Vol. 22: 115–124, 2013
doi: 10.3354/esr00541

ENDANGERED SPECIES RESEARCH
Endang Species Res

Published online December 2

# Haulout patterns of Saimaa ringed seals and their response to boat traffic during the moulting season

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ABSTRACT: Conservation of the Critically Endangered ringed seal *Phoca hispida saimensis* population in Lake Saimaa in Finland requires broader knowledge of the behavioural ecology of this subspecies. Understanding Saimaa ringed seal haulout patterns and their response to boat traffic is crucial for designing sustainable land use and tourism guidelines. Responses of unidentified seals to small outboard motor boat traffic were studied during the moulting season. The median distance at which the seals responded to an approaching boat was 240 m. GPS-phone tags were used to study both circadian and seasonal haulout behaviour patterns of individual seals (n = 8) during the open-water season. The average post-moulting haulout duration was 6 ± 5 h (SD), with a maximum of over 26 h. The seals spent more time hauled out at night (between 21:00 and 06:00 h) after the moult. The time spent hauled out and the haulout frequency declined from early summer to autumn. An individual seal had an average of 13 haulout sites, which were an average of 2.5 km apart. Approximately half of these haulout sites were located in the core 50 % of the individual seals' home ranges. The high level of site fidelity emphasizes the need to identify suitable haulout areas and to develop measures for protecting the main resting sites of this endangered population. Additionally, guidelines for seal watching should be developed in order to mitigate the potential disturbance caused by increasing tourism on Lake Saimaa.

KEY WORDS: *Phoca hispida saimensis* · *Pusa* · Tourism · Haulout patterns · Disturbance · Moult · Seal watching · Conservation



## INTRODUCTION

The current population estimate for the Saimaa ringed seal *Phoca hispida saimensis* is around 300 individuals (Metsähallitus 2012, www.metsa.fi/sivustot/metsa/fi/Luonnonsuojelu/Lajitjaluontotyypit/Uhanalaisetelaimet/Saimaannorppa/Hyljekanta2012/Sivut/default.aspx). This freshwater subspecies is categorized as Critically Endangered (Kovacs et al. 2012) and is also included in the European Union's Habitat Directive as a species that needs designated Special Areas of Conservation and overall strict protection (Council Directive 92/43/EEC, Annexes II and IV). Among other activities, destroying and impairing breeding and resting areas are forbidden by national legislation (Nature Conservation Act 1096/1996; Finnish legislation available at www.finlex.fi). The current main breeding areas have been identified (Sipilä 2003, Ministry of the Environment 2011, Niemi et al. 2012), but the important haulout areas still have to be identified and conservation plans implemented.

Unlike the marine ringed seals, which regularly moult on sea-ice platforms (e.g. Heide-Jørgensen & Lydersen 1998, Kelly et al. 2010) and are pelagic during the open-water season (Smith 1987, Harwood & Stirling 1992), Saimaa ringed seals mainly moult and haul out on terrestrial sites (Hyvärinen et al. 1995, Kunnasranta 2001, Kunnasranta et al. 2002). The moulting period starts in late April on the

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ice, but the peak of the moult occurs on terrestrial sites after the ice breaks up in early May, and continues to the second week of June (Hyvärinen et al. 1995). During the moult, the seals spend extended periods hauled out on the shorelines of islands and islets during the day and night (Hyvärinen et al. 1995, Kunnasranta et al. 2002). Since the Saimaa ringed seals tend to use the same terrestrial haulout sites year after year (Koskela et al. 2002), it is easy to predict their location for tourists. In addition, the sites are easily accessible to human visitors by boats. Recently, tourism in Lake Saimaa has increased, and the seals are considered an important tourist attraction (Tonder & Jurvelius 2004). Seal-watching trips primarily take place during the moult from May to June in the central distribution area of the seals. At that time, the seals are visible on shorelines, typically solitary or occasionally in loosely organized groups of a few animals (Sipilä & Hyvärinen 1998). However, there is no documentation of the effects resulting from boat traffic on these seals, and no guidelines on how to approach them without causing disturbance.

In the present study, the seals' response to outboard motor boat traffic during the moulting season was examined. The results can be used to assist in developing guidelines for commercial tourism and private boat users in order to mitigate the potential human-induced disturbance to Saimaa ringed seals. Furthermore, the haulout patterns of seals were studied during the open-water season to describe circadian patterns and to identify suitable haulout habitats. These results have important implications for identifying the main resting areas of Saimaa ringed seals and planning sustainable land use.

