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Impact on breeding birds of a semi-offshore island-based windmill park in Åland, Northern Baltic Sea

Effekten på den häckande fågelfaunan av en vindkraftspark på småöar på Åland, norra Östersjön

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Abstract

Breeding bird populations were monitored at a windmill park on Båtskär in southern Åland archipelago 2006–2011. The area is in the outer archipelago and consists of four islands holding six windmills. The operation of windmills started during fall 2007. An environmental impact assessment for the area was done in 2002. The area holds 850–1050 pairs of breeding birds annually. Two species had significantly decreasing trends, namely herring gull Larus argentatus (annual decrease 6.9 pairs, p=0.003) and lesser black-backed gull Larus fuscus fuscus (annual decrease 2.8 pairs, p=0.004). The reason for the decline of the herring gull population is unlikely to be related to the windmill park. However, the close proximity of a windmill to the breeding colony of lesser black-backed gull has most likely contributed to their decline. Some species like swallow Hirundo rustica, house martin Delichon urbicum and auks Alcidae have benefitted of the construction of the windmill park and utilize new small environments created by the construction.

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Background

During the last decade, wind power has been built increasingly on land, shores and large islands, with a current trend to build more offshore parks. Semi-offshore building on small islands and islets is rare; only few areas in the world have such possibilities, as are found around Åland.

The effects of wind power on birds have been studied mainly in North America and Europe, and these studies have mainly dealt with the impact of small units having a nominal capacity of less than 1 MW. Studies have dealt with raptors (Carwin et al. 2011, Lucas 2008), breeding birds on farmland (Pearce-Higgins 2009) and wintering birds (Devereaux 2008, Larsen & Guillemette 2007). Some studies have concentrated on bird collision (Desholm et al. 2006, Hüppop et al. 2006, Petersen et al. 2006, Drewitt & Langston 2008). Effects on coastal breeding terns have been studied in Belgium (Everaert & Stienen 2007), but studies of breeding birds on small islands having large (>1 MW) wind turbines are lacking. In the Baltic Sea area studies from Sweden (Petterson 2005) and Denmark (Petersen et al. 2006) describe results from offshore parks.

Desholm (2007) presents a model to examine different species' sensitivity to increased mortality due to windmill parks. Although knowledge of the effects of wind power on birds is increasing, local conditions may result in very different effects on local and migrating bird populations.

Selecting sites for windmills should incorporate economical and ecological aspects (Haaren & Fthenakis 2011) and the cumulative impacts of several windmill parks must be assessed (Carrete et al. 2009, Masden et al. 2010). In these decisions making processes all available information on the risks of wind power to birds is valuable.

The aim of this paper is to present a summary of the results of breeding bird counts in a semi-offshore windmill park in the northern Baltic Sea, and discuss the impacts of windmills to breeding bird populations.

Windmills

The park consists of six Enercon E-70 2.3 MW units, with hub height 64 m and rotor diameter 70 m. In 2010, the electricity production was between

Figure 1. Map of the Båtskär archipelago with the location of the windmills.
Karta over Båtskärs öar och vindkraftverkens placering.

6.1–6.4 GWh per unit. The construction begun during autumn 2006 and the park was in production in late fall 2007. The area is one of the windiest in Finland and the dominant wind direction is from south west.

Area

The area consists of a group of five islands or islets, south of Åland in the Baltic Sea (lat 59° 57.736', lon 19° 57.384') at the edge of open sea (Figure 1). Baltic Sea is a brackish water area that has practically no tide. The smallest islet Österbådan (0.5 ha) is swept over in storms and has no breeding birds. Two smaller islets Ryssklubben (1.5 ha) and Kummelpiken (3.1 ha) have open rock, ground vegetation and small bushes in sheltered places. There is one windmill on both islets. On Kummelpiken there is a stone field on the south side and on Ryssklubben there is a small mire.

Lilla Båtskär (5.1 ha) has been heavily exploited by man. It had earlier a pilot station and an iron

Figure 2. View from the roof of the mine tower to north. In front Lilla Båtskär's harbor and in the background Stora Båtskär.
Vyn från gruvtornet mot norr. I förgrunden är Lilla Båtskärs hamn, i bakgrunden Stora Båtskär.

mine, which was built in the 1950s but operated only a couple of years. The island has a sheltered harbor with substantial breakwaters and a few service buildings: a large main building to host the pilot station on the top of the island and a 33 m high mine tower. Most of the island is altered by man, with gravel fields and exploded rock with some vegetation, bushes and single trees. On the west side there is open natural rock. The island is a popular leisure boating destination during summer due its excellent harbor (Figure 2). The windmill is placed on the south side of the island. During 2011 a new test place for smaller wind power units was built on the north-west shore of the island.

