Piloting novel monitoring methods for Baltic ringed seals in the Archipelago Sea

TURKU AMK
TURKU UNIVERSITY OF APPLIED SCIENCES

Luke
LUONNONVARAKESKUS

Action: A3.2 Photo-ID and aerial censuses in the Archipelago Sea

Deliverable A3.2: Report on photo-ID and aerial censuses in the Archipelago Sea

Project acronym:	Our Saimaa Seal LIFE
Project full title:	Working together to save the Saimaa Ringed Seal in changing environment.
Grant / Contract No.:	LIFE19/NAT/FI/000832
Instrument:	Financial Instrument for the Environment and Climate action (LIFE)
Duration:	5 Years
Project start date:	01 / 09/2020
Project expected end date:	31 / 12 / 2025
Date of this document:	01 / 02 / 2024
Produced by:	Jussi Laaksonlaita, Olli Loisa, Juha Niemi, Nanni Piiparinen (TUAS) & Mervi Kunnasranta (LUKE)
Name of the beneficiaries:	Turku University of Applied Sciences (TUAS) Natural Resources Institute Finland (LUKE)
Submitted:	02 / 02 / 2024

Contents

Abstract

The subpopulation of the Baltic ringed seal (Pusa hispida botnica) living in the Archipelago Sea, SW Finland is small and spread out within a large geographic area. Currently, the population is estimated at ca. 200-300 individuals. Climate change is considered as a major threat for the southern populations of ringed seal in the Baltic Sea. Nowadays the outer parts of the Archipelago Sea are free of ice in most winters, and in the future ice cover is expected to become more and more seldom. This may have severe effects to the reproduction for a species dependent on ice and snow for its breeding.

The ongoing Our Saimaa Seal LIFE -project pilots novel monitoring methods suitable for ice-free conditions and develops concrete conservation measures, such as artificial nests, that could improve breeding success of the species under changing environment. This report summarizes the progress and preliminary findings of subaction A3.2, “Photo-ID and aerial censuses in the Archipelago Sea”.

In 2021-2023, extensive boat-based surveys were conducted in the Archipelago Sea, combined with aerial transect line census by airplane (2021), and observation type aerial counts carried out with a helicopter (2022 and 2023). Photo identification (photo ID) has been tested and developed during the project. The established photo-ID catalogue will serve as basis for further photo-ID studies and may be utilized for population estimate in the future.

Due to sensitive nature of the sites and to avoid disturbance to the animals, the exact locations of the seals encountered during the surveys are not presented in this report. The detailed information is provided to the authorities for conservation and management purposes.

The project has received funding from the LIFE Programme of the European Union. The material reflects the views by the authors, and the European Commission or the CINEA is not responsible for any use that may be made of the information it contains.

Hanke on saanut rahoitusta Euroopan unionin LIFE-ohjelmasta. Aineiston sisältö heijastelee sen tekijöiden näkemyksiä, eikä Euroopan komissio tai CINEA ole vastuussa aineiston sisältämien tietojen käytöstä.

1. Introduction

The subpopulation of the Baltic ringed seal (*Pusa hispida botnica*) in the Archipelago Sea, SW Finland (see Fig. 2) is small and spread out within a large geographic area. Currently, the population is estimated at ca. 200-300 individuals (Nordström et al. 2011; Halkka & Tolvanen 2017). At the end of the 1800s' and early 1900s' the Archipelago Sea was still one of the significant areas for the species in Finland and ringed seals were abundant (Bergman 1958). However, overhunting and consecutive mild winters resulted the collapse of the population in 1930s (Bergman 1958; Stenman et al. 2008). In the early 21st century, WWF Finland raised a concern of the state of the Archipelago Sea ringed seal population, resulting inventories carried out between 2002 and 2011 (Nordström et al. 2011). The current population estimate is based on the results of these surveys.

Climate change is considered as a major threat for the southern populations of ringed seal in the Baltic Sea. Nowadays the outer parts of the Archipelago Sea are free of ice in most winters, and in the future ice cover is expected to become more and more seldom. This may have severe effects to the reproduction for a species dependent on ice and snow for its breeding. The ongoing Our Saimaa Seal LIFE project pilots novel monitoring methods suitable for ice-free conditions and develops concrete conservation measures, such as artificial nests that could improve breeding success of the species under changing environment.

In the subaction A3.2, "Photo-ID and aerial censuses in the Archipelago Sea", we develop novel monitoring methods suitable for ringed seals in the Archipelago Sea including the Province of Åland area. TUAS is responsible for the boat surveys and photo-ID, LUKE for the aerial censuses, and WWF Finland for the live web camera (in action E4). The subaction will also provide information for the purposes of actions A6 and C2 and will possibly gain new knowledge on the extent of nasal discharge, observed in the Archipelago Sea population in last decades (link to action A4). Camera traps will be later utilized for monitoring human caused disturbance and predation (action D2). The results will be used in action A6 to identify suitable new protected areas for the species in the Province of Åland area.

2. Boat-based surveys gained knowledge on the distribution of the rare ringed seals of the Archipelago Sea

Due to climate change, the seasonal ice cover period has shortened drastically, and in many years the outer parts of the Archipelago Sea are entirely or partly free of ice. Thus, the ringed seals are

rarely able to use the sea ice as a platform for breeding and moulting, and therefore the traditional census method based on transect line aerial counts of ice-covered areas, can be considered not applicable, since most likely at least proportion of individuals haul-out on land due to deficient ice-cover (Nordström et al. 2011; Halkka & Tolvanen 2017). Earlier studies have shown that in ice-free conditions boat surveys are a practical method to survey the occurrence of the ringed seals (Miettinen et al. 2005; Nordström et al. 2011; Halkka & Tolvanen 2017).

During 2002-2011, WWF Finland carried out surveys in the Archipelago Sea in cooperation with the Game and Fisheries Research Institute (since 2015 Natural Resources Institute Finland – LUKE), and Metsähallitus Parks & Wildlife, Finland (Miettinen et al. 2005; Nordström et al. 2011; Halkka & Tolvanen 2017). The surveys combined aerial censuses and counts by using a hovercraft in ice-covered conditions and boat-based surveys if the outer parts of the archipelago were free of ice during the haul-out period. The results of the surveys showed that the distribution of the Archipelago Sea subpopulation seems to be concentrated in the eastern parts of Archipelago Sea, which have the highest likelihood of ice formation. The current population estimate, 200-300 individuals, is based on these surveys. Ahola & Nordström (in Halkka & Tolvanen 2017b) stated that that due to the issues in observability, the aerial surveys may fail to detect a significant proportion of seals. Moreover, due to relatively small number of seals sighted in some years, and because of the lack of long-term monitoring data, trends in Archipelago Sea subpopulation cannot be detected.

