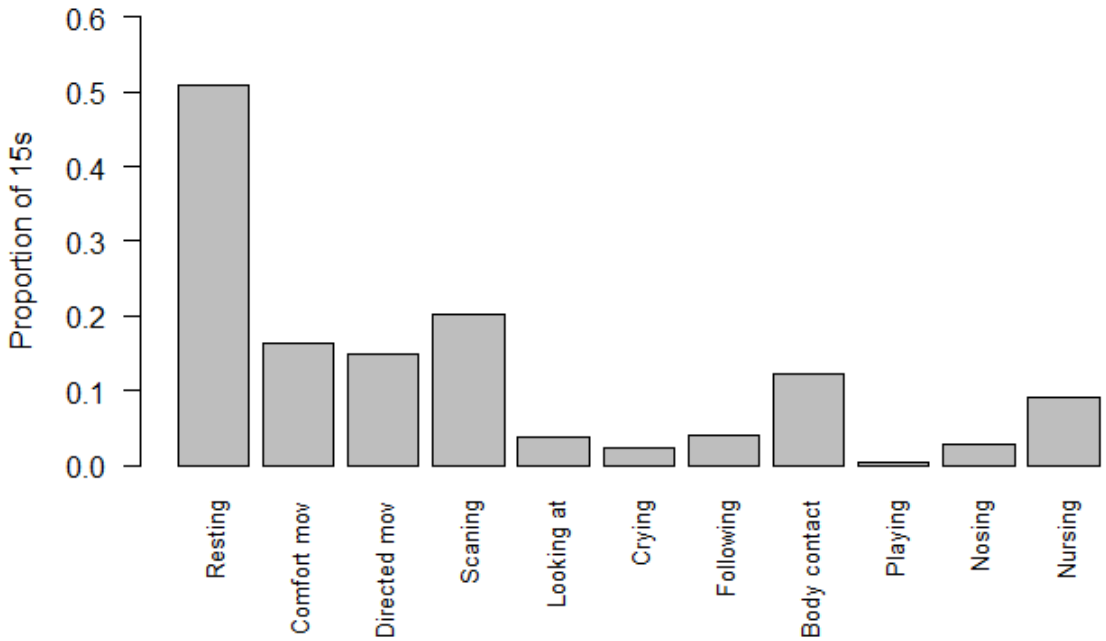
206 *their mother (MP = mother-pup)*

207 Grey seal pups spent most of their time sleeping. When they were active, they scanned, did

208 comfort movements, moved, suckled and nosed their mother (Figures 9 and 10). They did

209 not look at other seals a lot. They hardly ever cried and played. The frequency these

210 behaviours were observed did not change with the age of the pup (see Appendix A, TABLE i).



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212 *Figure 9: Proportion of each behaviour observed for grey seal pups*

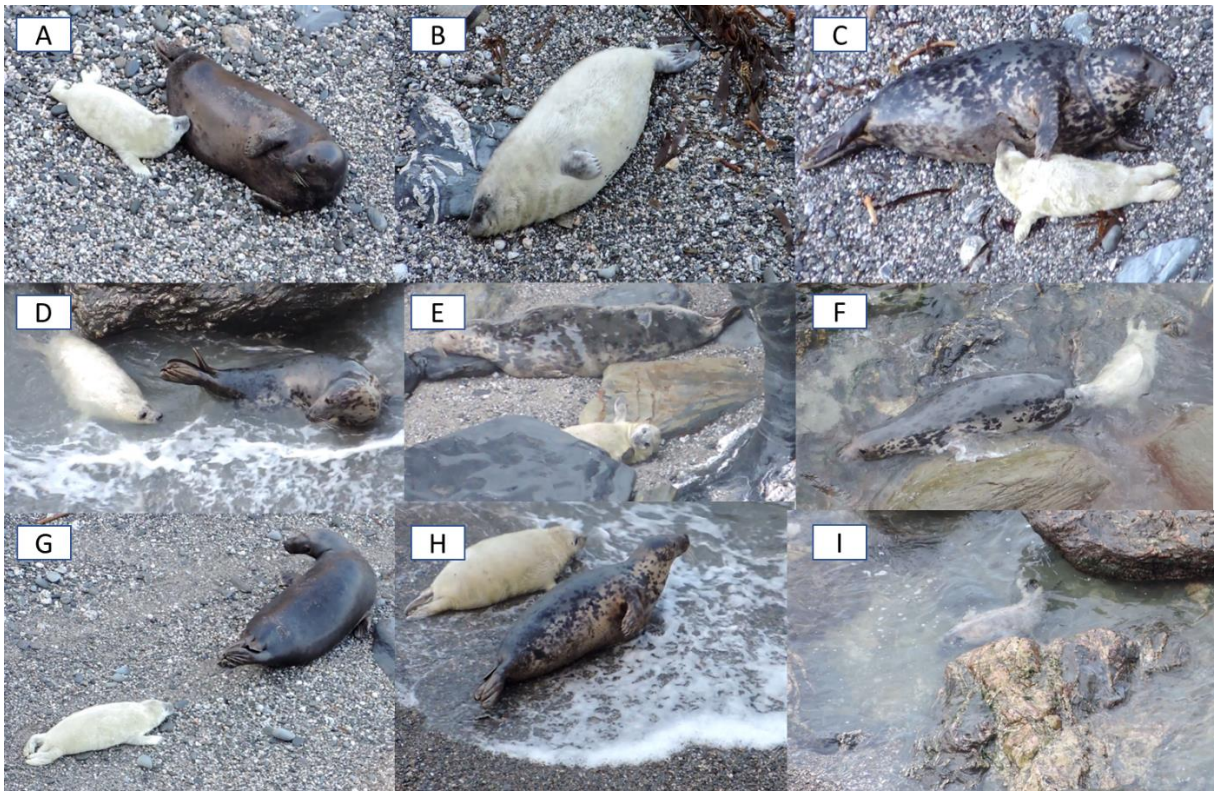
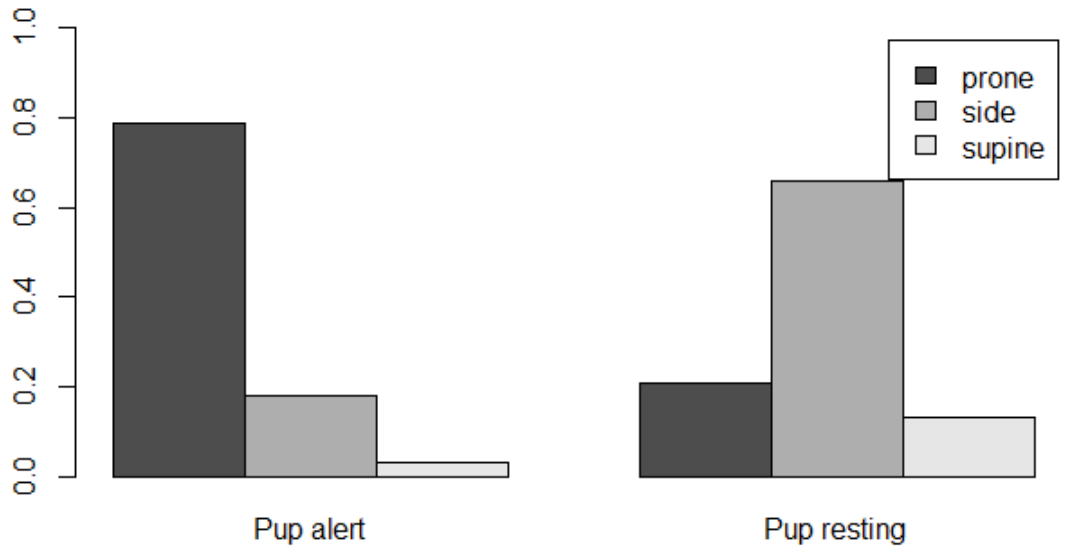


