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The Barnacle Goose (*Branta leucopsis*) in the archipelago of southern Finland – population growth and nesting dispersal

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We studied the population growth and expansion of Barnacle Goose (*Branta leucopsis*) in Helsinki archipelago, southern Finland. Barnacle Goose breeding was first recorded in Helsinki in 1989. During our study 1996–2013 the number of nesting geese increased from 24 to 740 pairs. We analyzed the role of protected islands in the population growth, and the factors behind differences in growth rates. Our study data consisted of 104 islands. Of these, 29 are protected from private recreational activity (nature reserve or military areas) and were established prior to the start of our study. We predicted that protected areas would have a positive impact on Barnacle Goose population growth. In part of the study period (2002–2013) the population growth in our study area was much steeper in protected islands compared to islands with open access. However, breeding densities in those unprotected islands were higher than in protected islands in the early years of the study. We found that the most important factors affecting pair numbers in islands are island size and the time it has been inhabited, in addition to island distance from the islands southeast of Helsinki, where breeding expansion started. Island protection had no effect on the breeding geese numbers or current densities on the islands. Results indicate that early breeders like Barnacle Geese do not benefit from island protection probably because the recreational use of the islands is scant early in the spring.

1. Introduction

Barnacle Goose (*Branta leucopsis*) originally bred in the arctic zone from Greenland to West Siberia, and formerly only used to migrate through the Baltic Sea (Madsen *et al.* 1999). The first breeding attempt in the Baltic was observed in Sweden in 1971, over 2,000 kilometers away from its traditional arctic breeding grounds in Russia (Larsson *et al.* 1988, Svensson *et al.* 1999). The first breeding attempt in Finland was recorded in 1985 (Väisänen *et al.* 1998). Recently, approximately 3,500 Barnacle Goose pairs are estimated to breed in Finland, over one third of which breed in semiurban habitats in the archipelago of Helsinki (Väänänen *et al.* 2011, Hario & Rintala 2014). In the Baltic Sea Barnacle Geese usually breed in grassy or bushy islands and islets (Feige *et al.* 2008).

The Barnacle Goose is well adapted to breeding in the vicinity of urban areas in Finland (Väänänen *et al.* 2011). The first breeding in the Helsinki metropolitan area was recorded in 1989, but by 2010 the number of nesting Barnacle Geese was already estimated at 1,440 pairs (Väänänen *et al.* 2011). Geese nest in the archipelago, and broods use urban lawns in the vicinity of water for foraging. By nesting on small islands and islets geese avoid predation by terrestrial mammalian predators, such as Red Fox (*Vulpes vulpes*) and Raccoon Dog (*Nyctereutes procyonoides*), and by moving to urban lawns broods minimise the predation risk by avian predators such as White-tailed Eagles (*Haliaeetus albicilla*) (Väänänen *et al.* 2011, see also Leito & Tuur 2008 and Black *et al.* 2014).

Breeding time is a period strongly affecting the fate of waterfowl populations. Nest predation alone is one of the most important factors influencing offspring production of birds (Newton 1998). Hoekman *et al.* (2002) found that nesting success was the most important vital rate explaining population growth rate of mid-continental Mallards (*Anas platyrhynchos*) in North America; it accounted for 43 per cent of the variation in population growth.

In addition to nest predation, breeding waterfowl females are exposed to an increased predation risk during the nest and brood stages (Newton 1998). Human-induced disturbance may additionally affect waterfowl during various periods of their life cycles (Madsen *et al.* 1998, 2009).

In contrast to smaller waterfowl species, adult survival may be a more important factor affecting goose populations (Forslund 1992), and the importance of various factors may vary during the course of a population growth (e.g., Cooch & Cooke 1991, Larsson & Forslund 1994). However, nest predation is also important in geese. Bêty *et al.* (2001) found that fluctuations in lemming density were associated with nesting success of Greater Snow Geese (*Anser caerulescens atlanticus*) in the Canadian High Arctic. Goose nesting success varied from 22% to 91% between years, and the Arctic Fox (*Alopex lagopus*) was the main egg predator. The Arctic Fox acts as the alternative prey hypotheses predicts: fox focus on hunting goslings, when lemming populations are low (Bêty *et al.* 2001).