The surveys conducted by WWF Finland were the first extensive effort to investigate the distribution, breeding success and population size of the Archipelago Sea subpopulation (Nordström et al. 2011). However, the surveys mainly covered the areas within the joint cooperation area for the Archipelago National Park, and especially areas belonging to the Province of Åland were inadequately surveyed (Nordström et al. 2011; Halkka & Tolvanen 2017). Nevertheless, the knowledge and experiences gained during these past surveys, provided a useful base for the implementation of the subaction A3.2.

2.1 Boat-based surveys in the Archipelago Sea

To successfully collect photo-ID data, it was necessary to get more up-to-date information on the distribution of ringed seals and detailed knowledge on the areas, which they favour during the moulting season. It was decided to conduct extensive boat-based surveys that covered the whole area of the Archipelago Sea and parts of Province of Åland. Based on the previous knowledge, in the Province of Åland the distribution of ringed seals is focused on the eastern archipelago (Nordström et al. 2011; Halkka & Tolvanen 2017), although ringed seals are seen rarely also

elsewhere. Boat-based surveys were carried out during April-May in 2021-2023, but occasional sightings have been recorded also in the other seasons.

The behaviour and locations of the animals during the haul-out season is affected by weather conditions. The ringed seals mostly haul out on wind sheltered shoals and treeless islets and prefer calm and sunny weather conditions. The weather conditions may also affect the number of seals hauling out, and in order to get more reliable data on the occurrence, surveys should be done in good weather conditions (Nordström et al. 2011). Based on the earlier experiences, the ringed seals can be best observed in the afternoon and evening in calm conditions (Miettinen et al. 2005).

In the core areas, tens of ringed seals may gather to haul out on rocky islets and their vicinity, but in the other parts of the archipelago, seals are often seen singly or in small groups (Miettinen et al. 2005; Nordström et al. 2011). In the surveys conducted in 2021-2023, on average of 3,2 seals were seen per sighting (Fig. 1). The number is close to similar than reported in previous surveys done in the Archipelago Sea (Miettinen et al. 2005; Nordström et al. 2011).

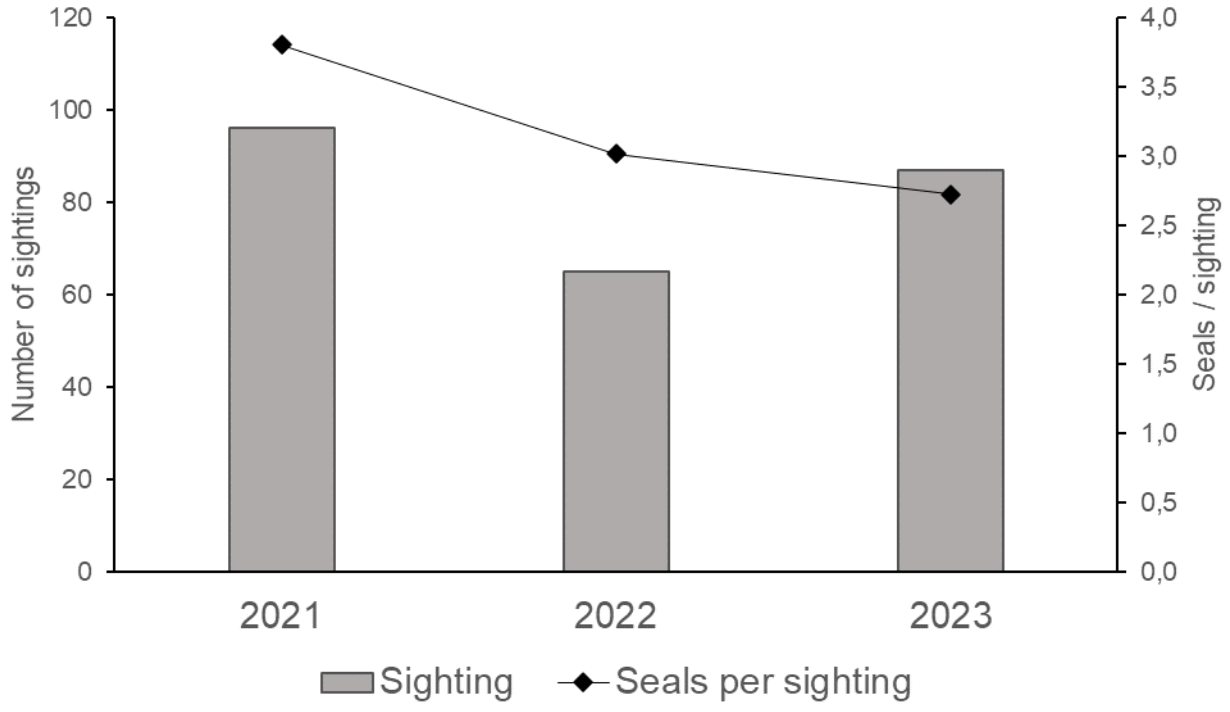

Figure 1. *In the years 2021-2023, 65-96 sightings were made during the boat surveys in April-May, with an average of 3,2 seals per sighting. The results are similar than in studies done in the past (Nordström et al. 2011; Miettinen et al. 2005)*

Effort and focus of boat-based surveys has varied between the years. The surveys conducted in past three moulting seasons have covered most parts of the Archipelago Sea (Fig. 2). The number

of survey days was 19-20 per year (Table 1). In 2022, more attention was given to remote areas and surveys were done with multiple boats, which resulted in larger survey kilometre effort (Table 1).