Figure 10: behaviour of pups in different situations. A: Pups suckling, mother looking at pup, dry zone; B: lone pup resting on side, dry zone; C: Pup searching for nipples, mother guiding her pup with her foreflipper, dry zone; D: Mother and pup looking at each other, water's edge; E: pup doing comfort movements, supine, mother resting, dry zone; F: Pup following mother and trying to suckle, mother moving, water's edge; G: Pup following mother, mother checking at her pup, dry zone; H: mother and pup scanning, water's edge; I: lone pup at water's edge.

The body position of the pup was principally prone when they were alert, and they rest mostly on their side (Figure 11). They are the least often supine.



223

224 *Figure 11: Proportion of time pups were observed in the different body position when they*

225 *were alert or resting. Dark grey: prone; grey: on side; light grey: supine*

226

227 *Presence or absence of the mother*

228 The activity of pups changed when they were alone or when they were with their mother

229 (Figure 12). They slept 43% less when they are with their mother as they spent more time

230 interacting with her (see Appendix B TABLE ii and Fig. I-IV). Most of the body contacts

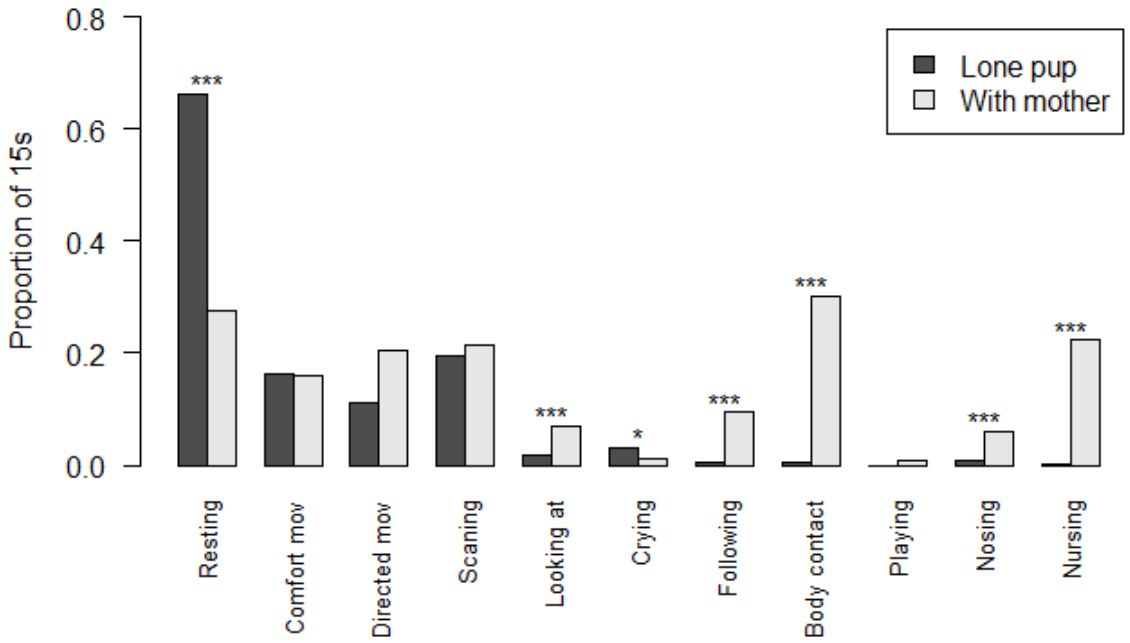
231 happened with the mother. These occurred most often when they were nursing and when

232 they were nosing. Nosing could be nose-to-nose contact or nose-to-body contact. The

233 mother did more often nose-to-body contact than did the pup. The mother did not only nose

234 her pups but she also touched it with her foreflippers to guide it toward her nipples during

235 nursing periods, or when they were in the water.



236

237 *Figure 12: Differences of behaviour when the pup is alone (dark grey) or when it is with its*

238 *mother (light grey). Significance of log likelihood ratio test: * = P <0.5; ** = P <0.01; *** = P*

239 *<0.001*

240

241 *Rehabilitation pups*

242 The behaviour of 7 rehab pups was compared to the behaviour of the wild pups used in the

243 previous analysis. All rehab pups were filmed when they were alone. Thus, the behaviour

244 was compared to the wild pup observed alone. In rehabilitation, some behaviours observed