Stora Båtskär (15.3 ha) is clearly the biggest of the five islands. There is an old pilot station from the 20th century, which has recently been renovated and will later hold a museum. The island has higher rocks and deeper shores on the northern side and has sheltered bays on the southern side. There are some small skerries in the sound between Lilla and Stora Båtskär. The island has small ponds that partly dry in hot summer periods. There are large areas of mire and moor vegetation (such as heather and juniper scrub). Some sheltered places hold birches, common alders and rowans. Three windmills are located on the island, one at the east end, one at west end and one in the center on northern higher rocks. By the central windmill there is a switchgear station and open insulated wires connect two other windmills to it. Tracks for four-wheelers are built between the units, and these tracks run on the bare rock with wooden bridges leading over small gorges. The water areas around Stora och Lilla Båtskär belongs to a small nature reserve.

The area is surrounded by three shipping channels carrying traffic between Mariehamn in Åland, Turku in Finland and the rest of the Baltic Sea. The channel on the northern side runs through a narrow sound. Every time a large vessel passes the sound, heavy currents first suck water from the bays of Stora Båtskär and then the water flows back soon after the vessel has passed. Traffic of large vessels is responsible for most of the erosion on shores and sheltered waters in the Archipelago Sea, as there is no tide, and natural currents thus depend mostly on winds and air pressure.

As a control, a planned windmill park "Stenarna" 22 km NW from Båtskär was used. Stenarna is a group of six islands and islets. It is similar to Båtskär but the disturbance level due to boating etc. is very low and the islands are further apart.

Material and methods

We did bird counts three times a summer, in early May, June and July. The method was adapted from Hildén et al. 1991, with the exception that for each round, birds were counted early in the morning from the roof of the mine tower with a telescope and binoculars, and also walking around all islands. The tower count gave good estimates for black guillemots *Gepphus grylle*, razorbills *Alca torda* and sea ducks like velvet scooters *Melanitta fusca* and eiders *Somateria mollissima*, whereas waders, passerines, gulls and terns were best spotted from ground level. When calculating the results, the higher figure of each species was used. For most of the species, the number of pairs was counted by dividing the maximum number of adult individuals by two, which gives a good estimate. When extraordinary high numbers of birds was observed at one of the three visits, half of the highest count exceeding the second highest one was assumed to represent migrants or locals from nearby areas. We noted nests and broods of all species during the counts. We counted nests of eider, herring gull *Larus argentatus* and greater black-backed gull *Larus marinus* in May and lesser black-backed gull *Larus fuscus fuscus* in June. Bird carcasses around the windmills were monitored during all visits. The numbers of breeding pairs from year 2002 are from the EIA report (Anon. 2002). Båtskär were surveyed in 2002, and in 2006–2011. Stenarna (control) was surveyed in 2006 and in 2009–2011.

Linear regression was used to examine the effect of operation of the windmill park (operation=0 for years 2002, 2006–2007 and operation =1 for years 2008–2011), and year on changes in population sizes for bird species having at least one year with 20 or more pairs in the area (7 species). For the same seven species Mann-Kendall test for trends were calculated. The Bonferroni correction for significance level 0.05 resulted in a corrected level of 0.007. Shannon index was calculated ($-\sum p_i \ln p_i$, where p_i is the fraction of pairs of species i) for each year for the whole area and for all species. Analyses were made with SPPS 19 (IBM corp.) and R 2.11 (www.r-project.org).

Results

Båtskär

The total number of breeding pairs varied from 844 to 1047 (Table 1). The most abundant species during the survey period were black guillemot (307–398 pairs in 2002–2011), eider (188–229 pairs) and razorbill (149–210 pairs). These three species

Table 1. The number of breeding pairs in Båtskär windmill park. The years that the windmill park has been operating are marked with a grey background.
Antalet häckande par I Båtskärs området. De åren vindkraften har varit i gång är i tabellen märkta med grå bakgrund.