The main reason for creating protected areas for birds is their need for undisturbed conditions during the breeding season and their need for suitable foraging habitat. In Britain, where urbanisation is a clear threat for many animal species, several rare bird species now depend on protected areas. Without protected areas, some species may be lost (Jackson & Gaston 2008). Little is known of the role which protected areas play on the population dynamics of waterfowl. Much more is known of the natal philopatry or increased refuge use of waterfowl from early autumn to winter (Owen & Black 1990, Madsen & Fox 1995, Madsen *et al.* 1998, 2009, Väänänen 2001).

The archipelago around Helsinki offers unique possibilities for studying the factors affecting population development of waterfowl, and the Barnacle Goose is a feasible model species for studying this topic. Firstly, as with most waterfowl species, female geese in particular show natal philopatry and fidelity for nest sites (Owen & Black 1990). Nesting Barnacle Geese tend to nest year after year on the same islands, a phenomenon also observed in the Helsinki archipelago (Luostarinen M. unpubl.). Secondly, nearly two hundred islands and islets occur in the large area from shore to the outer archipelago covered by a monitoring programme in the archipelago of Helsinki, 28 of which are closed (military area) or protected from private recreational activities. The archipelago therefore has a mosaic of protected and unpro-

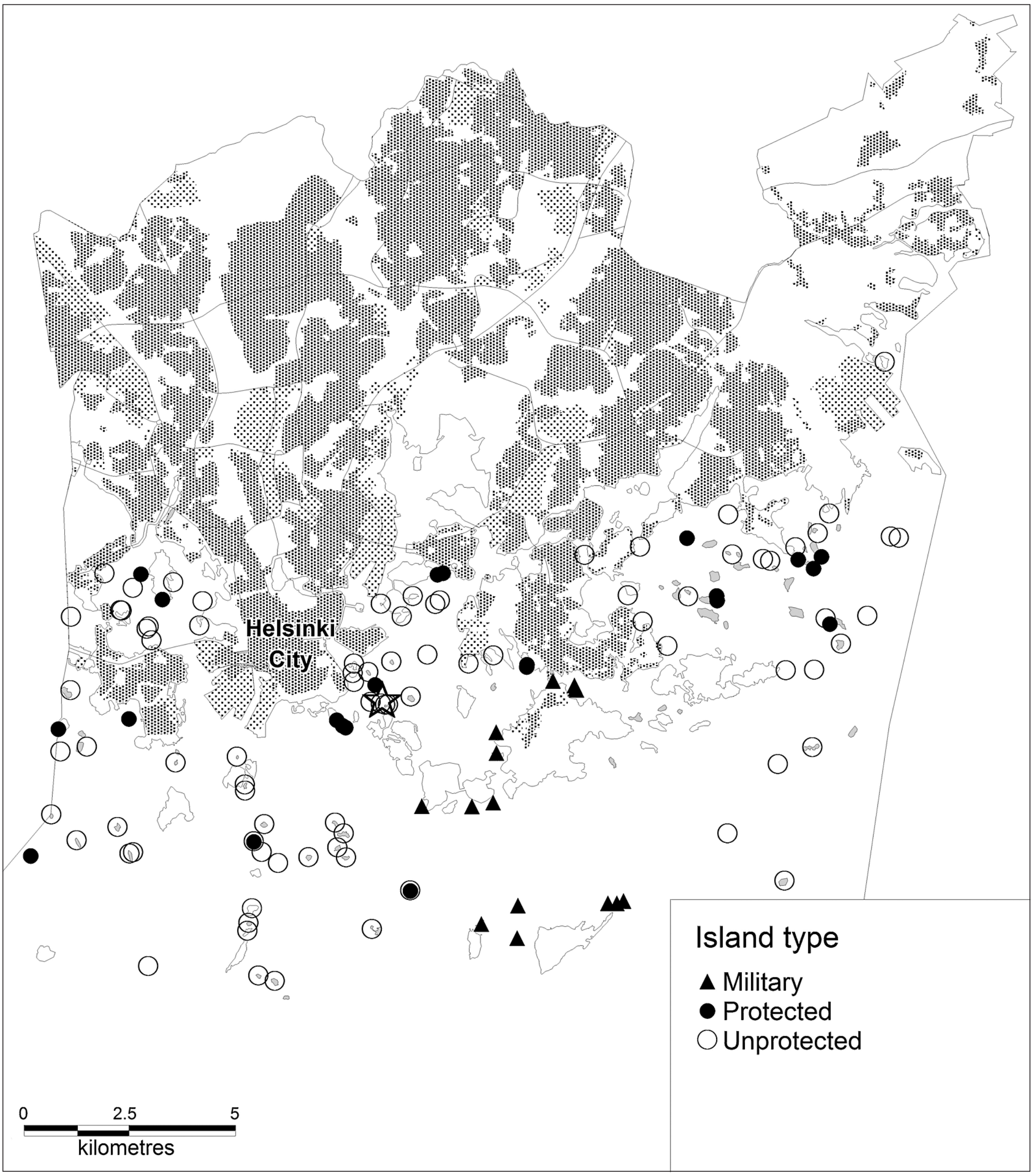

Fig. 1. Distribution of Barnacle Goose breeding islands and islets in Helsinki archipelago. Star indicates the focal point of population settlement. Rasters show areas with buildings or other intensive land use forms, such as harbours or industry areas.

tected islands and islets; these nature reserve areas in our data were established before the Barnacle Goose began to breed in the Helsinki archipelago. Thirdly, Barnacle Geese change their habitats throughout the breeding season: they use different habitats during the nesting and brood periods, exhibiting landscape complementation (Väänänen *et al.* 2011). Barnacle Geese therefore select their nesting islands mainly for nesting instead of brood rearing. Because of the high number of islands and islets available for nesting, geese have flexible possibilities for freely selecting attractive nesting sites.

We study the role of size, distribution and protection status of islands and islets in the population growth and breeding numbers of Barnacle Geese. We hypothesise that protected islands and islets have a positive impact on breeding Barnacle Goose. In other words, we predict that breeding numbers of Barnacle Geese increase more rapidly in areas with restricted human activity.

Table 1. Island mean area (hectares) in different groups. SD = standard deviation.

Group	N	Median	Mean	SD
Unprotected	75	0.390	0.777	0.940
Protected	18	0.390	0.943	1.988
Military	11	0.790	0.875	0.774

2. Material and methods

2.1. Study area