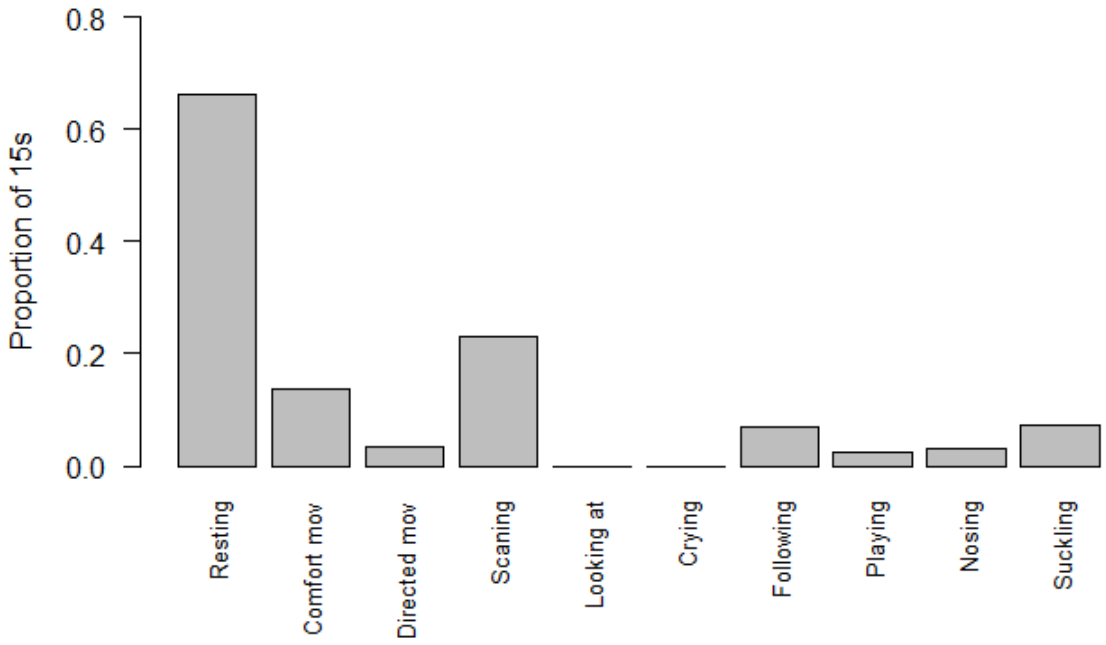
245 only in the presence of another seal in the wild were recorded when pups were alone (Figure

246 13). One pup played. He was the only one that was also observed in the water. It played

247 both in the water and on the dry zone. Two pups suckled on themselves or on objects and 3

248 pups nosed objects. At few occasions, pups were observed drinking water or eating piece of

249 fish which was not observed in the wild.



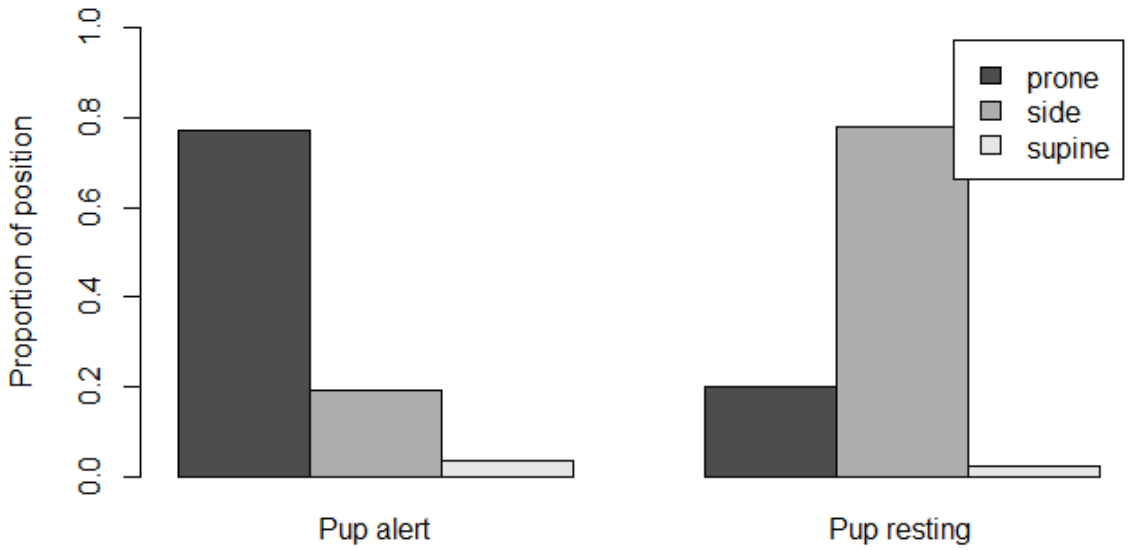
250

251 *Figure 13: Proportion of behaviours of rehabilitated grey seal pups*

252 Pups were observed mostly prone when they were alert and on their side when they are

253 resting. The supine position was the least observed both when they were alert or resting

254 (Figure 14).



255

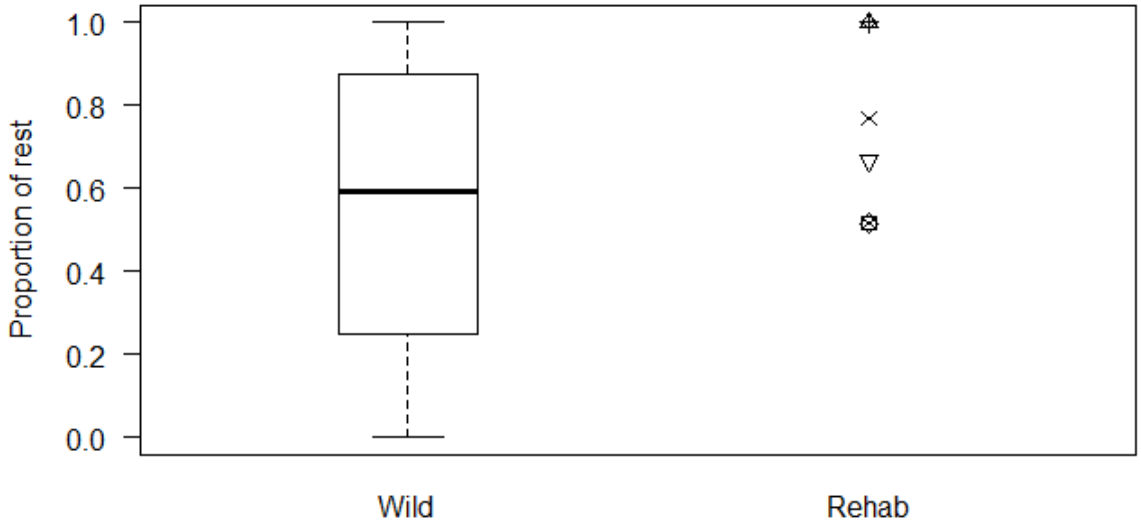
256 *Figure 14: Body position of grey seal rehabilitated pups when they were alert or resting*

257 *Detailed comparison for each behaviour*

258 Five of the 7 pups were observed sleeping more than the mean for wild lone pups (Figure

259 15). The three pups from Exploris slept 100% of the time. The mean proportion rehab pups

260 were observed sleeping was 78%.



261

262 *Figure 15: Resting behaviour of lone wild pups and 7 rehab pups. Each symbol represents one*

263 *rehab pup.*

264 Only two pups were observed moving (Figure 16). They were observed moving respectively

265 8% and 3% of the time.