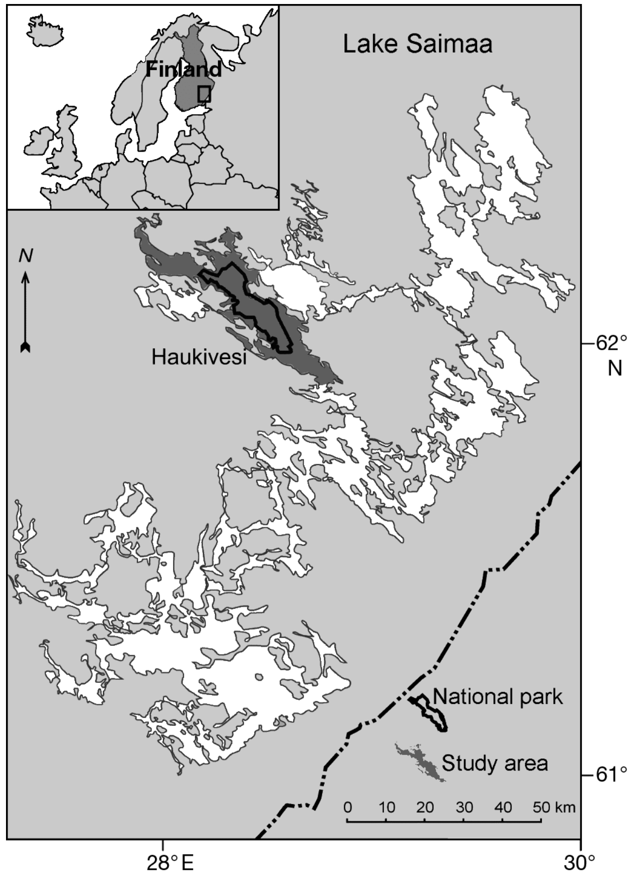


Fig. 1. Study area (dark grey) in the Lake Haukivesi basin. It incorporates Linnansaari National Park (outlined in black). white indicates surface area of Lake Saimaa

## MATERIALS AND METHODS

This study was conducted in Lake Haukivesi basin (62° 09′ N, 28° 18′ E), which is one of the main breeding areas of the Saimaa ringed seal (Fig. 1), during the open-water season (between ice breakup in early May to freeze-up in late November). The study area encompasses Linnansaari National Park, a popular tourist resort with various outdoor activities.

The responses of free-ranging seals to outboard motor boats (open boat, length ca. 5 m, with 50 or 60 hp engine) were recorded during the moulting season (May and early June) from the haulout sites in 2006 to 2010. Due to the labyrinthine nature of the lake, the seals were first detected at various distances (mean 360 m, range 30 to 900 m). After detection, seals were approached directly or by passing parallel to the shore, in a manner similar to the typical tourist boat. The seals were approached closely enough to allow proper observation, but not closely enough to deliberately cause them to enter the water. The response of each seal to the boat's approach was classified as (1) no response or (2) response (2a: lifting head, i.e. alert, or 2b: entering the water). In all cases, the final response of the seal and its final proximity to the boat were recorded. The distance was measured with a GPS plotter or from map charts. As individual seals were unidentified, it is likely that several approaches were made towards the same seal. This was unavoidable given that most seals are not individually marked; we return to this point in the 'Discussion'. Using Generalized Linear Models in SPSS Statistics 19, we fitted a multinomial logistic regression model (Hosmer & Lemeshow 2000) with cumulative logit link function to determine whether the distance between the boat and the seal explains the seal behaviour (no response/alert/enter the water).

The cumulative predicted probabilities produced by this model allowed us to make predictions of the probability of seal responses at different distances from the boat.

Eight Saimaa ringed seals (Table 1) were captured and equipped with a GPS-phone tag (Sea Mammal Research Unit, St. Andrews University, UK) at the end of their moulting season in various years during the period 2007 to 2011 (see Niemi et al. 2012) under the permits obtained from the local environmental authorities and the Animal Experiment Board in Finland (permit number: ESAVI-2010-08380/Ym-23). The tags collected GPS position, haulout, dive, temperature and time data (McConnell et al. 2004). The haulout was identified when the tag's wet-dry sensor had been dry for 10 min (the 10 min were then included in the haulout duration) and ended when the sensor became wet for 40 s.

Data from each individual provided by the tags were used to calculate 3 variables describing the haulout patterns for each month during the open-water season: (1) average duration of a haulout event, (2) time between successive events and (3) proportion of a day (24 h) spent on the haulout (%). Changes in duration of the haulout events and the time between the events throughout the study period were determined by fitting a linear mixed model in SPSS. Animal ID was included in the model as a random effect and month as a covariate.

For further analyses, the haulout behaviour for each GPS-instrumented seal for each hour was recorded (where '1' indicated that the seal was hauled out and '0' indicated that the seal did not haul out during the hour). The daylight data were calculated using a converter (www.moisio.fi/taivas/aurinko.php), which employed the algorithm retrieved from the NOAA (www.srrb.noaa.gov/highlights/sunrise/calcdetails.html). The tracking periods were divided into 2 separate seasons: the early post-moulting season (late May to June) and the post-moulting season (from July to the end of the tracking period, Table 1). We fitted a logistic regression model (Hosmer & Lemeshow 2000) to determine whether daylight or season explained the haulout behaviour during each hour, with individual included as a random effect in the model and time as a within-subject variable. A first-order autoregressive (AR1) working correlation matrix was chosen in the model, to take into account the temporal autocorrelation of observations.