The archipelago of Helsinki is a versatile breeding habitat. The archipelago can be divided into three main zones: the inner, middle and outer archipelago. The shores in the inner archipelago contain luxuriant vegetation as the rivers and brooks import nutritious water to the bays from the interior. The amount of drifting sediment in the water is also high. The shores have many valuable bird bays such as Laajalahti, Vanhakaupunginlahti and the Östersundom area. The water quality in the middle archipelago in the Helsinki area is moderate. Some of the islands are large and wooded, but many smaller open islands also exist. The waters are fairly sheltered, and the waves and surfs coming from the sea abate between the islands. The Common Eider (*Somateria mollissima*), gulls and terns, and the Canada Goose (*Branta canadensis*) are some of the typical breeding species. Barnacle Geese most commonly nest in the middle archipelago zone. The outer archipelago is on the brink of the open sea. The majority of the islands and islets are rugged and nearly treeless, while a few bigger wooded islands are at the edge of the outer archipelago. The Black Guillemot (*Cepphus grylle*), the Common Ringed Plover (*Charadrius hiaticula*), the Common Eider and larids are some of the typical breeding species of the outer archipelago.

The study area has 179 islands or islets (later islands) where at least one bird count has been conducted during the study period. We have available Barnacle Geese data for statistical analyzes from 104 islands. Of these islands, 18 are protected, 11 are closed military islands and 75 are open access (hereafter unprotected) islands to the public (Fig. 1, Table 1).

In the Helsinki archipelago, the most recent protection area (one island) was established in 2002. However, the Barnacle Goose did not breed on this island during our study period. The number of protected islands effectively remained unchanged during our study period. Most Barnacle Geese breeding islands are rather small, averaging less than one hectare.

It is to be noted that breeding bird counts have concentrated on good bird islands. Single pairs of nesting Barnacle Geese and other archipelago species may breed on bigger wooded islands, but they are not considered in our study. Predation by e.g. the American Mink (*Neovison vison*) has been observed on our study islands. In some years, mink predation has been relatively high (Matti Luostarinen, personal observation).

2.2. Survey of breeding pairs

M. Luostarinen performed all the bird surveys during the years 1996–2013. He visited each island three or four times during the breeding season. Bad weather occasionally prevented fieldwork, and some islets were visited less than three times during a season. Due to this reason, some islands vere not surveyed annually and there are some gaps in our data. The nesting islands in the Helsinki archipelago are usually rocky and bare. Nesting Barnacle Geese pairs were therefore very easy to find because of the open nesting area and, in addition, the male goose is visible when guarding the incubating female. Counts were taken during a 15–30-min stay per island; a longer census time would have resulted in damage to the nesting result. The total number of Barnacle Geese records used in our study is 1,073.