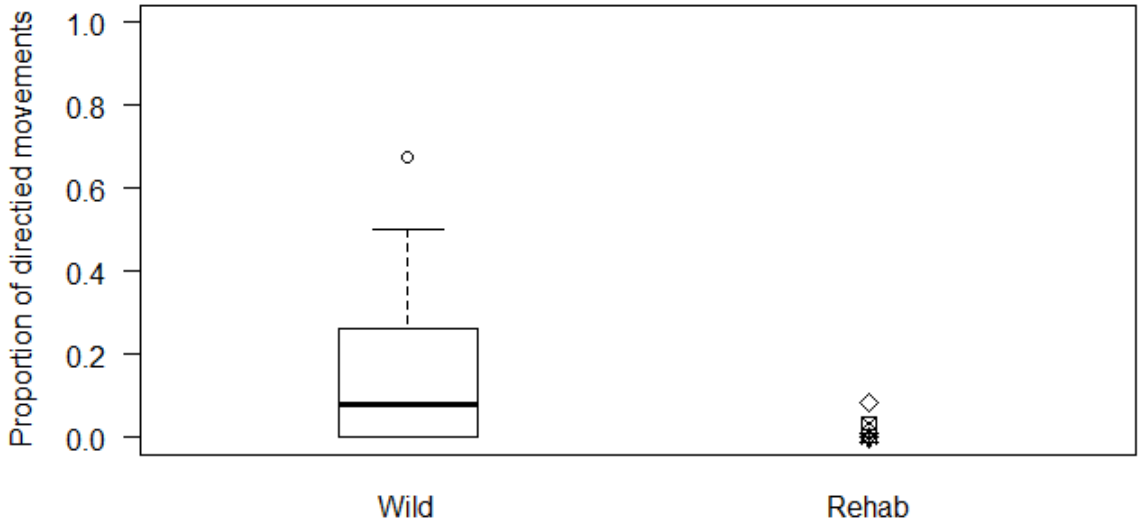
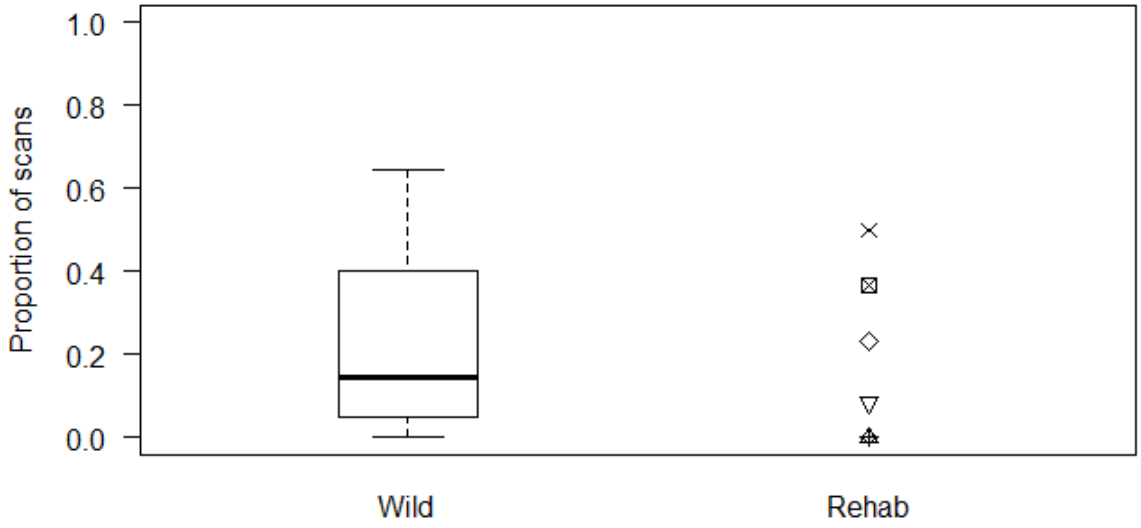


Figure 16: Directed movements of lone wild pups and 7 rehab pups. Each symbol represents one rehab pup.

In rehabilitation, it seems to have an important individual difference in the proportion of scanning (Figure 17). The proportions range from 0% to 50% depending on the pup. Nevertheless, none of the pups were out of the range of wild lone pups.



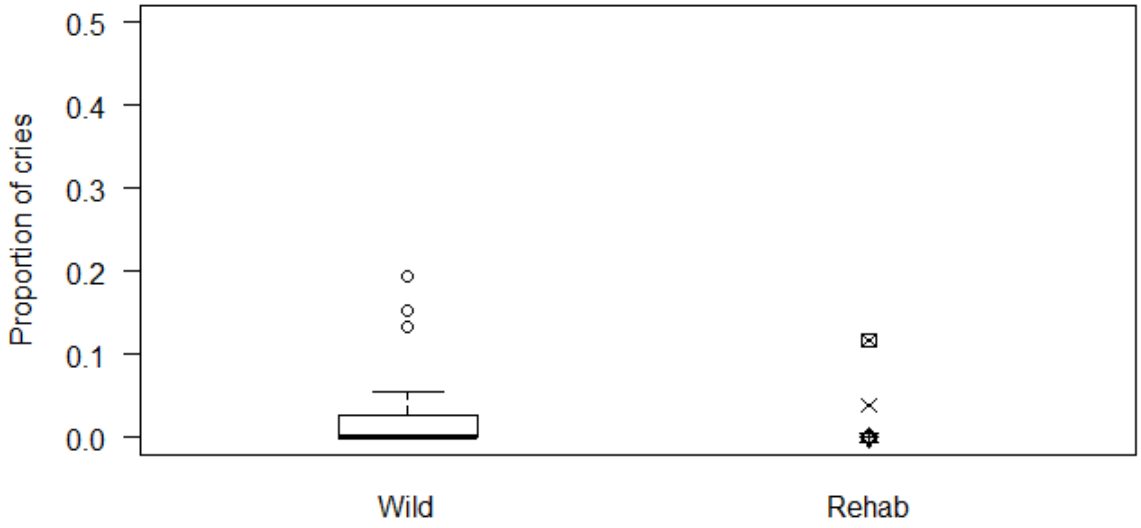
272

273 *Figure 17: Scanning behaviour of lone wild pups and 7 rehab pups. Each symbol represents*

274 *one rehab pup.*

275 Only two rehab pups cried (Figure 18). The proportion of crying for the pups that cried do

276 not seem different from the proportion of the wild lone pup that cried.