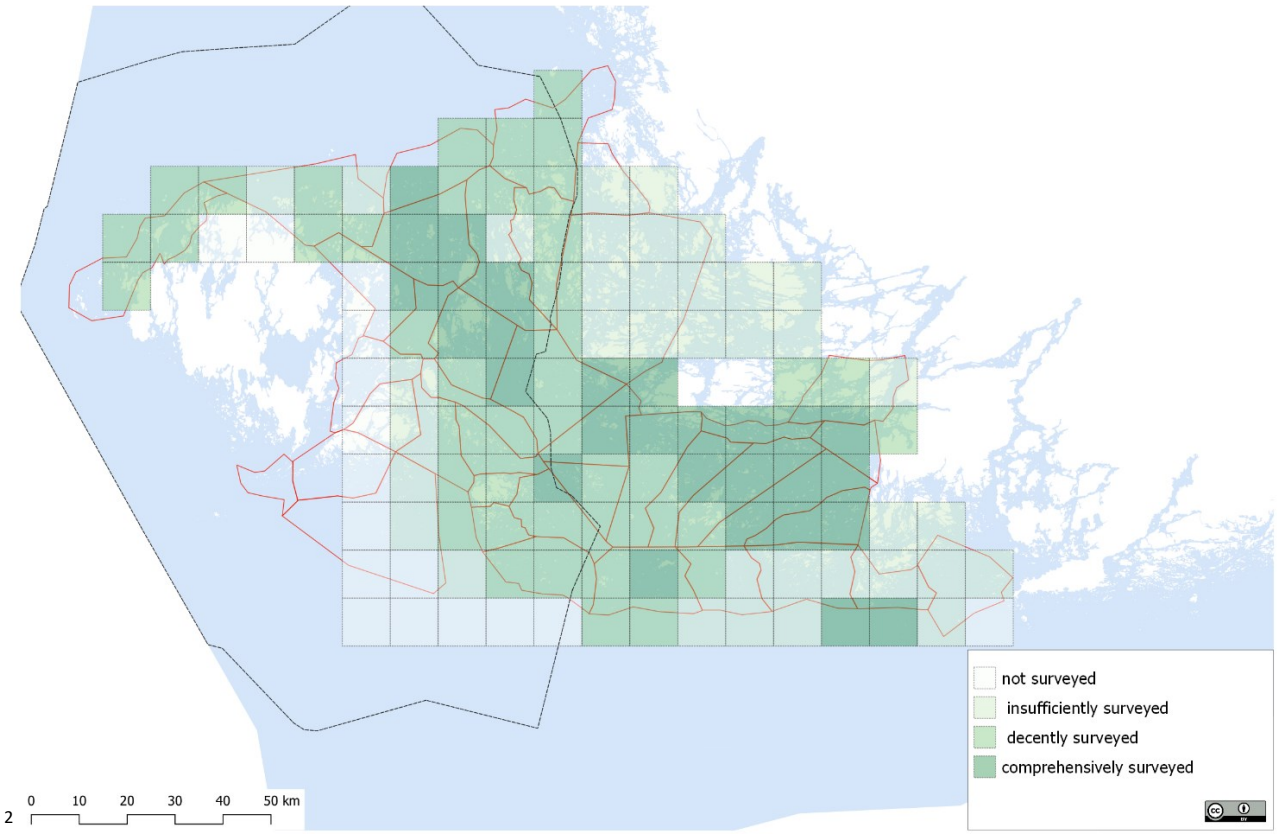

***Figure 2**. In the action A3.2 and A.6, extensive boat-based surveys were carried out in the Archipelago Sea during the moulting seasons in 2021-2023, alongside with collection of the photo-ID data. The map shows estimated survey effort per grid size of 10 × 10km. The red segments illustrate the areal division used in the surveys in 2022. Grey line illustrates the boundaries of Province of Åland. Estimation of effort includes coverage and precision of surveys and number of visits.*

In 2021, surveys were conducted mainly by one boat and most of the observation was done in the parts of the archipelago which ringed seals are known to prefer during their haul-out season (Nordström et al. 2011; Högmander pers. comm.). In the core area, tens of seals gather to a limited area of archipelago, and several survey visits to this area increased the total count and the average group size (Fig. 1, Table 1). Also, the total number of seal encounters was the highest in 2021 (Table 1). Most survey effort was given to the known core area, in order to identify suitable sites for the collection of photo-ID data. Based on the timing and distances of the sightings in 2021, approximately 110 individual ringed seals were seen.

Table 1. *Number of seals encountered, sighting occasions and survey effort (days and kilometres covered during the boat surveys in springs 2021-2023). It needs to be noted that some seal encounters most likely include multiple sightings of same individual seals. Boat kilometres consists of distance covered by all the boats used during the project. In 2022, all survey routes were logged, distances for the 2021 and 2023 are estimates.*

	2021	**2022**	**2023**
Ringed seals encountered	365	196	237
Sighting occasions	96	65	87
Survey effort days	19	19	20
Survey effort kilometers	≈ 2000	4118	≈ 3000

In 2022, it was decided to carry out more extensive survey using several boats simultaneously and covering large areas systematically. The aim of this approach was to survey extensive areas thoroughly and simultaneously in good conditions and get more precise information on the distribution and abundance of the seals in the project area. The project area (the Archipelago Sea and the Åland archipelago) were divided into segments (see Fig. 2) which were surveyed with one or several boats depending on their extent and geography, and weather conditions at the time. For each segment, date and time, weather conditions and estimate of the survey effort was recorded. This approach also enabled to survey areas that has been surveyed only superficially or not at all in the past. However, the challenging wind conditions slightly hampered the implementation and the timing of the surveys, and some areas were only surveyed insufficiently or in bad conditions. At a conservative estimate, at minimum 64 individuals were seen in 2022.

In 2023, the focus of the surveys was mostly in the areas of the Province of Åland (for action A.6) and the other areas that were only superficially surveyed in the earlier years. These complementary surveys improved the knowledge on the occurrence of ringed seals outside the known core areas. In 2023, at minimum ca. 62 individual seals were sighted during the boat-based surveys.

2.2 Conclusions

The past three years of boat-based surveys has provided new and more detailed information on the occurrence of the ringed seals in the Archipelago Sea (Fig 3). This information is essential for planning and implementing the conservation measures in the later phase of the project. Even though carrying out boat surveys is prone to weather conditions and logistical factors, the past years have shown that it is a functional way to search for sites used by the seals and collect images of individuals for photo-ID studies.

Compared to the earlier surveys, there is possible changes in the occurrence. Some areas that were identified important for the seals previously (Nordström et al. 2011), e.g. in some southern parts of the Archipelago Sea, seem to be less used by the seals nowadays during the moulting

season. Boat-based surveys have revealed that especially in the northeastern Åland, ringed seals seem to be more abundant than estimated by Nordström et al. (2011) and Miettinen et al. (2005). However, it needs to be noted that the previous surveys were not as extensive. The conducted surveys support the findings of earlier studies that during the moulting season seals seem show high site-fidelity, favour certain islets within relatively limited areas, and may gather to big groups up to over 30 individuals. This highlights the need of effective and adequate conservation measures in the core areas, since based on the current population estimate, significant part of subpopulation gathers to these sites.

