New Monitoring method: thermal imaging and use of drone

Action A3: Remote sensing approaches as a novel monitoring tool for ringed seals

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Introduction

Wildlife conservationists and researchers have increasingly turned to new non-invasive technologies while searching for cost-effective methods to study the key life history events and behavior patterns of endangered species. Some of the approaches utilized also in pinniped monitoring include, for example, game camera traps (Actions A3, D1 and D2) and passive acoustic underwater monitoring (Action D2). In addition, thermal imaging and aerial drones have been used for detecting marine mammals and/or measuring their condition in various environments.

Thermal imaging is based on infrared radiation, which is emitted by an object and can be detected by cameras with appropriate sensors. Thermal imaging has been used for a wide range of applications in wildlife surveys, typically of terrestrial mammals. However, during the past few decades, thermal imaging has become more common also in pinniped studies where it has been applied especially in aerial surveys and censuses (Burn et al. 2006, Cunningham et al. 2010, Chernook et al. 2014, Conn et al. 2014, Sigler et al. 2015, Christman et al. 2022). Surveys with pinnipeds have shown infrared technology to be the most suitable at detecting seals against cold/cool substrate, which provide a starker thermal contrast.

Drones are unmanned aerial vehicles (UAVs) that can be remotely controlled, or they fly autonomously using software-controlled flight plans. The use of drones has increased over the past decade with the purpose of improving non-invasive data collection in pinniped monitoring and research (Carroll et al. 2024, Larsen & Johnston 2024). Drones are typically equipped with varied sensors, such as barometric altimeters or high-resolution cameras. Potential benefits of drones include repeat and on-demand monitoring, high-resolution coverage at large extents and morphometric photogrammetry (Larsen & Johnston 2024).

In this Action A3, we piloted two new technologies as noninvasive and potentially cost-effective monitoring tools for Saimaa ringed seals. First, we determined whether the use of thermal imaging cameras would improve detections of Saimaa ringed seals in different seasons or habitats for estimating usage of lairs or finding lair locations, occupancy of artificial lairs (Action D2) and improving detectability of seal individuals (Action A3). Second, we tested the suitability of drones as part of non-invasive health assessment (Action A4) (morphometric photogrammetry) for remote Saimaa ringed seal body mass/condition determining.

Thermal imaging in Saimaa ringed seal monitoring

Field tests with handheld high quality thermal imaging binoculars (Pulsar Accolade LRF XP50) were carried out in the Haukivesi basin of Lake Saimaa, during both ice covered and open water seasons, as part of other monitoring activities. We used the high-definition color sensor of the binoculars to detect thermal sources with red, orange, and yellow colour indicating warmer temperatures.

We did not detect any seals or seal-made structures (lairs, breathing holes) using thermal imaging binoculars during the subnivean season in winter. In addition, in tests with artificial lairs, we did not detect any seal occupancy of lair boxes, however, a 'false thermal image', caused by temperature variation between inside and outside of the nest box, was detected (see Fig 1).

Figure 1. *A 'false thermal image' of an artificial nest box on 3rd of March 2024. Orange color indicated a heat source seemingly emitted, for example, by a seal, but lair censuses and camera traps inside lair cavity (Action D2) showed that structure had not been used by seals during the entire season and therefore thermal source was related to the temperature difference between the nest box and the environment.*

Figure 2. *A Saimaa ringed seal with wet hair hauled out on rock on 2nd of October 2020 in Haukivesi basin of Lake Saimaa.*

During the open water season, seals that were hauled-out on rocks were the easiest to detect when temperature difference between the animal and surrounding environment was the largest. This is typical during nighttime, when the surface temperature of the seal is significantly warmer than that of the environment, or when temperature difference is caused by wet hair (Figure 2). During the daytime in summer, the surface temperature of objects in the environment (rocks, trees) and seals are typically quite similar, which makes detecting seals from thermal images difficult (Figure 3).