2.3. Statistical analyses

We first examined population growth in the Helsinki archipelago. We calculated the breeding population trend using the TRends and Indices for Monitoring data (TRIM) programme (European Bird Census Council) (Pannekoek & van Strien 2001). TRIM is an open-source software tool commonly used in bird monitoring across Europe (www.ebcc.info). It accounts for overdispersion and serial correlation, and interpolates missing observations using a Poisson general log-linear model, if needed. We used island type as a covariate to determine whether the population trends varied between island type groups. Trend differences between groups were tested with a paired *t*-test. Before 2002, no pairs lived on military islands and comparison of the population growth index was not possible.

Possible differences in island size between groups were tested with an independent samples Mann-Whitney *U*-test. Tests were performed using Systat 12 statistical software (Systat Software Inc., San Jose, CA, USA). Differences in size were tested between protected islands versus the other two groups. The size of the different island types (Table 1) did not differ (unprotected vs. protected $U = 667.0$, $P = 0.938$, unprotected vs. military $U = 459.5$, $P = 0.543$ and military vs. protected $U = 123.0$, $P = 0.281$).

Secondly, we analysed which factors could be behind the observed differences in population growth rates. Population growth rate is typically assumed to depend on population density, which can be related to the time period the population has had time to inhabit a certain habitat patch (Begon *et al.* 2006, Gunnarsson *et al.* 2013). To take into account these possible factors affecting the growth rate of the geese population on various island types, we explored the distance of the islands from the focal point (Pormestarinluodot, small islands south-east of the city of Helsinki, from where breeding expansion started), the time length that islands had been inhabited and goose pair densities. We analysed this using data from 101 islands, and the same data were used later for the pair number analysis, because the island-specific data needed for these analyses were not available for certain islands (i.e. the counting areas of certain islands varied during the research period). Firstly, using an independent samples Mann-Whitney *U*-test, we checked whether the distance of the island types differed from the focal point, where several pairs were observed as early as 1996. Secondly, we used the independent samples Mann-Whitney *U*-test to explore whether the inhabited years differ between the island types.

We formed two groups: one included the protected and military islands (eg. restricted access islands), and the other contained the unprotected islands. We calculated the maximum number of inhabited years for every island and compared them between the island types. Thirdly, we also used independent samples Mann-Whitney *U*-test to study population densities in the two island types. For this analysis, we calculated the annual average pair density for both island types. We first compared the entire research period, and after that the first ten years (1996–2005) to account for the early stage of population growth. Furthermore, we also tested the island specific densities in the two island types in the year 2002, which was the starting point of the TRIM-analysis.

The number of breeding pairs in the various island types was analysed with generalised linear mixed modelling (Zuur *et al.* 2009) using the lme4 (Bates *et al.* 2016) and lattice (Sarkar 206) libraries in R 3.0.2 (R Development Core Team 2013). We assumed a negative binomial distribution due to the large variance in the pair numbers. The yearly number of pairs on the 101 islands was explained by habitat and temporal factors. The island type (protected, unprotected) was a factor variable. Larger islands might support higher numbers of geese, and thus the island area was used as an explanatory variable.

Breeding goose dispersal within the archipelago was accounted by calculating the distance of the islands from the expected focal point. To include the island-specific duration for population growth we also calculated the number of years during which geese had been present on each island and the type-specific interaction of the islands. The duration of the inhabitation years was calculated so that each island was given a value for every inhabited year: for example, islands inhabited continuously from 1996 to 2013 were given values from 1 to 18. We realise that some islands had nesting pairs already prior to 1996, which causes a bias in our data analysis (see Results).

The data have a nested structure and a random part was therefore included in the model, and different random effect scenarios were fitted. The