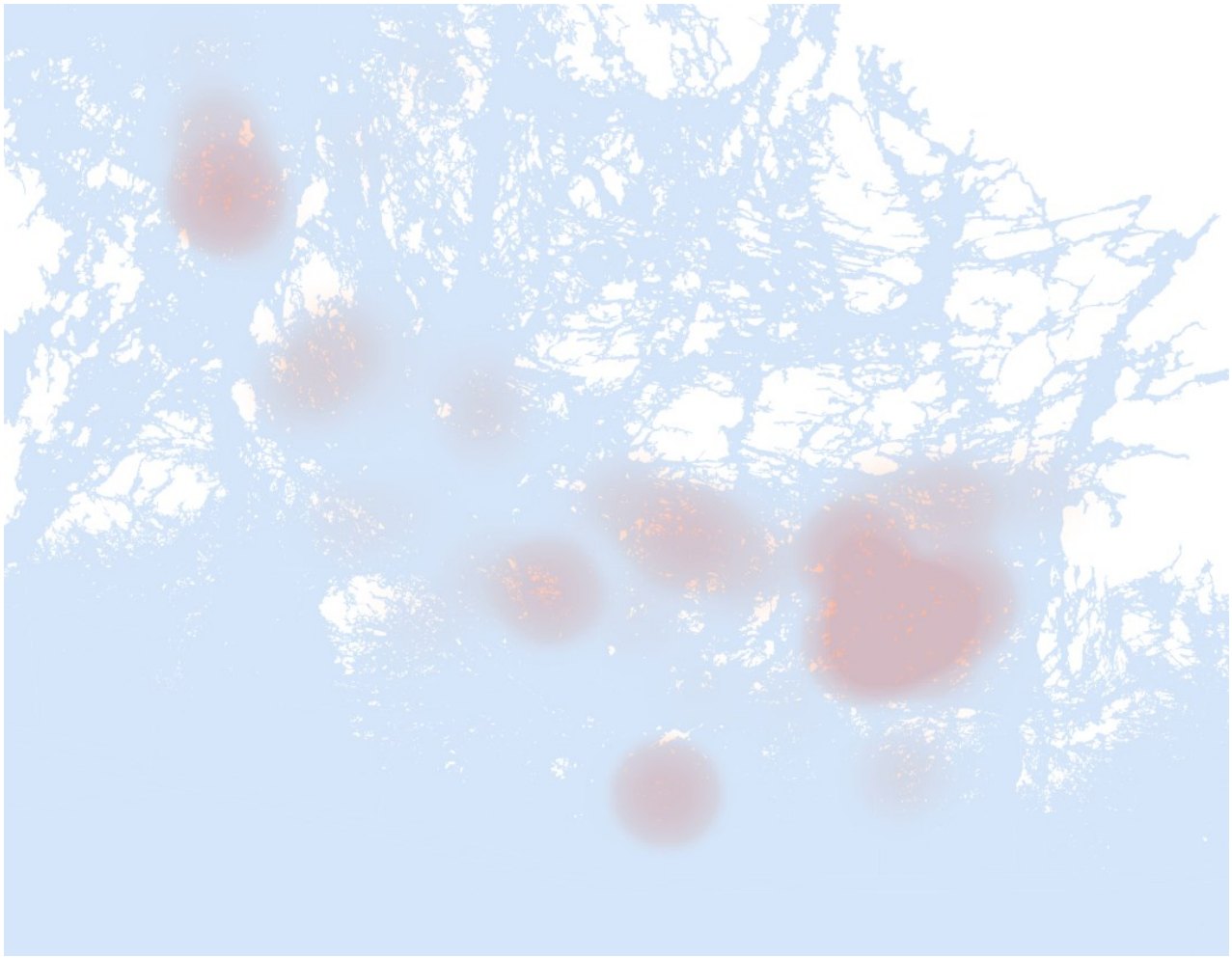

***Figure 3**. Haul-out distribution of ringed seals in the Archipelago Sea based on the sightings made during the boat-based surveys in springs 2021-2023. Colour intensity of the heat map depends on the number of encountered seals. In general, seals seem to favour areas with low level of anthropogenic activities.*

Boat-based surveys alone do not allow absolute abundance estimates, but it may be applicable method, accompanied with aerial surveys, to estimate abundance and distribution, and monitor population trends of the Archipelago Sea subpopulation. Based on the sightings, their timing and distances, minimum number of individual animals seen varied from 62 (2023) to 110 (2021). These

are only conservative estimates based on actual sightings, and most likely the absolute numbers are higher. The total number of seal sightings per season were higher than in previous boat-based surveys in 2002-2005 and 2015-2016 (Nordström 2011; Halkka & Tolvanen 2017). This most likely result from higher survey effort and more visits to the core area. At this stage, more precise estimate cannot be provided, or major changes detected in the subpopulation size. However, it is essential to continue to monitor the state of the subpopulation, as the ice-free winters get more common, which most probably threatens the reproduction. Also, to get more precise estimates of abundance, novel monitoring tools, such as photo-ID studies, need to be further developed.

3. Aerial censuses in the Archipelago Sea – impossible in the future, or is it?

Typically, ringed seal population estimates are based on censuses on moulting seals. During the other time of year, seals spend most of their total time submerged, but when moulting, they are out of water and visible. Therefore, basking seals on the surface of the ice during the moult provides the best opportunity to count how many ringed seals occur in the specific area. These censuses cover individuals over one year old, when pups shed their lanugo hair typically already in the snow lair. Estimation of the size of ringed seal populations has been conducted using a variety of methods, but aerial surveys are the leading approach in varied ringed seal locations globally (e.g. Helle 1980, Härkönen & Heide-Jørgensen 1990, Frost et al. 2004, Trukhanova et al. 2013).

Aerial censuses by fixed wing airplanes have been carried out also in the Archipelago Sea during the early stage of the ringed seal moulting in April during the years, when there has been some kind of sea ice cover (Halkka & Tolvanen 2017). However, mild winters with low population density in fragmented archipelago habitat have hampered reliability of this transect line census method, which is more suitable for open sea ice field conditions. Especially, during the last decade, ice-free conditions during the main moulting period in April have not enabled traditional census methods anymore in the Archipelago Sea. In addition, Photo-ID studies carried out in this action, have indicated that moulting of the Baltic ringed seals may happen also on the terrestrial platform and peak later in the season in May. Therefore, more accurate census methods, which could cope with mild winter induced challenges in censuses, are needed. The main aim of this action has been to develop census tools for gaining more reliable estimate on numbers and distribution of rare ringed seals of the Archipelago Sea.

3.1 Aerial censuses in practice

During the Our Saimaa Seal LIFE –project, aerial censuses on Baltic ringed seals of the Archipelago Sea have been carried out in early springs 2021, 2022 and 2023.