277

278 *Figure 18: Crying behaviour of lone wild pups and 7 rehab pups. Each symbol represents one*

279 *rehab pup.*

280 There was not an obvious difference in the proportion of comfort movements between wild

281 lone pups and rehab pups (Figure 19).

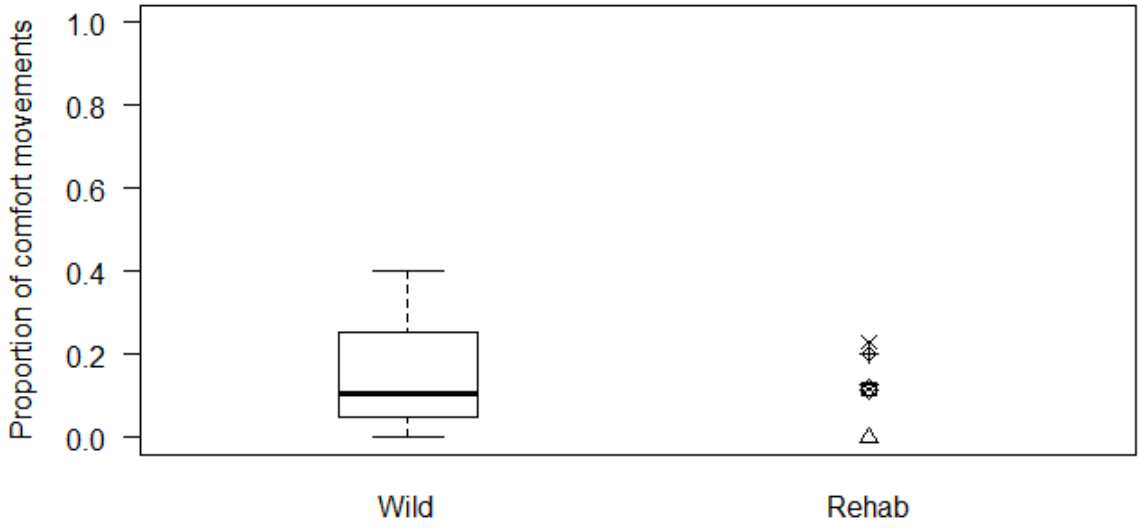
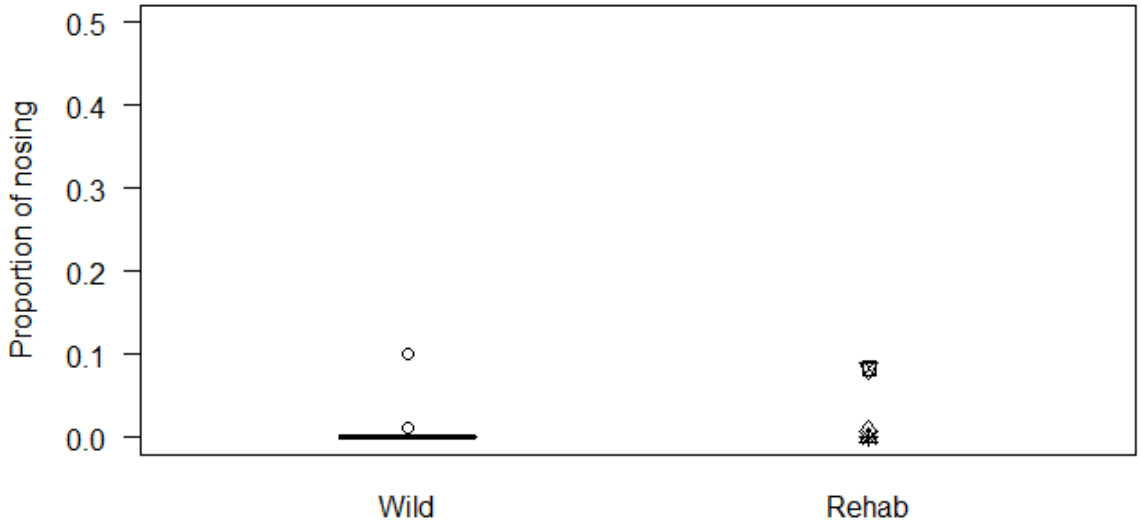


Figure 19: Comfort movements of lone wild pups and 7 rehab pups. Each symbol represents one rehab pup.

There were no body contacts possible in the rehabilitation cells. However, 2 pups were observed suckling (Figure 20) and 3 were observed nosing (Figure 21) on themselves and objects.



288

289 *Figure 20 : Nosing behaviour of lone wild pups and 7 rehab pups. Each symbol represents one*

290 *rehab pup*

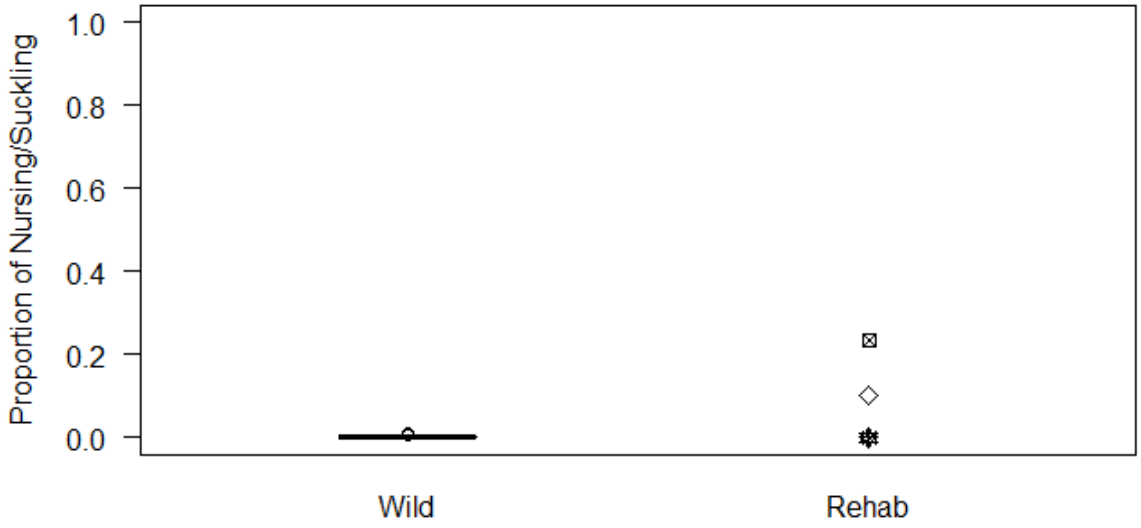


Figure 21 : Suckling behaviour of lone wild pups and 7 rehab pups. Each symbol represents one rehab pup

Discussion

In rehabilitation pup can be kept in condition that are very different from what they would encounter in the wild (isolation, limited access to water) [7]. This can affect their social development and their chance to adapt when they are released in the wild [26]. In order to inform rehabilitation centres about the specific needs of pre-weaning grey seal pups, this thesis described the behaviour of wild pre-weaning grey seal pups and described their interaction with their mother. In a second time, I compared these results with 7 rehab grey seal pups of the same age.