The numbers and locations of haulout sites used by individual seals were defined by haulout locations provided by the GPS tags and confirmed using ArcGIS 9.3 software (ESRI 2008). To determine the intensity of usage at each haulout site, the core area of the individuals' home range was estimated using the 50% adaptive local convex hull method (*a*-LoCoH; Getz & Wilmers 2004, Getz et al. 2007). Haulout locations inside the core areas were categorized as intensively used sites (Harris et al. 1990). The home range analyses were conducted using the 'adehabitat' package (version 1.8.3, Calenge 2006) for the R 2.13.2. statistical software (R Development Core Team 2011). The distances between the haulout sites were measured using Hawth's tool extension (version 3.27, Beyer 2004) in ArcGIS 9.3 (ESRI 2008). To identify factors that may indicate a preference for these haulout sites, the characteristics of the core area of the home ranges were analyzed. The characteristics estimated were the size of the island, habitat type and compass azimuth of the haulout sites relative to the centre of the island. The habitat types were determined using the CORINE land cover 2006 database (25 m, CLC2006, ©SYKE). The compass azimuth was visually estimated only for islands over 5 ha in size to mitigate the GPS accuracy errors.

Table 1. *Phoca hispida saimensis.* Details from the 8 GPS-tagged Saimaa ringed seals and the duration of the study period. Dates are dd/mm/yy. F: female; M: male; Depl.: deployment; Dur.: duration; ICS: ice-covered season; SP: study period (where Start is the date of the first haulout, End is the last haulout before the ice-cover season or tag loss); –: no data available; d: days

| ID | Sex | Mass (kg) | Date of depl. | Last uplink | Dur. of depl. (d) | ICS start | SP Start | SP End | Dur. of SP (d) |
|---|---|---|---|---|---|---|---|---|---|
| HE07 | F | 57 | 01/06/07 | 09/12/07 | 191 | – | 02/06/07 | 24/11/07 | 175 |
| KJ07 | M | 52 | 25/05/07 | 29/12/07 | 218 | – | 25/05/07 | 30/12/07 | 219 |
| TO07 | M | 55 | 03/06/09 | 28/03/10 | 298 | 14/12/09 | 04/06/09 | 11/12/09 | 190 |
| VI09 | M | 124 | 26/05/09 | 11/12/09 | 199 | – | 26/05/09 | 08/12/09 | 196 |
| OL10 | F | 59 | 31/05/10 | 02/04/11 | 306 | 27/11/10 | 01/06/10 | 15/11/10 | 167 |
| LI10 | F | 48 | 21/05/10 | 15/07/10 | 55 | – | 25/05/10 | 14/07/10 | 50 |
| ER11 | M | 66 | 20/05/11 | 22/09/11 | 125 | – | 21/05/11 | 20/09/11 | 122 |
| TE07 | F | 52 | 31/05/11 | 13/02/12 | 258 | 02/01/12 | 31/05/11 | 30/12/11 | 213 |

Furthermore, the numbers of buildings (including residential, summer cottages and other buildings; ©National Land Survey of Finland 2012, data updated in 2010) on the islands with intensively used haulout sites of tagged seals were calculated, and direct distances from building to the nearest haulout site were measured. To locate additional moulting sites, boat surveys were carried out between 2006 and 2012 in Haukivesi basin.

## RESULTS

In total, 219 events were recorded in which unidentified seals were approached mimicking typical tourism boat practices. Most of the approaches were made towards a solitary seal (n = 191), but occasionally 2 or 3 seals were hauled out on the same shoreline (number of groups: 15; the discrepancy between the total n for seals in groups plus individual seals and the total number of events is explained by the fact that data are missing for some individuals). The majority of the individual seals responded to the approaching boat by lifting their heads (alert; 62 %), and entering the water (27 %; Fig. 2). Only 11 % of the individuals did not respond at all. The median approach distance between the boat and seal, of seals that did not respond to the boat, was 300 m (range 50–600 m), the median distance at which seals were classified as alert was 240 m (range 30–600 m), and the median distance at which seals entered the water was 146 m (range 30–500 m; Fig. 2a). The seals were more likely to be alert and to enter the water when the distance to the approaching boat was reduced (multinomial logistic regression; parameter estimate for distance = −0.007, $p < 0.001$). According to the cumulative predicted probabilities produced by the model, at a distance of 300 m (median distance for the seals that did not respond), the probability that the seal would become either alert or would enter the water was >90 % and the probability that it would enter the water was <20 % (Fig. 2b).