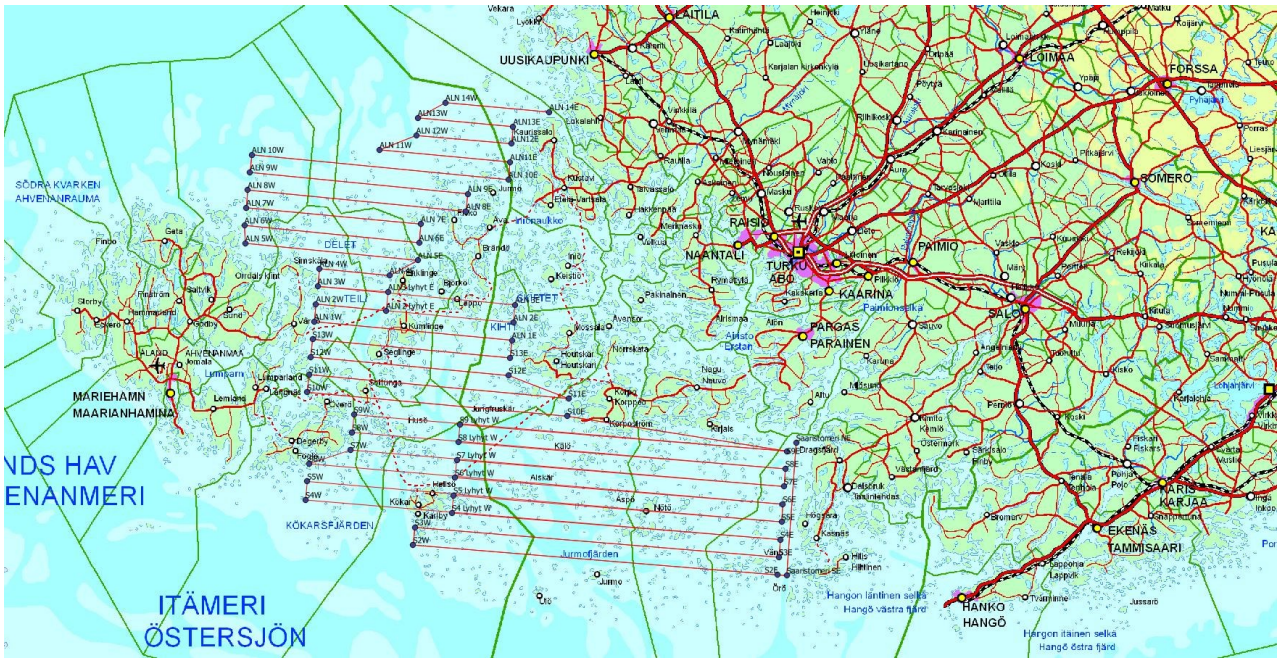

Figure 4. *Study area map of the Archipelago Sea showing beforehand planned transect lines for ringed seals aerial censuses.*

In 2021, the surveys were done by fixed wing single motor airplane (Cessna 170) during the early stage of the moulting season in late March and early April. The modified line-transect census of ringed seals basking on ice were used: seals seen from the strips (strip width space around 2 nautical miles, Fig. 4) were counted and photographed (Fig. 5), if possible. Censuses were carried out in the known core ringed seal distribution areas of the Archipelago Sea, and some conjunction sea regions of the Gulf of Finland. However, relatively weak ice conditions and early ice break up due to mild winter did not enable full-scale censuses. Therefore, censuses provided low numbers of ringed seals due to suddenly changed ice conditions.

Figure 5*. Baltic ringed seal hauling-out on the sea ice in April.*

The Baltic Sea ice seasons were mild in both winters 2021-2022 and 2022–2023. In springs 2022 and 2023 there was no sea ice in the Archipelago Sea during the main ringed seal moulting season in April. However, results of the photo-ID and boat-based surveys have indicated that ringed seals continue moulting on rocks later in season, if there are no sea ice available, and therefore aerial censuses were carried out in mid-May.

Figure 6. *Two Baltic ringed seals hauling-out on rocks in May.*

In 2022, ringed seal censuses were done very first time using a single-engine helicopter (Robinson R44), which has better visibility for observers and more agile movements compared to fixed wing planes. Also in spring 2023, the same helicopter approach was used. During the both springs, surveys were carried out in the main regions of the Archipelago Sea (including Åland waters) and focused on those haul-outs, which were discovered by boat surveys or were otherwise known to be used by ringed seals based on previous knowledge. The helicopter censuses did not follow a line-transect design, but field protocols followed survey type observations. Ringed seals hauling out on rocks were counted and photographed (Fig 6), if possible. Numbers of seals counted in aerial surveys were lower compared to numbers counted during the boat surveys. The main study area could be covered in a one aerial survey day (around 5 flight hours) and enables fast way to discover also new regions. In addition, high quality images may also be utilized in Photo-ID studies (Fig 7). However, noise from the helicopter may have disturbance effect for hauling-out ringed seals. Earlier study (Born et al. 1999) on the Artic ringed seals (P.h. hispida) indicated that the risk of scaring ringed seals into the water can be reduced if helicopters do not approach them closer than about 1500 m, and small fixed-winged aircraft not closer than about 500 m. More studies are needed for estimating how aircraft disturbance can be mitigated in surveys in the Archipelago Sea.

***Figure 7**. Close-up on aerial ringed seal image, which enables fur pattern identification for photo-ID purposes.*

3.2 Conclusions

Counting ringed seals of the Archipelago Sea from rocks in mid/late moulting season in May enables systematic time window for population monitoring, which is not depending on hampered sea ice conditions. In addition, the flexibility and manoeuvrability of small helicopters make them a novel tool to estimate ringed seal abundance and distribution, especially in combination with boat surveys. During the years, when logistically demanding boat survey efforts may not be possible to carry out due to weather conditions or other factors, a one-day flight effort in good weather can give baseline on local ringed seal population status. Images collected during censuses may be utilized for Photo-ID purposes. However, potential aircraft disturbance effect on ringed seals and therefore to results of census must be kept in mind.

4. Piloting the photo-ID procedures in the archipelago conditions

Photo identification (photo-ID) is commonly used tool to study wildlife animal populations and has been used long for studies of marine mammals (e.g. Wursig & Jefferson 1990; Felix et al. 2011; Kuningas et al. 2014; Maglietta et al. 2022). Individuals are identified, and later controlled from captured images which enables e.g. studying of survival, dispersal and site fidelity and population size by using the mark-recapture technique. Photo-ID provides alternative to more invasive methods such as tagging and GPS-tracking. Recently, the use of photo-ID methods has become more common for studies of pinniped populations (e.g. Hiby et al. 2007; Cunningham 2009; Cordes & Thompson 2015)

The ringed seals have a distinctive permanent pelage pattern which enables identification of individuals. Photo-ID has been used for the Saimaa ringed seal (*Pusa hispida saimensis*) for several years and the study is the most extensive photo-ID study conducted for pinnipeds. Furthermore, mark-recapture studies based on photo-ID data has proven to be potential way to estimate population size of ringed seals in Lake Saimaa. (Koivuniemi ym. 2016; Koivuniemi 2019)

In the action A3.2, photo-ID techniques utilized for the Saimaa ringed seal are piloted in the Archipelago Sea. Before the project, some photo-ID data of the Baltic ringed seals has been gathered mostly by voluntary work. The camera trapping has been tested on two sites in the Archipelago Sea with good results. From photo-ID data gathered in the years 2006-2008 and 2014-2018, the researchers of University of Eastern Finland (UEF) have been able to identify 56 individuals. This photo-ID data gathered in the past served as a basis of establishment of photo-ID catalogue in the ongoing project.

4.1 Camera trapping

The Saimaa ringed seal has high site fidelity, and camera trapping has proven to be effective and non-invasive monitoring method for the species (Koivuniemi et al. 2016). In the Lake Saimaa, camera traps are mostly used during the moulting season in spring to collect the photo-ID material. In addition to camera trapping, the individuals are photographed with DLRS cameras during boat-based surveys in Saimaa (Koivuniemi et al. 2016; Koivuniemi et al. 2019).