303 Frequency of behaviours of pre-weaning pups did not change with the age of the pup. These
304 results are similar to those of Kovacs [12]. Kovacs' proportion of behaviour did not change
305 with the age when pups were at stage I-IV. She found that, on beach areas, proportion of
306 time pups were idle (resting motionless in a prone position) did not change during the first
307 24 days. Kovacs pups were progressively more active after weaning.

308 These results are consistent with the ice-breeding origin of grey seals. In ice-breeding
309 populations, pups stay mostly inactive during the lactation period [17]. This could be a
310 strategy to minimize energy loss [27]. Pups do not have to learn to feed on fish before
311 weaning and most of the time, do not interact with seals other than their mother.

312 In our study, only a few pups were observed in water and playing. This is also similar to
313 Kovacs' results. Indeed, in her study, pups began to be found in water and playing only after
314 20 days with few exceptions. Grey seal pups born on ice do not go in the water before
315 weaning [17]. However, some pups of this present study were observed at water's edge or in
316 the water. One explanation of the presence of pups near water could be the mother
317 personality [28]. Some mothers could encourage their pup to go near or in the water.
318 However, pups were not always accompanied by their mother when they were close or in
319 water. One explanation could be the different temperatures between places where seals
320 breed on the ice and where they breed on shore. Pups born on shore do not fear
321 hypothermia as much as pup born on ice [29]. The differences could also be due to the
322 topography of the study area. The limit between the dry zone and the water was not abrupt.
323 Therefore, the area was relatively safe for pups to explore water's edge and water. It was,
324 most of the time, easy to get back on the dry zone. Thus, the topography might have not
325 refrained pup to explore further. It would be more difficult in case of ledges which were the

study area of Kovacs where transition between dry zone and water might be more abrupt, or on inland sites where access to the distance to water is very long.

One important difference between this study and Kovacs' study is the body position of the pup when resting. She found that pups were observed principally prone but on the present study, pups were prone principally when they were alert, but mostly observed resting on their side. However, this difference might only be due to a difference of protocols.

Rehab pups

In order to understand better the need of pup during their first weeks, we compared rehab pups' behaviour with wild pups. As only 7 pups in the rehab centre were of the same age of wild pup, we could not determine quantitative differences.

Proportion of several behaviours did not change between lone wild pups and rehab pups. Scanning behaviour seems to show an important individual difference in rehabilitation. Therefore, it is not possible to determine a difference between wild and rehab pups. It was also not possible to determine a difference in frequencies of comfort movements and cries between wild and rehab pups.

Pups were observed more often sleeping in rehabilitation than in the wild. But their body position when they were resting did not change between wild and rehab pups.

Movements in rehabilitation are low. Even if this could be due to the small place pups were house in, or because they spent more time sleeping.

Only one rehab pup played, but it played more frequently than wild seal pups. This pup was also the only one that was observed in water during its first three week. Although playing

was observed both in and out of water for this pup, water might enhance playing behaviour. This hypothesis is compatible with Wilson and Kleiman [30] findings that playing for harbour seals happened at the water's edge and, Wilson [31] reported that all play for harbour and grey seals was observed in shallow water.

Suckling and nosing should not be observed in rehabilitation. However, two pups nosed and suckled objects or themselves. These unexpectable observations could be due to an innate and spontaneous displaying of the behaviour even in inadequate situations. This could also be a response to stress, like isolation or hunger. In the case of chimpanzees (*Pan troglodytes*), grooming and social interaction is a way to temperate stress [32, 33].In the wild, it is when they are with their mother that social interaction and body contacts occur. When housed in isolated cells they have a lack of social contact. Even though they are limited in the wild, they are important for the natural development of the pup.

Thus, conditions that are important for the development of the pup might include space and social contacts. Even if grey seal pups are most of the time on their own, the time spend with their mother is important for their social development. In addition, even if they do not move a lot in the wild, they still explore their environment. Even though it is understandable that housing separately pups requiring medical treatments and hand-feeding is more practical, allowing pups to be in contact with other seals earlier in the rehabilitation process should be considered.

This thesis is part of a project on both grey seal and harbour seal pups' development. Therefore, the next step of this project is to compare these results with results on harbour seal pups. Contrary to grey seals, they stay with their mothers all the time and also follow

them into water [10]. It is mostly likely during this period that they acquired important social knowledge which may be crucial for their survival later.

Weaknesses of this study

During the pupping season, only 22 pups were recorded. Out of these 22, 7 were also found at water's edge and 3 were seen in water. This sample size was not sufficient for an accurate quantitative analysis of the behaviours in the three different zones. A more long-term study, including observation during several pupping seasons would allow to increase the sample size and could increase the sharpness of the analysis.

Because I was alone to cover all 4 beaches within a 3 hours period, it was not difficult to allocate long observation time for each pup. Observing pups during a longer period each day could have allow a more accurate identification of pups, to observe some pups more often, and from a younger age. I would probably have been able to collect more information about mother and pup reunion and separation which I only observed once each. In order to describe more accurately the pre- and post-lactation mother-pup interactions, I should have adapted the protocol to this particular moments to cover the whole nursing process, by filming longer or taking several consecutive video clips.

I should have been more rigorous on collecting more information other than video recording by taking more still pictures of pups and their neighbouring. This would have allowed me to have a better global understanding of pups in their natural environment and to be quicker and more efficient in the analysis of my main data.

391 In the rehabilitation centre, there were only 4 pre-weaning pups which is not enough for a
392 quantitative analysis. To increase the sample size, it would be necessary to collect data
393 during several years.

394

395 *Rehabilitation and conservation*

396 Rehabilitation on grey seals has an interest for the conservation of endangered seal species.
397 Indeed, several seal species are endangered and some were recently classified as extinct [3].
398 Among the 47 pinniped subspecies, 13 are classified as threatened and 6 cannot be assessed
399 because of a lack of information but some of these species are supposed to be threatened.
400 Some of the low concerned subspecies are in decline. This is the case for Northeast Atlantic
401 harbour seals. The Hawaiian monk seal (*Monachus schauinslandi*) is one of the most
402 endangered seal species. Even though there is now programmes to rehabilitate and prevent
403 their decline [34-38], for the conservation of these endangered species, there is an
404 advantage to confront and improve general rehabilitation technics with more common
405 species allowing pre- and post-release surveys. This is not possible with occasional cases of
406 critically endangered species. Nevertheless, pinniped species meet different ecological needs
407 as some are related to cold sea, like grey seals, and other to more temperate waters, like
408 harbour seals or Hawaiian monk seals. Therefore, to understand better species-specific
409 needs, it is necessary to conduct more comparative studies between species of different
410 ecological and social environments.