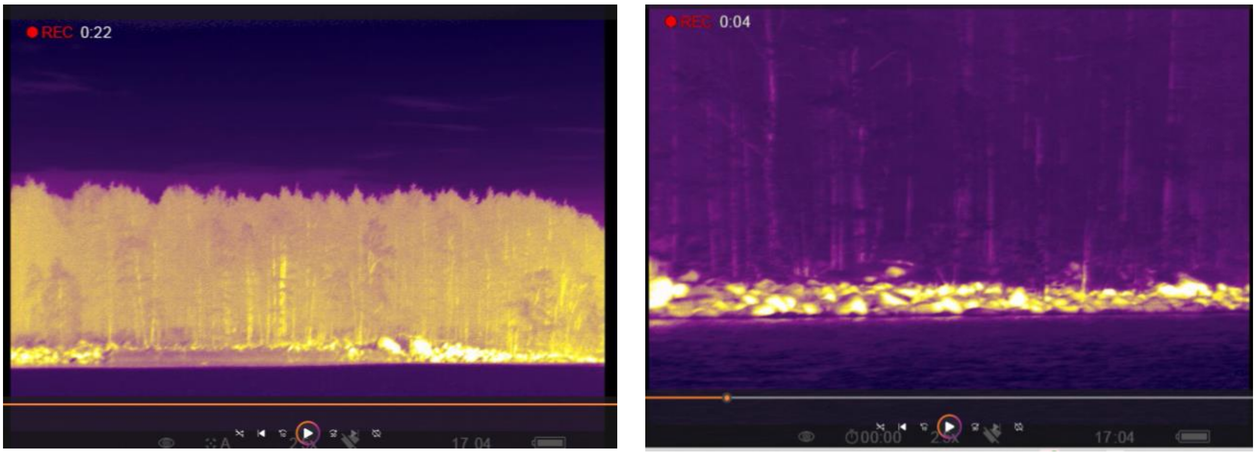

Figure 3. *Thermal images of haul out locations of Saimaa ringed seals during a sunny day in Haukivesi basin. Surfaces warmer than the surrounding environment can be seen illuminated in lighter colors against a darker, cooler backdrop.*

Poor results on seal occupancy obtained by thermal imaging during winter season can mainly be explained by the good insulation property of snow. In normal snow conditions, there is not enough heat loss from subnivean lair structures that could be detected by thermal cameras. In addition, small sample size taken from an elusive small population may explain the low detection ability. In general, it seems that thermal imaging does not provide cost-effective new data during the subnivean period. However, during mild winters thermal cameras may help detecting, for example, pups on open ice, as warm bodies against cold ice provide a stronger thermal contrast in images.

Thermal cameras can be used for spotting Saimaa ringed seals during the open water season, when they are in general more visible. However, it is likely that the same results can be achieved with ordinary binoculars. Best results can be obtained during seasons when temperature contrast between the animal and its surrounding environment is the largest, for example during nighttime.

Use of drones in Saimaa ringed seal monitoring

To test the applicability of an unmanned aerial vehicle (UAV) for aerial photogrammetry of free ranging seals, calibration tests were done with captive seals in zoo whose morphometric measurements were known. As there are no ringed seals, or seals in similar size, kept in captivity in Finland, the calibration tests were conducted during a research visit to the Fjord&Bælt aquarium in Denmark in April 2023. During the visit, four harbour seals were photographed using a DJI Mini 3 Pro drone, equipped with 3-axis gimbal and a 48MP camera, during seal training sessions. The seals at the aquarium are used to handling and they are measured every month for their length, weight and body girth. The UAV was flown at an altitude of about 15 m above ground, and 30-40 photos were taken while circling around the seal (with approximately 3-5 m radius from the seal, see Fig. 4) and from directly above the seal. A measuring tape was laid next to the animal as a scale while the photos were taken. The photos collected at Fjord&Bælt will be used for the verification/calibration of the photogrammetry method by comparison of morphometric distances estimated from photos to morphometric measurements taken manually from the same animals. Preliminary 3D-models (Fig. 5) have been built of the photographed seals using PhotoModeler Premium software from which the body girth (and volume) can be estimated and compared to manual measurements; however, this analysis is still ongoing. All drone flights were done by a registered pilot according to EU Regulation 2019/947 and 2019/945.