In the Archipelago Sea, the ringed seals live within large geographic area with high number of possible haul-out sites which could be assumed to result lower site fidelity. However, experiences gained during the project and previous studies (Nordström et al. 2011) have proven that the Baltic ringed seals seem to favour same haul-out sites year after year and show site-fidelity also in the individual level (Heiskanen 2022), even though there is high number of suitable haul-out sites available. Yet, the use of specific shoals and rocks for hauling out is affected by water level variation and wind direction. The past photo-ID pilot has been carried out in very limited location (one islet) in the outermost archipelago in south, and thus better spatial scale was targeted. Challenging weather conditions were acknowledged as a main challenge for the collection of photo-ID material by using camera traps. Since large numbers of ringed seals are known to gather to a few limited core areas and certain islets during the moulting season, the camera trapping was focused to these sites (Table 2) in order to collect enough data for the basis of Baltic ringed seal photo-ID catalogue.

***Table 2**. Number of deployed camera traps and monitoring sites per year in 2021-2023. Sites refers to an island or islet.*

	2021	**2022**	**2023**
N of deployed camera traps	27	40	39
N of sites (island/skerries)	4	8	4

The number of deployed camera traps and sites varied between the years (Table 2). In 2021, camera traps were deployed between April 19th and 29th. To one remote site, situating in the outermost archipelago, the deployments were done on 3rd of June due to challenging weather conditions. Camera traps were deployed until mid-August. In 2022, deployments were done between April 11th and May 13th, and in the year 2023, all 39 cameras were deployed before April 24th. In 2022 and 2023, most of the cameras were removed from the field after the moulting season in June, but some cameras were left to monitor if ringed seals use the sites also during summer and early autumn.

In all the sites, camera traps were deployed in wooden stands mounted between rocks or to a platform built from wood (Fig. 8). Height of the stands and installation height of cameras depended on exact installation spot. Rocks from near surroundings were used as a weight and support for the stands.

Figure 8. *Camera traps are directed to rocks or shoals that the seals use for hauling out. Cameras are installed to wooden stands that are easily removable.*

Camera traps were directed to single rocks or groups of rocks assumably used for hauling by the seals (Fig. 8). In some spots, multiple cameras were installed to a same stand and directed to shoot different directions. Cameras were set to take two pictures on 0,5- or 1-hour interval. The camera traps have passive infrared sensors (PIR) for motion detection, but it cannot be used for the purpose because of the movement of water and other wildlife. Several different game camera trap models were tested and used (e.g., Uovision 785, Uovision Glory Cam 20MP).

In the Archipelago Sea, water level variation up to 1,5 meters and high waves create a challenge to the use of camera traps. During the pilot, six camera traps were lost in the storms and some stands were overturn by the waves and cameras were soaked (Fig. 9). Moreover, unpredictable technical issues occurred in few cameras.

Figure 9. *Harsh weather conditions create are challenge for the use of camera trap in the archipelago. During the pilot in 2021-2023, six camera traps were lost in the storms and few cameras collapsed or overturned.*

In order to capture good quality images, the camera traps need to be mounted close enough to rocks or shoals used for hauling out. However, because of the risk of losing camera traps due to high water level variation or waves, in many sites the camera traps need to be deployed far away from the shoreline. As a result of this, the proportion of usable, good quality images is relatively low, due to limitations of resolution of camera traps and need of cropping of the images (Fig. 10). Moreover, since the camera traps are installed fixedly to certain position and direction, the pictures are easily over- or underexposed depending on the direction of sunlight.

Figure 10*. Example of a cropped camera trap image. In the archipelago the camera traps often need to be deployed far away from the shoreline due to water level variation and harsh weather conditions. Because of this, the images require a lot of cropping which reduces the quality of final images. Moreover, the resolution of cameras and challenging lighting conditions limits the number of usable image material.*

4.2 Utilization of live camera in collection of photo-ID data

In addition to camera traps, a live camera (action E4) has been tested and utilized in collection of photo-ID material. In 2022, the live camera was deployed to one of the islets within the core area, where up to tens of seals can haul out during the most intense moulting period. Live camera system assembles of remotely operatable camera, power supply (solar panels and batteries) and data transfer system, including antenna, GSM-modem and required cabling (Fig. 11). The system is operated through browser interface. The camera is zoomable and turns 360 degrees. Excluding a few short-term technical faults, the camera system has worked well without a need of unnecessary maintenance visits that could cause distraction to the seals.

The use of remotely operatable live camera was a success for photo-ID purposes. Since the live camera is movable and zoomable and has a good image quality, it has made possible to collect large amounts of high-quality images of seals when they gather to the shore of the islet to haul out. Moreover, it has given unique opportunity to observe the behaviour of seals and the timing of moulting. During the moulting season in April-May, the live camera was monitored almost daily if the wind conditions have been calm enough for seals to haul out. Daily monitoring has included census and recording of images of individual seals visible to camera.

By December 2023, 40 different individuals have been identified from the images gathered by the live camera and added to the catalogue. Identification has based on the pelage patterns of the right side, yet also other sides (left or belly) of 15 identified seals has been captured with the live camera. Moreover, 12 of the individuals has been controlled at the same site between different years.

***Figure 11**. The live camera assembly consists of remotely rotatable and zoomable camera, power supply and data transfer system. Due to zoom and good image quality the camera can be installed far away from the shoreline without risk of degradation by the waves or water level changes.*

In the spring 2022, the maximum number of seals visible at the same time was 37 individuals, and in the 2023, 28 individuals. The live camera has also proven that the wind conditions affect largely how eager the seals are to haul out. In 2022, the high season of moulting seemed to occur between April 25th and May 20th, whereas in 2023, the biggest numbers were seen between April 22nd and May 22nd.

The live camera has proven to have many advantages compared to camera traps. Higher resolution and possibility to remotely move and zoom the camera enables collection of better-quality images of individuals on a non-invasive way. When taking the photo captures, it is possible to target specific individuals and wait them to turn in a good position so that the pelage patterns are visible. Moreover, live stream makes it possible to follow individuals and capture different sides of them. Subsequent image processing is not required since the images are cropped and put into individual folders at the time of a capture. Yet, due to the costs of the assembly and maintenance,

the use of such cameras is constrained to a few locations, hence limiting data collection on a spatial scale.

Figure 12. *Remotely operatable live camera has proven to be functional and effective way to collect photo-ID data of the ringed seals in the Archipelago Sea, where tens of seals may gather to haul-out at the same rocky stretch of an islet.*

4.3 Photography of seals with system cameras

In addition to use of game camera traps and the live camera, the ringed seals have been photographed with system cameras (later DSLR cameras) during the boat-based surveys and dedicated photography trips. The advantage of photographing is that it enables good quality images of targeted seals, and in some cases, it is possible to get images of the same seal from different angles, which is not usually possible with fixedly mounted camera traps. Moreover, DSLR cameras provide a possibility to adjust exposure and sharpness on-site, which are often the weaknesses of images collected with the game camera traps. Photographing with DSLR cameras also has it disadvantages. It highlights the need for exact field notes and/or saving of GPS positions of images. In addition, in case of large amounts of images it is often time consuming to download and process the images. Images can be received also from e.g., birdwatchers and other layman observers, which may provide new information and improve spatial coverage of photo-ID data.