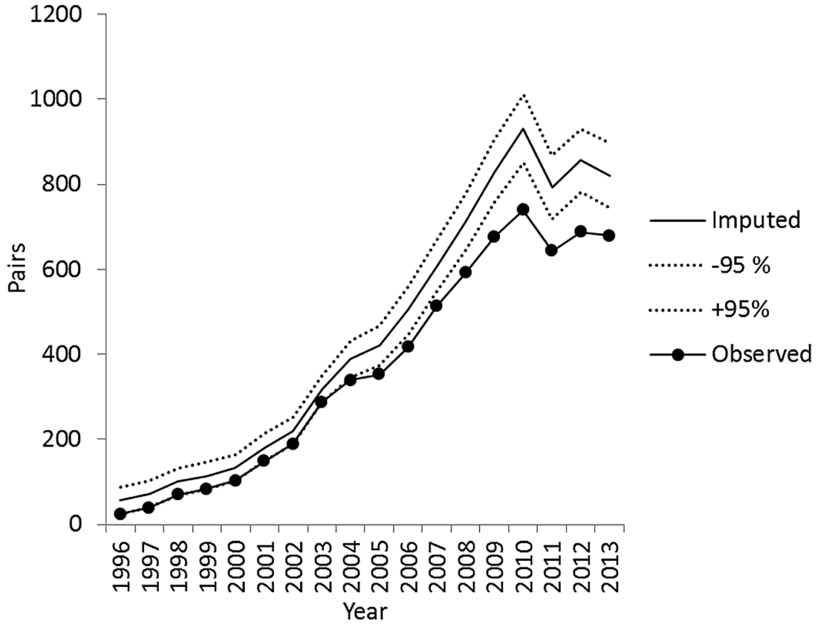

Fig. 2. Observed and estimated (imputed) number of breeding barnacle geese in Helsinki.

scenarios were: (1) a categorical random factor for the island effect, and (2) a random intercept and slope model for the inhabited years effect (a continuous covariate) per island (a categorical variable). The comparison of AICs of these two scenarios was made with the Anova function. Based on the AICs the scenario (2) had a slightly better fit. We additionally tested the effect of the interaction term, but it did not improve the model fit. Therefore we gave up of the interaction term, and thus the model explaining the pair number is as follows:

$$Pair\_number_{ij} = \alpha + \beta_A \times A_i + \beta_D \times D_i + \beta_T \times T_i + \beta_Y \times Y_{ij} + Z_{ij} \times a_{ij} + \varepsilon_{ij,} \quad (1)$$

where the $Pair\_number_{ij}$ is the pair number on island i in year j, where i = 1, ... 101, and j = 1996, ... 2013. α is the intercept and β the coefficient of the explanatory variables area (A), distance (D), island type (T) and inhabited years (Y) of island i in year j. The $Z_{ij} \times a_{ij}$ is a random term and represents the pair number–inhabitation year effect for each island; the term has a random intercept and island-specific slopes. The term ε_{ij} represents unexplained noise.

3. Results

3.1. Growth rate

The number of nesting Barnacle Goose pairs increased from 24 to 740 during the period 1996–2013. The TRIM analyses of the Barnacle Goose population revealed a strong increase (N = 18, Mean TRIM growth index = 2.800, $P < 0.01$, Fig. 2) in the Helsinki archipelago. Slight differences were observed in population growth slopes, which resulted in variable population indeces. The population trend of protected islands was steeper compared to unprotected islands (only the last 11 years were comparable between all three groups. Paired *t*-test, N = 11, $t = 5.010$, df = 10, $P < 0.001$, Fig. 3). The same difference was also found between military islands and unprotected islands (paired *t*-test, N = 11, $t = –4.371$, df = 10, $P = 0.001$), but no difference (paired *t*-test, N = 11, $t = 0.329$, df = 10, $P = 0.749$) was observed between protected islands and military islands (later these two are grouped as protected islands). Fifteen years after breeding was first recorded in the Helsinki archipelago, breeding goose pairs have already dispersed all over the archipelago (Figure S1 and S2).

We found slight differences in their population history when searching for possible explanations to the difference in growth rate between the two is-