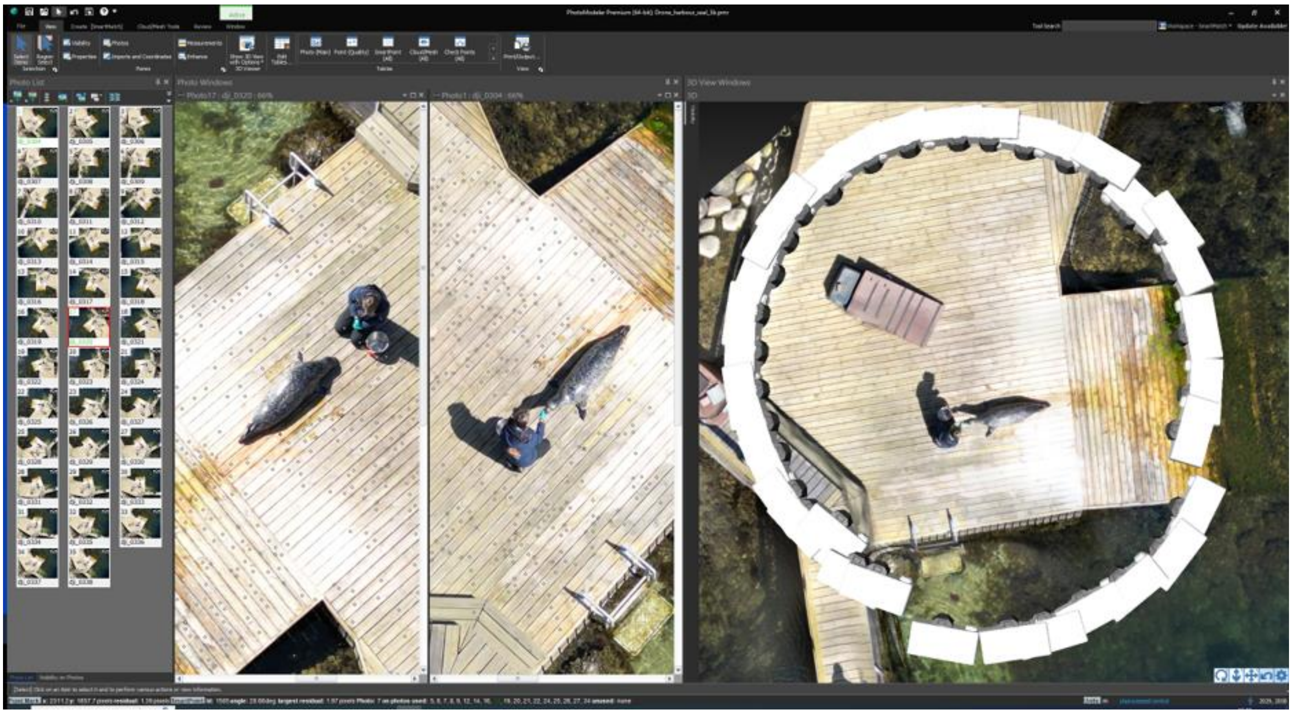

Figure 4. *A set of photographs taken with the UAV and processed using PhotoModeler Premium software. White boxes in the far-right image denote 3D-locations of the cameras at the time when images were captured.*