411 One other purpose of rehabilitation is to enhance public awareness about marine mammal
412 and the importance of conservation. The Cornish Seal Sanctuary (Gweek, Cornwall, UK)
413 shows videos about rehabilitation and give the possibility to virtually “adopt a pup”. They

414 also propose quiz for children. This allow to inform and heighten awareness of both adults
415 and children, and give to the public the feeling and the possibility of being directly invested
416 in the conservation for this species.

417 Finally, rehabilitation is important for scientific research and acquiring medical knowledge
418 [6]. Animal can be studied during their time among human. Indeed, most of the admitted
419 individuals are ill or injured. This provide also a considerable sample size to conduct
420 experiences that would not be able to be set in the field.

421 Comparative studies between rehab and wild pup on a same species as well as with different
422 species is important to allow rehab centre to be more efficient in their animal welfare and
423 the survival of young seals when they are released even if survival success is already high for
424 some species [39]. Comparative studies should also be done between different housing
425 conditions at a pre-weaning age i.e. alone, in pair, in groups, limited or unlimited access to
426 water. These conditions are found in some rehabilitation centres. In the case of orphan
427 harbour seals, when housing together at pre-weaning age, other pups could be taken as a
428 mother substitute [26, 40][Wilson and Jones, in preparation*].

429 Finally, as rehab pup are kept in rehabilitation much longer than the time they would spend
430 with their mother in the wild, it is necessary to also compare post-weaning pups' behaviour
431 between wild and rehabilitation conditions. This could allow to investigate whether there
432 are differences in development occur later in the life of the pup.

433

434 **Conclusion**

During their first weeks of life, the behaviour of wild grey seal pups does not change. This is mostly explained by their ice-breeding origins. Globally, rehab grey seal pups' behaviour is not much different from their wild counterparts. Nevertheless, differences are thought to be more important for harbour seal pups because the ecology of these two species are very different. However, these ecological differences between species are not considered enough by rehabilitation centres. Rehabilitation centres are important for the pup welfare and for pinniped conservation. Therefore, to be even more efficient, it is crucial to collect knowledge about each rehabilitated species and adapt protocol to each of them. This will allow to let pups develop in environment as close as possible form their natural environment and maximize their change of survival after release.

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APPENDIX

Supplemental analysis

A: Behaviours developments

TABLE i: Mean proportion of the different behaviours and chi2 and p-value of log likelihood ratio test of the change of these proportion through time

Behaviour	Proportion	Chi2	P-value
Rest	0.51	2.13	0.144
Directed movements	0.11	1.48	0.224
Following and approaching	0.04	1.2	0.666
Scanning	0.2	2.35	0.125
Crying	0.02	0.64	0.424
Comfort movements	0.16	1.11	0.292
Look at	0.04	0.49	0.485
Nursing	0.09	0.09	0.765
Nose	0.03	3.54	0.06

B: Difference of behaviour when pup is alone or with its mother

TABLE ii: Differences of proportion of behaviour when the pup is alone (LP) or with its mother (MP). Chi2 and p-value of log likelihood ratio test

Behaviour	LP	MP	Chi2	P-value
Rest	0.55	0.24	28.21	<0.001
Directed movements	0.14	0.09	1.47	0.226
Following and approaching	0.008	0.1	14.94	<0.001
Scanning	0.23	0.22	0.08	0.778
Crying	0.03	0.009	5.16	0.023
Comfort movements	0.14	0.2	0.51	0.447
Look at	0.04	0.09	22.87	<0.001
Body contact	0.005	0.37	35.91	<0.001
Nursing	0	0.09	20.25	<0.001
Nose	0.01	0.07	19.72	<0.001

Resting

Pup spent 43% more time sleeping when they are alone than when they are with their mother (Figure 14).

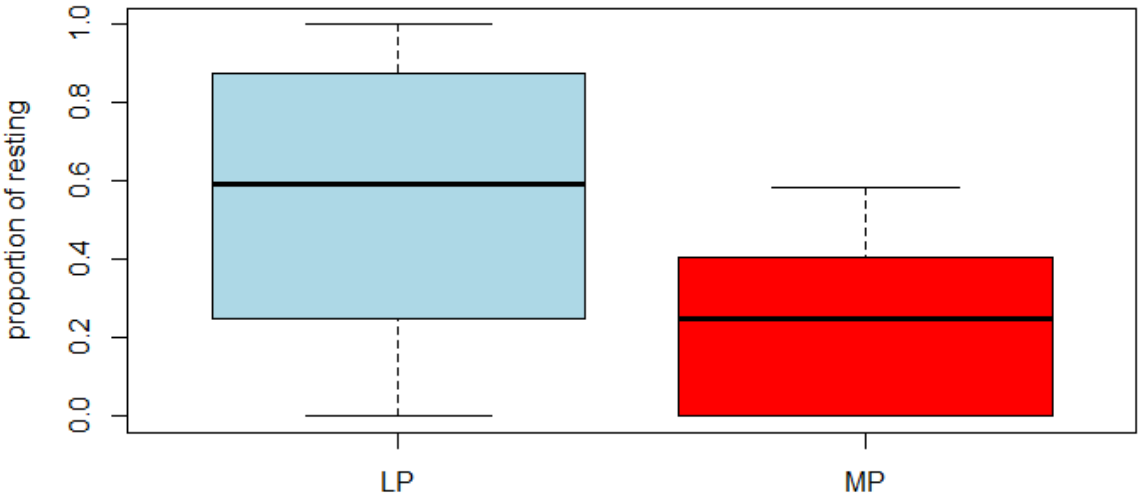


Fig. I: Resting behaviour depending of the presence (MP, red) or absence (LP, blue) of the mother.

Following

Pups rarely followed or approached other seals than their mother. It happened only 6 times (15 sec segments), when a pup was thought by the observer to be abandoned and looking for its mother. The mother was never seen and the pup disappeared two days later.

When they are with their mother pups follow or approach her 10% of their time. When the mother is moving, pups follow her 35% of the time (Figure 15). The mother usually moves to find a better place for her and her pup. One pup followed her mother while she was returning to the see but gave up after few metres. The mother was not observed checking at her pup before she was out of sight.