Altogether, 1000 haulout events by 8 tagged seals were recorded (Table 1). The average (± SD) duration of a haulout event was 5 h 57 min (± 4.59 h), ranging from 10 min to >26 h (Table 2). Haulout duration remained similar during the whole open-water season (linear mixed model, parameter estimate for month = 0.039, df = 46.66, $t = 0.352$, $p = 0.726$). The average time between the haulout events was 26 h 11 min (± 29.25 h, range 3 min to >18 d), increasing significantly towards the end of the open-water season (linear mixed model, parameter estimate for month = 6.807, df = 47.04, $t = 7.992$, $p < 0.001$; Table 2). On average, 19 % of time was spent hauled out during the open-water season (Fig. 3). The seals hauled out more during early post-moulting (late May to June; 25 % of the total time) than during the post-moulting season (July to end of the tracking period; 17 %; logistic regression, parameter estimate

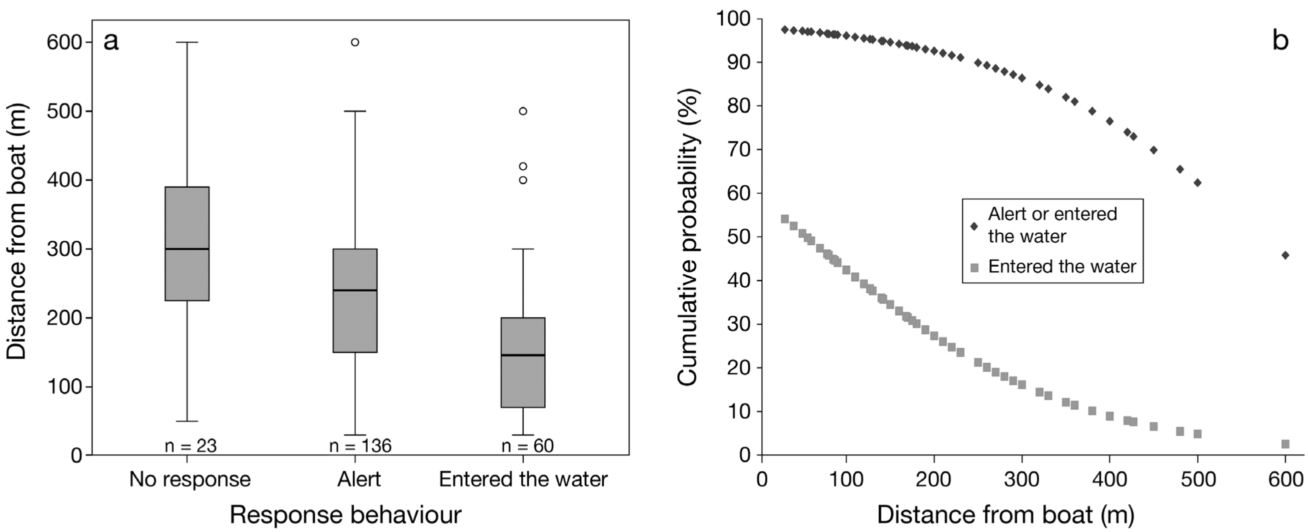


Fig. 2. *Phoca hispida saimensis.* Response behaviour of unidentified seals to boat traffic. (a) Distribution of boat distances in relation to the 3 categories of behavioural response; centre **bold** lines show median values, upper and lower boundaries of boxes indicate the 25 and 75 % percentiles, and the whiskers show the minimum and maximum distances unless outliers are present. (b) Cumulative predicted probabilities (produced by the multinomial logistic regression) of seal response related to the distance from the boat

Table 2. *Phoca hispida saimensis.* Annual variation in the haulout behaviour of 8 GPS-tagged Saimaa ringed seals. Dur.: duration (h); time between: mean time (h) between haulout events. Means are ± SD

| Month | Mean haulout dur. | Max. haulout dur./ID | Time between |
|---|---|---|---|
| May | 5.62 ± 4.95 | 19.29/VI09 | 9.71 ± 10.86 |
| June | 6.53 ± 5.40 | 26.39/TO07 | 22.2 ± 20.11 |
| July | 5.41 ± 4.13 | 19.28/TE07 | 22.93 ± 22.55 |
| August | 6.00 ± 4.52 | 23.06/TE07 | 21.18 ± 19.48 |
| September | 5.80 ± 4.19 | 19.09/TE07 | 23.90 ± 21.08 |
| October | 5.88 ± 4.53 | 22.69/VI09 | 40.38 ± 36.18 |
| November | 6.20 ± 4.39 | 18.29/TE07 | 43.70 ± 40.42 |
| December | 6.60 ± 4.14 | 15.69/TE07 | 63.60 ± 86.43 |
| Overall | 5.96 ± 4.59 | 26.39/TO07 | 26.19 ± 29.25 |