Figure 13. *Individual Phb060. With careful approaching it is sometimes possible to get the images of pelage patterns from each side of the individual at the same occasion. Photo: Markus Ahola*

To date, 28 individuals have been added to catalogue from images taken with DSLR cameras during the project, but there are still images to process from the field season 2023. Before the project began, the catalogue already included 38 individuals identified from the images taken by nature photographers. These images are mostly from the years 2006-2008 and 2016. These images have resulted in many controls. This has provided important information on the site fidelity and longevity of the ringed seal in the Archipelago Sea. In total, the database currently includes 26 controls of individuals originally captured with DSLR cameras.

Photographing with DSLR cameras during boat-based surveys is a practical way to collect photo-ID data from more remote areas outside of the known core areas, where ringed seals occur mostly singly or in small groups. However, even with super telephoto lenses it is needed to get close to the seals. Based on the experiences of the recent years, ringed seals may be extremely timid and escape from distances up to 500 meters; however, the individuals show large differences in sensitivity to human approach.

5. Establishment of photo-ID catalogue for the Archipelago Sea ringed seals

One of the aims of the project is to establish a photo-ID catalogue, which can be used to improve the population size estimate, as well as to be used for other research purposes in the future. The established catalogue includes data collected 2006-2019 and the images collected during the project. Prior to the actual identification of individuals, photo-ID work consists of multiple steps including downloading and undergoing of images from different sources, recording of seal sightings from the images and cropping and adjusting of images, after which they are filed to individual folders. Furthermore, metadata (e.g. date, time, location and photographer) are kept note. Thereafter, it is possible to start the actual identification.

5.1 Processing of images and identification of individuals

Sightings of the Baltic ringed seals are recorded as a part of the processing of images. From the camera trap images, this is done by visually reviewing all images. The live camera images are captured from the live stream while recording the sightings. DSLR images are used to supplement the associated field observation notes.

All raw images from camera traps and DSLR cameras are reviewed to select the images with high enough quality for photo-ID. This means that the image shows a ringed seal, the pelage pattern is visible on one or both flanks, belly or some other part of the body, and the images are of sufficient resolution and exposure that the pelage pattern can be seen clearly.

The images with high enough quality for photo-ID are filed in individual folders, cropped strictly, and edited when necessary to improve the visibility of pelage pattern (Fig. 14). For group images, the individuals are named on the image and cropped into individual folders. Processing of pictures is time consuming for camera trap and DSLR camera images. Live camera images are less time consuming since they are usually stored directly from the live stream to individual folders and then cropped and have higher picture quality.

Figure 14. *Left: Individual seals with visible pelage patterns are cropped into individual folders from the group images. Right: Picture shows the pelage patterns used for the identification.*

In the identification phase, the pelage patterns of individuals in individual image folders are manually compared with the pelage patterns of individuals in the existing database. Sightings of known individuals are added to the database Excel spreadsheet and good quality images to the database image folders. Addition of new individuals is currently based on the images of the ringed seal's right flank. In later stage it could be worthwhile to test if images of other sides of the seals could result larger number of identified individuals and matches. Furthermore, it is possible that AI based automated identification reduces the need of manual work in the future, and hence makes photo-ID work less time consuming and labour-intensive.

5.2 Introduction of Seal Codex

Codex is an open-source software platform that combines structured wildlife research with artificial intelligence, citizen science and computer vision to speed population analysis and generate novel insights for combating extinction (Wild Me 2023a). Its purpose is to assist scientists in collectively tracking individual animals within wild populations and estimating the size of those populations. Multiple researchers and organizations can utilize each installation to study a variety of species across different regions collaboratively. (Wild Me Documentation 2023b.) Codex is also a valuable tool for easier data storage and catalogue reconciliation (Wild Me 2023; Wild Me Documentation 2023).

Seal Codex is a research platform that uses artificial intelligence for the conservation of seals by automating individual identification and providing a common data model for collaboration. It is currently used for example for ringed seals, grey seals (*Halichoerus grypus*), and harbor seals (*Phoca vitulina*). Seal Codex uses a SIFT-based computer vision algorithm called HotSpotter, which analyses textures in image to find distinct patterning and then compares those to other images in the database. (Wild Me 2023b.)

With the introduction of Seal Codex, all the existing data of identified Baltic ringed Seals were transferred to the platform. This included 501 photographs and an Excel spreadsheet with sighting metadata for 138 identified individuals. Not all sightings included pictures, but there where at least one picture of each individual. A total of 677 sightings were added and 138 individuals were created on the platform. Data was transferred to Seal Codex in late 2023.

Sightings were added to Seal Codex with following information: date and time of the sighting (as accurately as possible), region (the Archipelago Sea), freeform location (name of the island and the specification of the area), exact location (coordinates), photography type (digital or camera trap), photographer, sighting origin (in this case “research”), species and sex (if identified). Created individuals were named as in the original data e.g., Phb001 (*P. h. botnica* and running numbering).

The biggest advantage of the Seal Codex platform is that it allows access to the data with login credentials without the need for external hard drives or organisation’s internal cloud services. Moreover, the platform seems to work well as a catalogue. The platform’s evolving map functionality, and possibility to have working recognition algorithm in future will also potentially benefit the research work, by decreasing need of manual work and by enabling the handling of larger number of images. If the Seal Codex is introduced for the Baltic ringed seals in other regions or countries of the Baltic Sea area, it could potentially work as a platform for collaboration and way to gain information on the movements of seals in the Baltic Sea.

6. Summary

The inventories conducted during the Our Saimaa Seal project have gained essential knowledge on the distribution and abundance of the Baltic ringed seal in the Archipelago Sea. Photo-ID has proven to be practicable way to collect information on the living in the sea area. By combining different methods, it is possible to gain more detailed information on not only the distribution and population size of the seals, but also information for life-cycle studies, such as survival, dispersal and demography. This knowledge will be directly utilized during the project for establishing new protected areas and other conservation measures for the ringed seals in the Åland islands (action A6). The experiences and observations from the Archipelago National Park area have already been taken into account in the ongoing update of park’s management plan. In the future, this knowledge can provide a basis for further studies and can be applied when planning conservation and management measures for other subpopulations of the ringed seals in the Baltic Sea, also in international level.

The piloting of the different monitoring methods in the Archipelago Sea has shown that the harsh environmental conditions set challenges for the monitoring. When working on such a vast area,

surveys are prone to wind and other weather conditions and their sudden changes, which may delay or hamper planned efforts, but also affects the detectability of the seals. Furthermore, the conditions highlight the need of experienced and skilled observers and other crew, and adequate equipment and gear. Also, when working in remote areas and bad conditions the safety issues need to be considered.