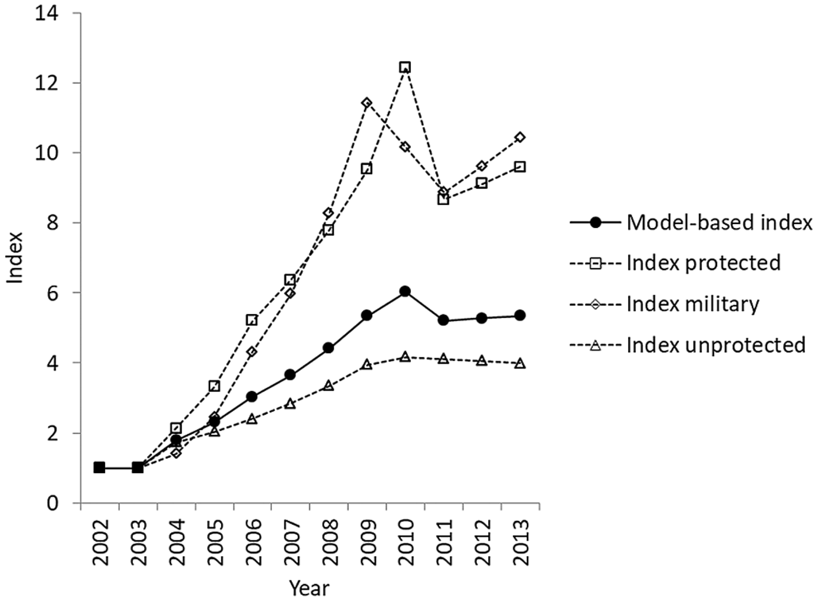

Fig. 3. Population changes at various island types. Before 2002 no pairs were observed on military islands and comparison of the population growth index was not possible.

land types. This was not due to the distance of the two island types from the focal point, because the distance did not differ between island types (N = 101, Mann Whitney *U* = 967.0, SE = 131.81, *P* = 0.676, protected island median = 5,171 m, unprotected median = 6,072 m). Accordingly, the independent samples Mann-Whitney *U*-test revealed no difference in the duration of goose occupancy on the two island types (*N* = 101, *U* = 1062.5, *SE* = 131.43, *P* = 0.758; protected median = 11; unprotected median = 10). Thus, it appears that goose populations have had a rather similar time period to increase in size on each island type. However, because our data collection began in 1996, the evaluation of occupancy duration for some of the islands is an underestimation. We believe that this concern mostly the time that geese have occupied unprotected islands. Islands with geese occupancy as early as 1996 are unevenly distributed between the two types: nine unprotected islands and two protected islands. Therefore, the unprotected island occupancy year distribution is slightly skewed to the left.

The possible underestimation of inhabitation times was visible in the population density analysis. Annual average pair densities of the two island types was fairly similar for the entire period: protected islands *N* = 18, median = 7.77 pairs/ha; unprotected islands *N* = 18, median = 10.37 pairs/ha. The difference is not significant (*N* = 36, Mann-Whitney *U* = 119.0, *SE* = 31.61, *P* = 0.181). Densities did not significantly differ in the year 2002 either (protected islands *N* = 24, median = 0.00 pairs/ha; unprotected islands *N* = 60, median = 0.24 pairs/ha; Mann-Whitney *U* = 699.0 *SE* = 93.97, *P* = 0.823. The number of islands does not sum to 101, but 84 due to lacking surveys of some islands in 2002). However, when we tested the yearly annual pair densities between island types during the first ten years, densities differed significantly (*N* = 20, *U* = 23.0, *SE* = 13.23, *P* = 0.043). Protected islands had significantly lower pair densities (*N* = 10, median = 1.37 pairs/ha) than unprotected islands (*N* = 10, median = 4.78 pairs/ha).

3.2. Pair numbers

We built a GLMM model to explain the number of pairs in different islands by using all four explanatory variables (island type, area, number of inhabited years and distance from the focal point) and the random term. Estimated parameters for the model clearly implies that the island type does not matter, while island area and the number of inhabited years were shown to be highly significant and the most important factors explaining the number of pairs on the islands (Table 2, Fig. 4 A and B).

Table 2. Estimated parameters of the analysis to the Barnacle Geese pair numbers in the Helsinki archipelago. Type category is a nominal variable and represent unprotected islands (reference category, i.e. intercept) and protected islands (protected and military combined). Estimated values for the random intercept term representing the between island variation = 0.76^2; random slope = 0.10^2 and correlation between random intercepts and slopes = –0.61.

Global model	Value	SE	*t*-value	*P*
Intercept	0.376	0.190	1.974	0.048
Area (log)	0.360	0.055	6.517	< 0.01
Type: Protected	0.145	0.163	0.890	0.374
Inhabited years	0.220	0.014	15.913	< 0.01
Distance	–0.057	0.024	–2.391	0.017

Distance from the focal point, islands south east of the City of Helsinki, showed to have an effect on pair numbers too, while the estimate is rather low.

4. Discussion

A breeding goose pair usually shows high site-fidelity, utilising knowledge of the surroundings, which may increase breeding success (Black 2001). Nest-site decisions in a breeding area may be affected by predation or possibly by the density of conspecifics in a colony (Prop & Quinn 2003, Väänänen *et al.* 2011, van der Jeugd *et al.* 2013).