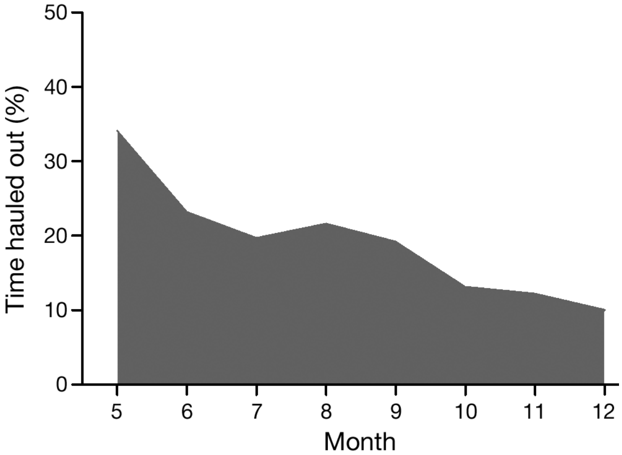


Fig. 3. *Phoca hispida saimensis.* Monthly proportion of total time hauled out by GPS-tagged Saimaa ringed seals (n = 8)

for season = −0.629, $p < 0.001$, odds ratio 0.533). The probability of haulout during nocturnal hours (peaking between 21:00 and 06:00 h; Fig. 4) was 1.4 times greater than haulout during daylight hours (logistic regression, parameter estimate = 0.341, $p < 0.001$, odds ratio 1.406).

A total of 104 different terrestrial haulout sites used by the 8 tracked seals were identified during the study seasons (Fig. 5). Individual seals used on average 13 ± 4.6 (SD) haulout sites (range 5–21). Overall, 46% of the sites were located at the moulting sites observed during the boat surveys in Haukivesi basin, and the remaining sites were situated outside established moulting areas. The median distance between the different haulout sites of an individual seal was 2.5 km (range 0.06 to 22.7 km, Fig. 6). Approximately half (51%) of the haulout sites used by individuals were located inside the most intensively used area of their home range (core area 50%).

Only the intensively used haulout locations were taken into account when evaluating the characteristics of the typical haulout sites. These sites (n = 53) were situated predominantly on the rocks on shorelines of islands (n = 41); only 1 was on a mainland shore. The median size of haulout islands was 4 ha (range 0.02 to 297.61 ha). The most typical habitat type was coniferous forest, which was dominant on all islands in the study area. Haulout sites were located in all compass azimuths, but the most preferred were the eastern (35%) and southern (29%) sides of the islands. Approximately one-third (34%) of the haulout islands included buildings. The average (±SD) direct distance to the closest building to the haulout site was 400 m (± 200 m). The median size of these islands was 46 ha (range 0.14 to 297.61 ha).

## DISCUSSION

When moulting, ringed seals haul out frequently and for long periods (Smith 1973a, Finley 1979, Smith & Hammill 1981, Kelly & Quakenbush 1990, Heide-Jørgensen et al. 1992, Hyvärinen et al. 1995, Born et al. 2002, Kunnasranta et al. 2002, Carlens et al. 2006), spending up to 60% of their total time hauled out (Kelly et al. 2010). This is due to the benefits of warmer skin temperatures and dry pelts whilst moulting (Boily 1995, Paterson et al. 2012). The present study supports previous findings, which have shown that the proportion of haulout events of ringed seals declines after the moulting season (Heide-Jørgensen et al. 1992, Kelly et al. 2010). However, in our study, prolonged haulout activity of Saimaa ringed seals was still seen during the early post-moulting period: seals spent 34 and 23% of their total time hauled out in late May and June, respectively. During post-moulting, the total time spent hauled out declined from 22% in July to 10% in December, which is similar to previous studies in the Arctic (Teilmann et al. 1999, Kelly et al. 2010). In general, Saimaa ringed seals spend less than 20% of their total time hauled out during post-moult (Hyvärinen et al. 1995, Kunnasranta 2001, present study). In our study, the average duration of a haulout event during the open-water season (ca. 6 h, max 26 h) was about twice that measured in Arctic ringed seals during the autumn (ca. 3 h; Teilmann et al. 1999, Born et al. 2002).

During moulting, haulout activity of ringed seals typically peaks in the afternoon (Smith 1973a,b, Finley 1979, Smith & Hammill 1981, Kelly & Quakenbush 1990, Lydersen 1991, Belikov & Boltunov 1998,