Year	2002	2006	2007	2008	2009	2010	2011
Eider	200	211	212	198	188	193	229
Wildfowl excl. eider	32	21	21	26	26	23	32
Waders *vadare*	10	9	5	6	5	4	6
Arctic skua *kustlabb*	1	1	1	0	0	0	0
Common gull *fiskmås*	116	51	60	61	62	62	81
Herring gull *gråtrut*	55	18	19	22	19	12	10
Lesser black-backed gull *silltrut*	49	47	37	40	30	28	26
Greater black-backed gull *havstrut*	4	2	1	1	1	1	1
Arctic tern *silvertärna*	51	37	35	28	15	24	68
Black guillemot *tobisgrissla*	337	355	398	352	333	307	333
Razorbill *tordmule*	165	210	196	195	175	149	190
Passerines* *tättingar*	27	47	52	44	44	41	37
Total	1047	1009	1037	973	898	844	1013
Breeding species *häckande arter*	29	26	28	28	27	26	25
Breeding species with five or more pairs *arter med fem eller fler par*	13	11	11	12	12	12	11
Shannon index	2.05	1.91	1.87	1.92	1.89	1.89	1.92

*Black grouse (0–1 pairs per year) is included in the numbers of Passerines. *Orre (0–1 par årligen) ingår i tättingarnas antal.*

covered 75–80% of all breeding pairs in the area. Common gull *Larus canus* was the most abundant gull (51–116 pairs) and arctic tern *Sterna paradisaea* (15–68 pairs) was the only tern breeding in the area. The commonest passerines were house martin *Delichon urbicum* (7–18 pairs) and swallow *Hirundo rustica* (4–16 pairs).

The black guillemots were breeding mostly in the stony breakwaters of the harbor of Lilla Båtskär, and to some extend also in man-made landing places on other islands. Most eiders bred on Stora and Lilla Båtskär. The razorbill utilized man-made landing places with large stone blocks and natural gorges and stone fields.

Regression analysis did not give any significant results when testing either before or after operation. Year was a significant predictor for one decreasing species, herring gull (B=-6.9, p=0.003). A simpler model with only year as predictor gave significant result also for lesser black-backed gull (B=-2.8, p=0.004). Mann-Kendall test for trends gave significant trend (decrease) only for lesser black-backed gull (tau=-0.905, p=0.007). The composition of the avifauna did not change during follow-up; Shannon index varied from 1.87 to 2.05, the number of breeding species was between 25 and 29 and the number of species with five or more pairs between 11 and 13.

Seven carcasses of birds that had collided with the windmills were found in four years: four herring gulls (two adults and two juveniles), two white tailed eagles *Haliaeetus albicilla* and one arctic tern. One crow *Corvus corone* cornix had clung to power lines between units on Stora Båtskär. Thus, the total number of observed carcasses due wind production was eight, two per year.

Stenarna

The control area Stenarna had a smaller number of breeding pairs (between 306–352 pairs). In Stenarna the most abundant species were black guillemot (120–156 pairs), arctic tern (50–103 pairs), eider (28–61 pars) and common gull (24–37 pairs). The razorbill was lacking from this part of archipelago (0–1 pairs yearly) and swallows and house martins were missing because there are no buildings.

Discussion

When trying to identify the effect of one specific factor, in this case of windmills, it is always possible that other factors may confound the results. Spring hunting on eider males was reintroduced in 2011 in Åland, and it is known from elsewhere that this kind of disturbance can have impacts on breeding site selection of eider females. But in Båtskär there was no hunting. Another factor could be a shift in human presence in general. But, as described above, all three most abundant species, the eider and the auks, clearly benefitted rather than suffered from human activities and/or constructions in the area. On Lilla Båtskär incubating females were very tame and used to humans working in the area. It seems that breeding close to buildings and even in buildings where human activities are often present protects incubating females from predation by white tailed eagles.

The decline of the herring gull colony on Båtskär can be related to the closing of the last rubbish tip in Åland on New Year 2006/2007. Rests of human food packages were commonly found in the colony in 2006, but in 2011 there were no signs of any usage of human waste in the colony. Another reason to decrease can also be that the large scale elimination of herring gulls at rubbish tips in the Finnish mainland has decreased the number of new recruits in Åland. Systematic elimination of herring gulls has led to a clearly decreasing population for example at the Gulf of Finland (Hario et al. 2009). Ringing recoveries have shown, that many first summer herring gulls move from Åland towards east and visit these rubbish tips during late summer and autumn before migration to wintering areas.