Increasing numbers of breeding Barnacle Geese in the Helsinki arghipelago led to the rapid occupation of new islands. In the beginning of the study period most of the islands were not used by breeding geese. The result implies that population growth rates between the island types might be affected by diverging population densities during the earlier years. Unprotected islands appear to be inhabited by geese slightly earlier, leading to higher pair densities at the beginning of the study period. However, we found no difference in the distance of the two island types from the focal point. Population growth led to increased pair densities on the breeding islands, which is again reflected in the growth rate. The TRIM analyses of the Barnacle Goose population indicate a strong recent population increase on protected islands, whereas the growth rate on unprotected islands showed a weaker increase, possibly as a response to higher pair densities. This pattern has also been found in e.g., Swedish Barnacle Geese (Larsson & Forslund 1994).

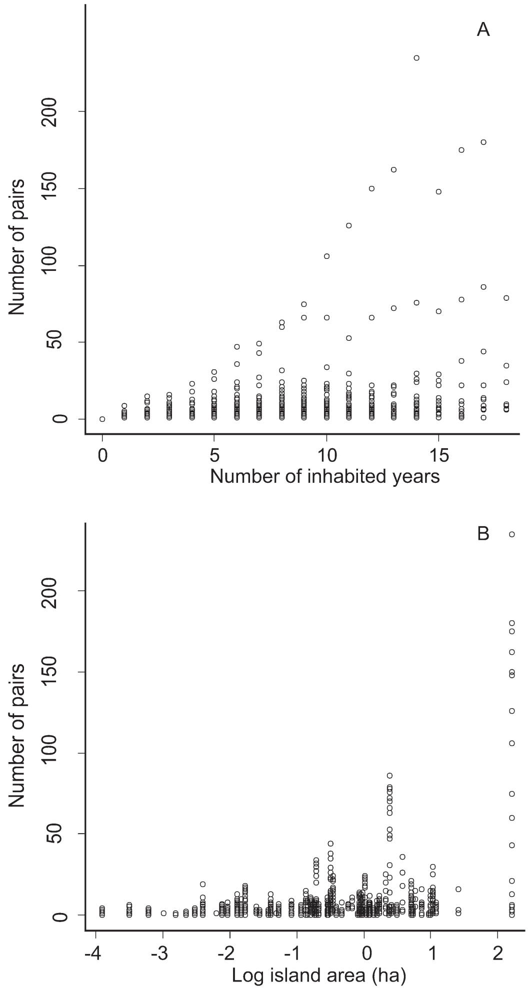

Fig. 4. A) The number of pairs in the islands increases with the number of inhabited years. Dots represent the number of pairs in the islands (N = 101) in the years 1996–2013 (i.e. every island has 18 dots). B) The number of pairs in the islands increases with the island area (natural logarithm transformed). Dots represent the number of pairs in the islands (N = 101) in the years 1996–2013 (i.e. every island has 18 dots).

Opposite to our hypothesis, pair numbers on the islands appear not to depend on the island status. Instead, our analysis reveals that pair numbers are explained by island area and occupancy duration. Both these had positive effect on pair numbers. They were also slightly affected by the distance from the focal point; remote islands were inhabited later. Larger islands may harbour larger numbers of geese, which are territorial during the nesting time. This also appears to be the case in our study. Nesting Barnacle Geese appeared to be able to choose nesting sites more equally than the pairs in a growing Mute Swan (*Cygnus olor*) population, where dominant pairs appeared to force lower-ranking pairs into suboptimal habitats (Nummi & Saari 2003).

The effects of human disturbance on geese depend on the timing and type of disturbance (Carney & Sydeman 1999, Madsen *et al.* 2009). We have no data on the frequency or intensity of recreational utilisation of the unprotected nesting islands. However, visitors occasionally illegally let their dogs move freely on the islands, which may increase disturbance and lead to decreases in the nesting success of waterbirds (Matti Luostarinen, personal comment). However, the protection of islands apparently does not affect the breeding numbers of Barnacle Goose. Human disturbance might thus not harm goose breeding, or disturbance is low during the most sensitive time. Barnacle Geese are early breeders and begin laying their eggs after mid-April. Incubating geese therefore probably do not suffer such high human disturbance as in warm summer days during the brood period. Therefore, human disturbance may not have as strong effect on nest site selection as we excpected.

In addition to the factors tested here, it is also possible that Barnacle Geese have nesting association with colonial larids. In our study area, the highest number of colonial larids (350 pairs of Common Gulls) were breeding on Harakka island, where the largest number of nesting Barnacle Geese were also found (a colony of more than 100 breeding pairs is now present). Gulls and terns are very efficient at detecting predators and attacking them, which also provides protection for waterfowl nests and broods (Väänänen 2000, Kurvinen *et al.* 2016, Väänänen *et al.* 2016).