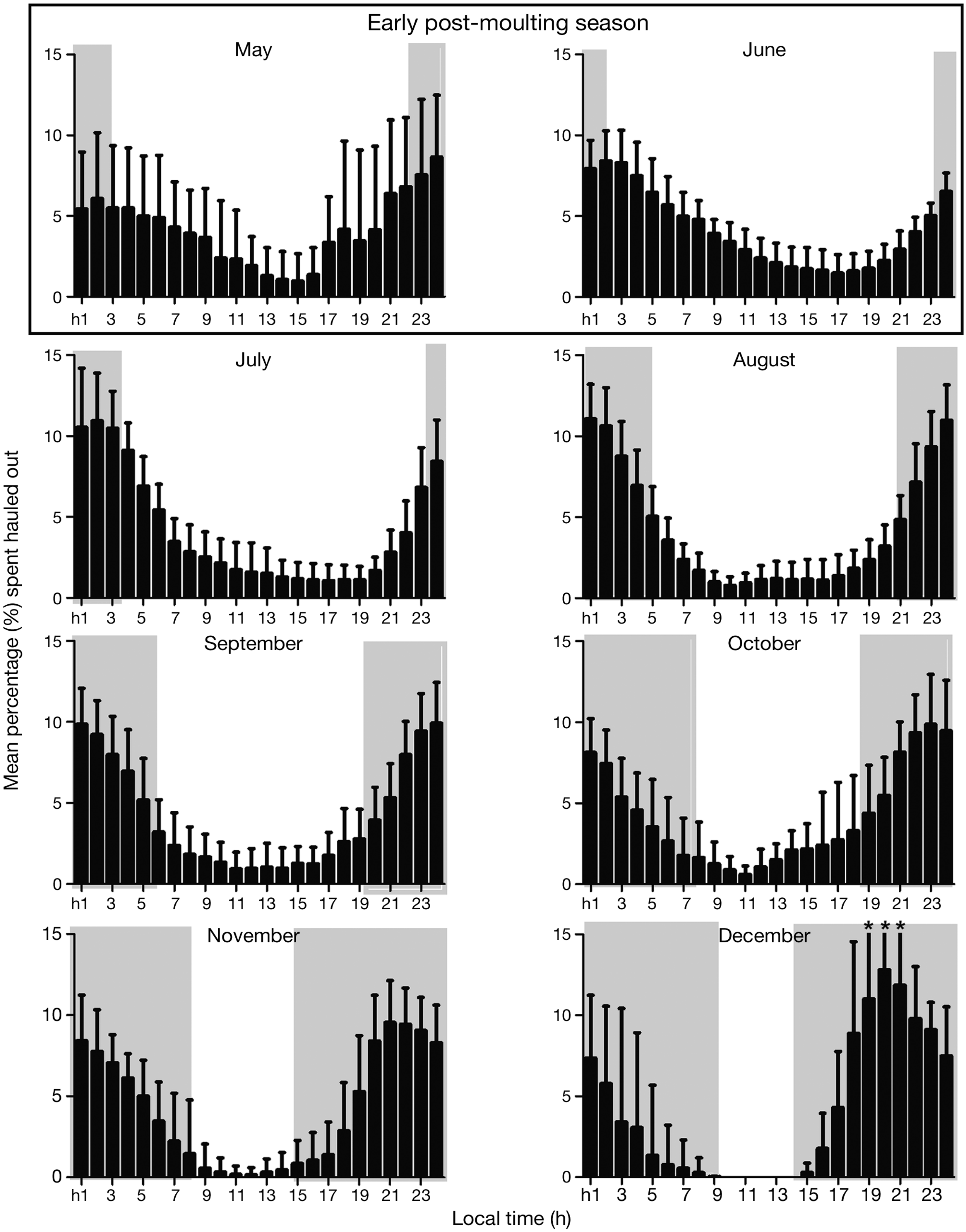


Fig. 4. *Phoca hispida saimensis.* Probability of GPS-tagged seals being hauled out during the open-water season. Bars give the mean percentage of the total haulout time with 95% confidence intervals. Grey areas indicate nocturnal periods. * indicates 95% confidence intervals above the scale (in the range 15.6 to 19.2%)

Carlens et al. 2006, Kelly et al. 2010), but the seals exhibit a nocturnal haulout pattern after the moult (Hyvärinen et al. 1995, Koskela et al. 2002, Kunnasranta et al. 2002, Härkönen et al. 2008), which was supported by the present study. Conversely, ringed seals in Greenland have not shown any circadian rhythm in their haulout behaviour (Heide-Jørgensen et al. 1992, Born et al. 2002). Changes in circadian haulout patterns and the overall preference of phocid seals to haul out may be related to changes in the amount of light, weather, tidal cycle and the seals' stage of moult (Smith 1973a,b, Finley 1979, Smith & Hammill 1981, Allen et al. 1984, Pauli & Terhune 1987a,b, Belikov & Boltunov 1998, Moulton et al. 2002, Sato et al. 2003, Carlens et al. 2006, Agafonova et al. 2007, Andrews-Goff et al. 2010). The timing of seal haulouts may be dependent on prey behaviour and foraging strategies (Sjöberg et al. 1999, Andrews-Goff et al. 2010). In Saimaa, the typical pelagic prey fish, such as smelt *Osmerus eperlanus* and vendace *Coregonus albula* (Kunnasranta et al. 1999), have been shown to disperse at night in surface layers and school near the bottom during daylight (Jurvelius et al. 1988, 2000). Therefore, the vertical distribution of prey species may partly explain the circadian haulout behaviour patterns of the seals. The nocturnal haulout behaviour of the Saimaa ringed seal is also suggested to be an adaptation to avoid human disturbance (Kunnasranta 2001, Kunnasranta et al. 2002).