The piloting and developing of conservation measures in the Archipelago Sea will continue in coming years mostly through actions C2 and D2. Furthermore, some effort will be given to collection of complementary photo-ID data and inventories of specific areas (especially in the Åland islands). Since the live camera (action E4) has proven to be effective tool for collection of photo-ID material, its use will be continued in the upcoming haul-out season in 2024. So far, collection of photo ID data with camera traps, system cameras and remotely operatable live camera have enabled identification of 140 ringed seal individuals.

Our Saimaa Seal LIFE -project has enabled more extensive inventories of the subpopulation of the Archipelago Sea than ever before. Recent years have proven that the subpopulation is small and needs urgent protection. The extent and variation of both ice and wind conditions in the area creates a challenge for monitoring, and hence the estimation of population size. Thus, monitoring methodology should be further developed and tested. Continuation of photo-ID work is needed to get more detailed information on the population and could be accompanied by other methods such as GPS-tracking. Up-to-date information on distribution and abundance is needed for successful implementation of concrete protection measures, such as development of artificial nests, which have already proven to be potential way to improve the breeding success of Baltic ringed seals. Moreover, the monitoring of reproduction success is important in order to understand the threat caused by climate change. It is still largely unknown how the ice-free conditions affect to the reproduction of ringed seals. Furthermore, more research is needed to evaluate effects of possible other threats, e.g. pollutants, marine traffic, energy production and by-catch mortality.

7. Acknowledgements

We want to thank all the volunteers who have contributed to the collection of photo-ID material and participated to surveys. Special thanks to Markus Ahola for his great voluntary effort, and Jouko Högmander and Heidi Arponen for sharing their experiences and knowledge. We want to also thank Ville Vasko, Aleksi Reini, Nea Laine and Milja Pursiainen, who have participated work.

The material reflects the views by the authors, and the European Commission or the CINEA is not responsible for any use that may be made of the information it contains.

8. References

Bergman, G. 1956: Sälbeståndet vid våra kuster. Nordenskiöld-samfundets tidskrift 16: 49–65.

Born, E.W., Riget, F.F., Dietz, R. & Andriashek, D., 1999. Escape responses of hauled out ringed seals (Phoca hispida) to aircraft disturbance. Polar Biology, 21, pp.171-178.

Cordes L. S. & Thompson, P. M., 2015. Mark-resight estimates of seasonal variation in harbor seal abundance and site fidelity. Popul Ecol. 57: 467–472.

Cunningham L., 2009. Using computer-assisted photo-identification and capture-recapture techniques to monitor the conservation status of harbour seal (Phoca vitulina). Aquat. Mamma. 35: 319–329.

Felix, F., Castro, C., Laake, J. L., Haase, B. & Scheidat, M., 2011. Abundance and survival estimates of the southeastern Pacific humpback whale stock from 1991–2006 photo-identification surveys in Ecuador. J. Cetacean Res. Manage., 3: 301–307.

Frost, K. J., L. F. Lowry, G. Pendleton & Nute, H. R., 2004. Factors affecting the observed densities of ringed seals, Phoca hispida, in the Alaskan Beaufort Sea, 1996–99. Arctic 57: 115–128.

Halkka, A & P. Tolvanen (eds.) 2017. The Baltic ringed seal – An Arctic seal in European waters – WWF Finland report 36.

Helle, E. 1980. Aerial census of ringed seals Pusa hispida basking on the ice of the Bothnian Bay, Baltic. Holarctic Ecology 3: 183–189.

Hiby, L., Lundber, T., Karlsson, O., Watkins, J., Jussi, M. & Jussi, I., 2007. Estimates of the size of the Baltic grey seal population based on photo-identification data. NAMMCO Sci Publ. 6: 163–175.

Härkönen, T. & Heide-Jørgensen, M.P., 1990. Density and distribution of the ringed seal in the Bothnian Bay. Ecography, 13(2): 122-129.

Koivuniemi, M., Auttila, M., Niemi, M., Levänen, R. & Kunnasranta, M. 2016. Photo-ID as a tool for studying and monitoring the endangered Saimaa ringed seal. Endangered Species Research 30: 29-36. DOI: https://doi.org/10.3354/esr00723.

Koivuniemi, M., Kurkilahti, M., Niemi, M., Auttila, M. & Kunnasranta, M. 2019. A mark–recapture approach for estimating population size of the endangered ringed seal (Phoca hispida saimensis). PLOS ONE 14: e0214269. DOI: https://doi.org/10.1371/journal.pone.0214269.

Kuningas, S., Simila, T. & Hammond, P. S., 2014. Population size, survival and reproductive rates of northern Norwegian killer whales (Orcinus orca) in 1986–2003. J Mar Biol Assoc. UK. 94: 1277–1291.

Maglietta, R. Carlucci, R., Fanizza, C. & Dimauro, G. 2022. Machine Learning and Image Processing Methods for Cetacean Photo Identification: A Systematic Review. IEEE Access, vol. 10, pp. 80195-80207. doi: 10.1109/ACCESS.2022.3195218.

Miettinen, M., Halkka, A., Högmander, J., Keränen, S., Mäkinen, A., Nordström, M., Nummelin, J. & Soikkeli, M. 2005. Itämerennorpan (Phoca hispida botnica) esiintyminen Saaristomeren alueella – yhteenveto vuosien 2002–2005 kartoitustyöstä. Summary of the report: Itämerennorpan (Phoca hispida botnica) esiintyminen Saaristomeren alueella (WWF Suomen raportteja n:o 22, ISBN 952-5242-12-9, ISSN 0788-0804).

Nordström, M., Högmander, J., Halkka, A., Keränen, S., Kunnasranta, M., Nummelin, J., Miettinen, M., Niinimäki, T. & Tolvanen, P. 2011. Itämerennorppa Saaristomerellä – unohdettu uhanalainen. – Maailman luonnonsäätiön WWF Suomen rahaston raportteja 28. Saatavilla: https://wwf.fi/app/uploads/4/b/p/efezqizeypezfkytiyub6sa/wwf_raportti_28_itamerennorppa_2011.pdf.

Stenman, O., Blomberg, T. & Nordberg, M. 2008: Vikaren på Åland under de senaste hundra åren. Skärgård 2008(2): 36-41.

Trukhanova, I.S., Gurarie, E. & Sagitov, R.A., 2013. Distribution of hauled-out Ladoga ringed seals (Pusa hispida ladogensis) in spring 2012. Arctic, pp.417-428.

Wild Me. 2023a. Codex: A new age of Wildbook. Cited 12.12.2023. https://www.wildme.org/codex-and-wildbook.html

Wild Me. 2023b. Seal Codex. Cited 12.12.2023. https://www.wildme.org/seal-codex.html

Wild Me Documentation. 2023. An Introduction to Codex. Cited 12.12.2023. https://docs.wildme.org/product-docs/en/

Wursig, B. & Jefferson, T.A. 1990. Methods of Photo-identification for small cetaceans. Individual Recognition of Cetaceans. Use of Photo-identification and Other Techniques to Estimate Population Parameters. Special Issue no. 12. International Whaling Commission, Cambridge, UK.