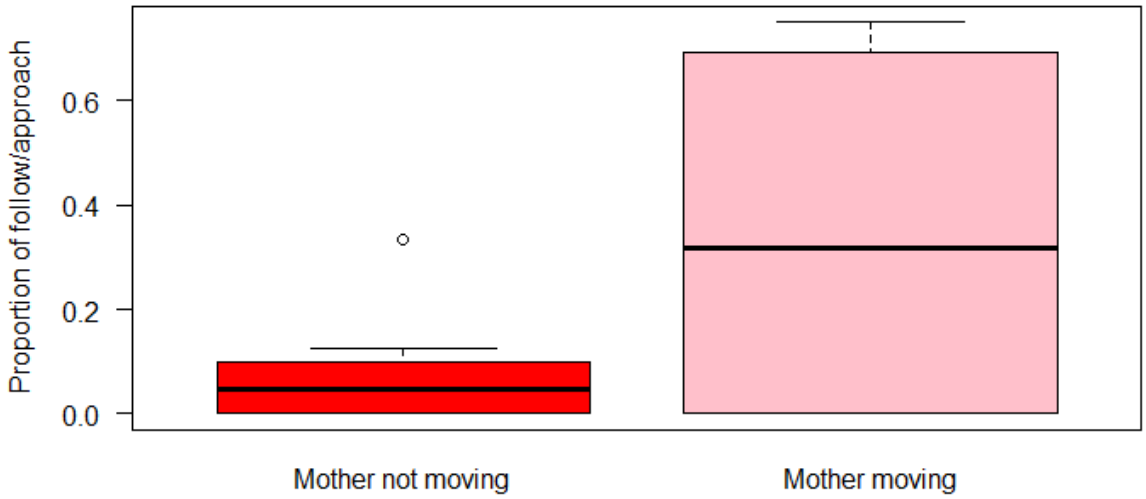
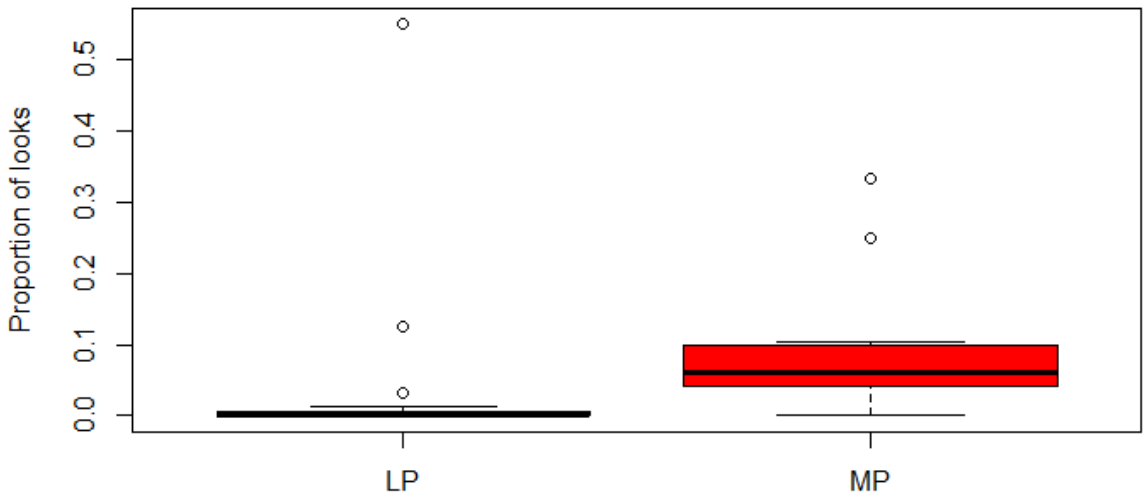


Fig. II: Proportion of time pups spent following or approaching their mother. When the mother is moving (pink) the pups follow their mother. When the mother is not moving (red), the pups approach

Looking at other seals

Pups look more often at their mother than at other seals (Figure 16). Only two pups were observed looking at adult seals. One pup checked frequently at an adult seal who approached the pup when it was alone. Another one was the same supposed abandoned pup that followed other seals.



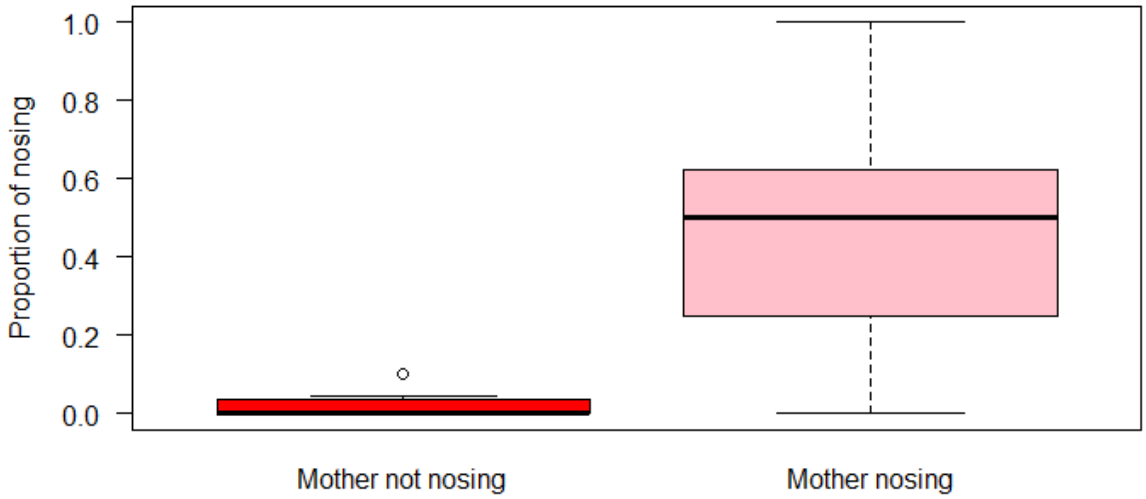
585

586 *Fig. III: Looking at other seal, when the mother is present (MP, red) or absent (LP, blue)*

587 *Nosing*

588 Pups nose mostly their mother (Figure 17). Only the presumed abandoned pup nosed
589 another adult seal who approached it. Two pups were observed nosing rocks. Pups nose
590 more often their mother when she also noses her pup that when she does not nose. (Log
591 likelihood ratio test, P < 0,001). Thus, there is more mutual nosing.

592



593

594 *Fig. IV: Pup's nosing behaviour in mutual nosing (pink) or one side nosing (red)*