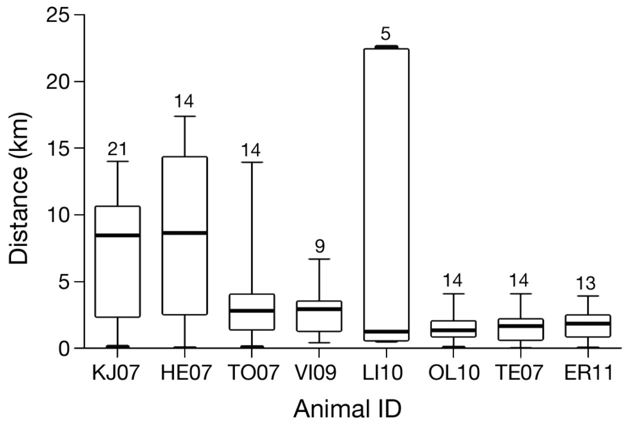


Fig. 6. *Phoca hispida saimensis.* Distances (km) between the different terrestrial haulout sites of individual GPS-tagged seals (n = 8). The number of haulout sites used by each individual is shown above the bars; centre **bold** lines show median values, upper and lower boundaries of boxes indicate the 25 and 75% percentiles, and the whiskers show the minimum and maximum distances

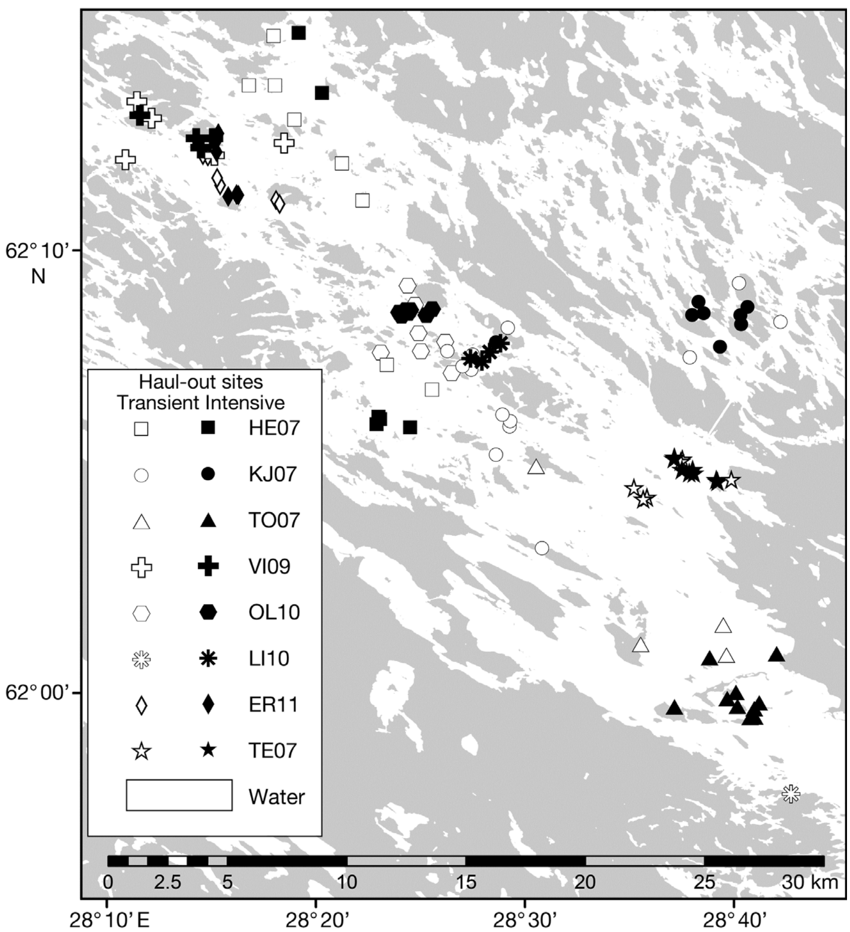


Fig. 5. *Phoca hispida saimensis.* Haulout sites of GPS-tagged Saimaa ringed seals (n = 8). The grey areas are land. Haulout sites of individual seals are marked with unique symbols, with black symbols indicating the intensively used haulout sites

The present study supports previous findings, which have shown that Saimaa ringed seals exhibit a high degree of site fidelity (Kunnasranta 2001, Koskela et al. 2002, Kunnasranta et al. 2002, Valtonen et al. 2012). In the present study, the median distance between haulout sites of individual seals was 2.5 km, with the maximum distances ranging from 4 to 23 km. These are greater distances than Koskela et al. (2002) reported (from 3 to 13 km) for ringed seals in Lake Saimaa. This may be due to the different tracking techniques (VHF versus GPS). GPS technology allows tracking of animal movements in more detail than VHF radiotracking (Cagnacci et al. 2010), and therefore the VHF method may miss significant animal movements (Kochanny et al. 2009). In addition, the number of haulout sites is known to increase with tracking duration (Cunningham et al. 2009). The average number of haulout sites (n = 13) and the proportion of intensively used haulout sites (around 50% of haulout locations) of individual Saimaa ringed seals were the same as those of harbour seals *Phoca vitulina* (on average 13 haulout sites, 52% intensively used of total) tracked with satellite relay data loggers in Scotland (Cunningham et al. 2009).