Predation by gulls or White-tailed Eagle may stabilise population growth of Barnacle Geese in the future. The successful recovery of breeding White-tailed Eagle in the Baltic has increased the predation of Barnacle Geese in the largest geese colonies in Gotland (Sweden), which led to decreasing brood production and breeding numbers of geese (Black *et al.* 2014). A similar phenomenon is also well-documented in Common Eider on the south-west coast of Finland; the presence of breeding White-tailed Eagles negatively affected the breeding numbers of Common Eider (Kurvinen *et al.* 2016), and predation of incubating females has increased during recent decades (Jaatinen *et al.* 2011). The White-tailed Eagle is additionally becoming more common year after year in the Helsinki metropolitan archipelago. The majority of eagles are non-breeders, but breeding pair numbers have also increased in the archipelago area.

5. Conclusions

Barnacle Geese have expanded very efficiently to breed in the Baltic Sea. Their population has grown during the last decades, and the number of breeding sites has increased rapidly (Forslund & Larsson 1991, Feige *et al.* 2008, Väänänen *et al.* 2010, Black *et al.* 2014). Based on our results, the Barnacle Goose population in the Helsinki archipelago has also increased rapidly, and appears not to be harmed by human disturbance. Population growth appers to have ceased during the last study years, which could indicate population stabilisation. Previously Väänänen *et al.* (2011) reported an average growth of 22.5% per year for the breeding Barnacle Goose population in Helsinki and the surrounding cities during years 2003–2010, preceeded by a period of even higher annual growth.

We found that the availability of protected islands does not affect the breeding numbers of Barnacle Goose. They appear to be able to utilise islands regardless of their protection status, while the size of the breeding island, population history and current population density may better explain population growth and status in the future.

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Valkoposkihanhen (*Branta leucopsis*) populaatiokasvu ja pesimälevittäytyminen saaristossa Etelä-Suomessa

Tutkimme valkoposkihanhen pesimäpopulaation kasvua ja levittäytymistä Helsingin saaristossa, Etelä-Suomessa. Valkoposkihanhen pesintä todettiin ensimmäisen kerran Helsingissä vuonna 1989. Vuosien 1996–2013 tutkimusjaksolla pesivien parien määrä kasvoi 24:stä 740 pariin. Analysoimme suojeltujen saarten roolia populaation kasvussa ja mahdollisia syitä kannan kasvueroihin erilaisten saarten välillä. Tutkimusalueemme koostui 104 saaresta. Näistä 29 on virkistyskäytöltä suljettuja alueita (luonnonsuojelualueita tai sotilasalueita) ja ne on perustettu jo ennen tutkimuksen alkua. Oletimme, että suojelualueilla olisi myönteinen vaikutus valkoposkihanhipopulaation kasvuun.

Osassa tutkimusjaksoa (vuosina 2002–2013) populaation kasvu tutkimusalueella on ollut paljon voimakkaampaa ihmisten liikkumiselta suojelluilla saarilla verrattuna saariin, joissa on vapaa maihinnousu. Viimeksi mainituilla saarilla populaation kasvu oli kuitenkin voimakkaampaa tutkimuksen alkuvuosina. Tuloksista käy ilmi, että saarten parimääriin vaikuttavat tärkeimmät tekijät ovat saaren koko ja se, kuinka pitkään valkoposkihanhet ovat saarta asuttaneet. Lisäksi parimäärää ennustaa myös saaren etäisyys Helsingin kaakkoispuolella olevista Pormestarinluodoista, joista kannan levittäytyminen saaristoon alkoi. Lähempänä alkupistettä olevilla saarilla on enemmän pareja. Saaren suojelulla ei ole vaikutusta pesivien valkoposkihanhien määrään tai tämänhetkiseen pesimätiheyteen.

Tulokset osoittavat, että keväällä varhain pesivät lajit kuten valkoposkihanhi, eivät välttämättä erityisesti hyödy saarten suojelusta, koska saarten virkistyskäyttö keväällä on vähäistä.

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Online supplementary material

Supplementary Fig. 1 shows the year of the first breeding attempt of Barnacle Geese at each island. Supplementary Fig. 2 (a–c) shows the distribution of breeding Barnacle Goose pairs in the years 1996, 2005 and 2013.