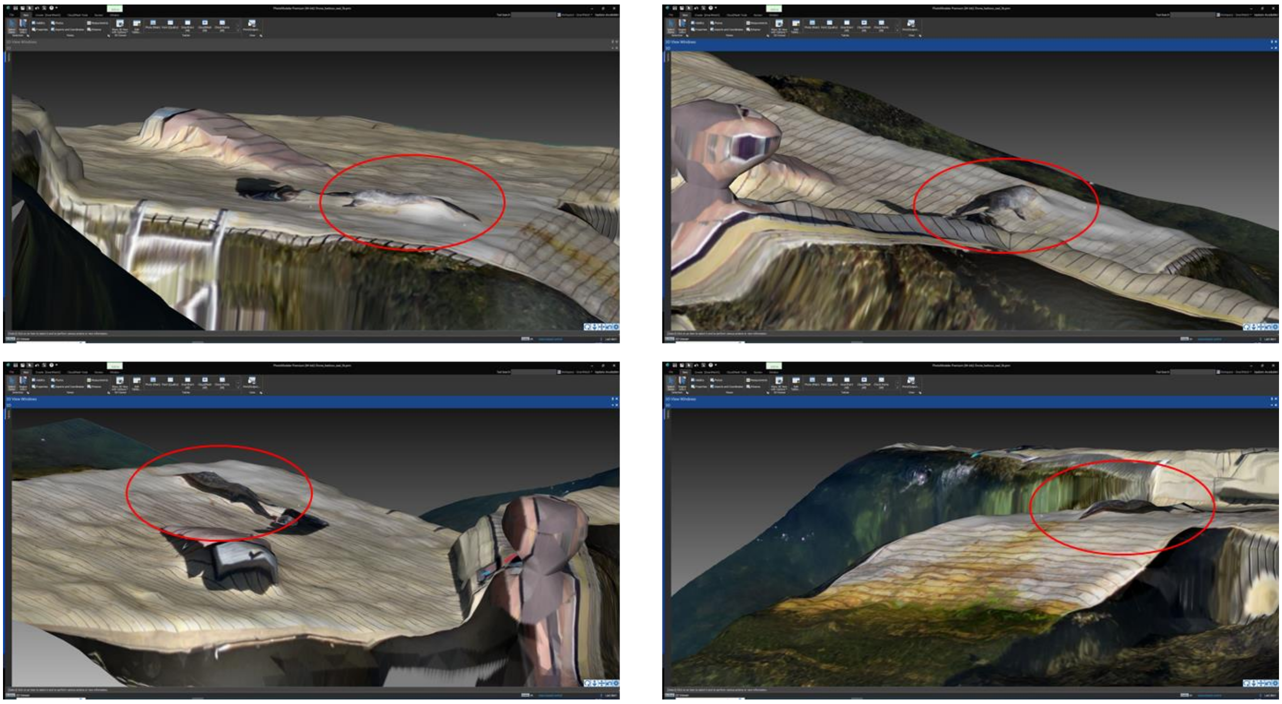

Figure 5. *Preliminary 3D-models of a harbour seal, created from 2D images taken with a drone camera using PhotoModeler Premium software.*

Preliminary results from captive harbour seals indicate that drone photogrammetry has the potential to be used also in non-invasive body condition estimation of the free ranging Saimaa ringed seal, as photographs can be taken instantaneously from different angles to the seal. In Lake Saimaa, game camera traps (Action A3) have been used for photogrammetry purposes so far, but also these results are still preliminary. However, unlike game cameras, UAVs offer the possibility to photograph the seal directly from above. This is extremely useful as the photogrammetric width of the animal can be estimated because the altitude of the drone is recorded. This photogrammetric width estimate can be then used together with the photogrammetric height to calculate the maximum girth of the animal (girth measured at the widest part of the seal, just under the fore flippers), using the formula of an ellipse. Maximum girth can then be used as an index of body condition as it correlates significantly ($R^2 = 0.628$, $p < 0.001$) with the thickness of the abdominal blubber, which, in turn, is considered a core indicator of nutritional status of marine mammals by HELCOM (HELCOM, 2018).

In addition to the health monitoring pilot project, UAVs can be used to collect images and videos from Lake Saimaa and used for communicational purposes.

Future perspectives and continuity

Our pilot tests demonstrate that current thermal imaging technology cannot improve monitoring of Saimaa ringed seals. In addition, they provide reliable detection data only under specific circumstances. Therefore, current techniques in thermal imaging do not provide a more reliable and cost-effective monitoring tool for population monitoring, when compared to current methods.

Drone photogrammetry, on the other hand, has the potential to be used in non-invasive body condition estimation of the Saimaa ringed seal, as photographs can be taken instantaneously from different angles to the animal and potentially used to create a 3D model of the seal. In addition, maximum girth, calculated based on photogrammetric measurements of height and width of the seal using the formula of an ellipse, can be used as an index of blubber thickness and ultimately the body condition of the seals.

Despite on these relatively modest results of our pilot study, on-going advances in sensor technology, combined with other novel technologies such as deep learning), may provide new approaches in the future that complement, or even replace, current monitoring methods.

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