The average distance between any building and a haulout site was 400 m. However, national parks are characterized by a low number of buildings. Due to the high degree of site fidelity of the seals, legislative protection of terrestrial haulout sites would benefit the Saimaa ringed seal. Although the choice of the exact haulout sites may be affected by the water level in the lake, which can change between years, some characteristics describe the most abundant haulout areas in the present study; the most preferred size of a haulout site island was small, less than 5 ha, and the haulout sites were situated in most cases on the eastern and southern shores of the islands.

There were some obvious limitations of the disturbance study design; given that most seals were not individually marked, the data represented a non-independent set of observations of seal behaviour made at random distances from the seals due to the geography of the study habitat. In the future, the disturbance study could be improved by a different study design, e.g. by collecting data on how the animal was approached in more detail and by setting distances (from boats to observed seals). Nevertheless, the study suggests that the response of moulting ringed seals to boat traffic varies by distance. The median distance at which seals showed no response was 300 m. At a distance of 240 m, over half of the seals approached were 'alert', and at approximately 150 m, the seals typically entered the water. In general, Arctic ringed seals are known to have a high degree of vigilance on their ice platforms, and the response distances to anthropogenic disturbance have been shown to vary from 200 to 5000 m. (Smith & Hammill 1981, Kelly et al. 1988, Born et al. 1999, Blackwell et al. 2004). Terrestrially moulting ringed seals in Lake Saimaa seem to tolerate anthropogenic disturbance at shorter distances than ringed seals in the Arctic hauled out on ice. This behaviour of Saimaa ringed seals could be explained by some degree of habituation to boat traffic and also by a lack of predators. However, the response distances reported here are similar to studies of hauled-out harbour seals on terrestrial sites (Allen et al. 1984, Suryan & Harvey 1999, Henry & Hammill 2001, Johnson & Acevedo-Gutiérrez 2007, Osinga et al. 2012). Some studies (e.g. Andersen et al. 2012), however, have reported greater response distances in harbour seals.

In order to mitigate the unintentional as well as deliberate disturbance caused by boat traffic, our results should be taken into account and guidelines should be developed for tourism. The seals tend to be reluctant to enter the water during the moulting season (Moulton et al. 2002) and they are therefore easily visible to tourists. However, they are vulnerable to disturbance at this time, and entering water may prolong the moult and incur an energetic cost (Paterson et al. 2012). Long-term anthropogenic disturbance, like camping or anchoring, have caused seals to move away from shoreline haulouts permanently (Yochem et al. 1987, Agafonova et al. 2007).

Based on the median distance for no response, 300 m may be considered a 'safe' viewing distance of the Saimaa ringed seal. However, due to the labyrinthine nature of the lake with very narrow paths, this distance may be impossible to enforce. It might be more useful to focus attention on boating practices. The nature of a boat's approach has been shown to affect the response of harbour seals (Allen et al. 1984, Suryan & Harvey 1999, Andersen et al. 2012). Our observations during the present study confirmed that in some cases seals entered the water due to backwash from the boat or to boat operation (stopping and changing direction). Therefore, seal-watching operations should be conducted quietly, at low boat speeds, passing the seals steadily without changing direction or stopping; direct approaches toward seals should be avoided (e.g. Allen et al. 1984; www.nmfs.noaa.gov/pr/education/viewing.htm; www.marinecode.org/documents/Guide-web.pdf). When viewing the seals, attention should also be paid to their behaviour, as we found considerable variation in individual responses. Furthermore, land use allocation (e.g. cottages, camping and anchoring sites) should take into account the location of seal haulout sites in order to mitigate long-term disturbance sources within important haulout areas. The present study has provided valuable information that can be used to devise conservation guidelines for this population of Saimaa ringed seals. However, with increasing interest in eco-tourism and recreational activities in this region, it is imperative that we develop a more comprehensive knowledge of the haulout sites situated throughout the Saimaa ringed seal distribution area (see Niemi et al. 2012), in order to enhance the protection of this Critically Endangered population.

*Acknowledgements.* The present study was supported by the Finnish Ministry of the Environment, the Raija and Ossi Tuuliainen Foundation, WWF Finland and the Finnish Ministry of Agriculture and Forestry. Additional support was provided by Fortum and the Finnish Cultural Foundation, the North Karelia Regional Fund (M.N.). We thank all of our field assistants for their invaluable work, especially T. Laitinen. Thanks also to M. Kurkilahti for statistical advice, K. Kyyrönen for assisting with the figures and E. Oksanen for technical support. We thank the Sea Mammal Research Unit personnel for technical advice. Acknowledgements are due to T. Sipilä and T. Kokkonen from Metsähallitus for their productive cooperation. I. Holopainen, H. Hyvärinen, S. Oksanen and M. Valtonen are acknowledged for the valuable comments on the manuscript and H. Shiels for linguistic revision. This manuscript was greatly improved as a result of comments from 2 anonymous reviewers and the Responsible Editor, P. Stephens. This article is part of the studies recommended by the national conservation strategy and action plan of the Saimaa ringed seal.

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*Editorial responsibility: Philip Stephens, Durham, UK*

*Submitted: April 4, 2013; Accepted: August 23, 2013*
*Proofs received from author(s): November 5, 2013*