The lesser black-backed gull colony is close to the windmill on Kummelpiken but did not change its place due to construction. However, there were two strong declines, one by 21% in 2007 and another by 25% two years later. Then decline has continued but at a lower rate. The decline of this species cannot be explained by the closure of the rubbish tips since no food rest were found in the colony in any years. It is possible that some pairs did not adapt to the windmill and moved to other colonies. Observing the colony from the Lilla Båtskär's mine tower did not show any disturbance due to windmill and no lesser black-backed gull carcasses were found in 2008–2011. There was no construction work going on where the lesser black backed gulls breed during the breeding season 2007 and thus possible impact on breeding population may have come from work on other islands.

When looking at the total number of breeding pairs and their relative changes there was some decline in both areas in 2009 and 2010 and increase in 2011 (Figure 3). This suggests that reasons for changes may be outside these limited areas of the archipelago, possibly wintering conditions or

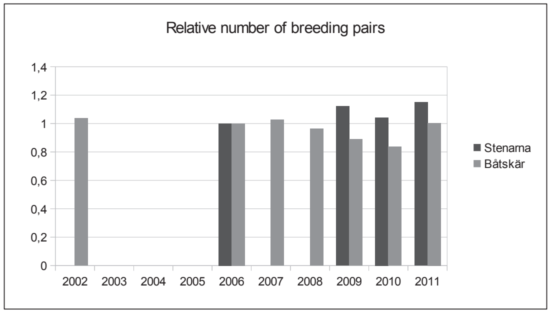

Figure 3. The relative number of breeding pairs, 2006=1. *Det relativa antalet häckande fågelpar; år 2006 motsvarar ett.*

breeding success of these species in larger areas during earlier seasons. The winters 2009–2010 and 2010–2011 were cold in northern Europe and the ice cover of the Baltic Sea was more extensive than for years (240 000 km2 in 2009–2010 and 315 000 km2 in 2010–2011; www.itameriportaali.fi). This may have caused some increased mortality to overwintering birds in the Baltic Sea. Almost all black guillemots and razorbills overwinter in the Baltic basin.

Carcasses were sought only during three breeding bird counts and thus the number of found carcasses is a clear underestimate of real deaths due to collisions (Krijgsveld et al. 2009, Huso 2011). In this part of the outer archipelago there were no observations of foxes or other mammals which eat carcasses during 2006–2011. Thus carcass removal is limited to birds, mainly to larger gulls, crows, ravens *Corvus corax* and white tailed eagles. The landscape is fairly open and not too difficult for searching for carcasses. Smaller carcasses like small passerines disappear faster than for example gulls of which some remains are found long after death. The carcass search covered spring and early summer, but one carcass search should have been done in late summer after the breeding season. The results show that collision is not a major threat for local breeding birds. The first collided white tailed eagle was a second calendar year bird from Sweden and the other was a 15 years old bird born in the Archipelago Sea, Finland. Both birds are assumed transients, not local birds.

Conclusions

This case shows that building wind power close to bird colonies can have relatively low negative impacts on local breeding avifauna. The local wildfowl fly very low close to colonies and the three most abundant species in Båtskär, black guillemot, eider and razorbill, are not in significant risk for collision. Gulls and terns show larger collision risk and this risk becomes active especially during sudden disturbances like boaters walking on islands with unleashed dogs or during white tailed eagle's hunting. During normal operation and weather conditions, local gulls and terns seem to avoid rotating blades well.

Disturbance and habitat loss may have caused the decline of lesser black-backed gull, a species that is classified as vulnerable in Finland (Mikkola-Roos et al. 2010). The building of this windmill park has also created some new small environments like sand roads, stony landing places and restoration of old houses. These activities have been beneficial at least for auks, eiders, swallows and house martins. The coin has always two sides and careful planning can increase the positive effects while diminishing the negative ones. Long follow-up studies are needed to discern any long term effects of wind power production.

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Sammanfattning

Jag följde den häckande fågelfaunan i Båtskärs vindkraftpark i Ålands yttre skärgård mellan 2006 och 2011. Området består av fyra holmar på vilka det årligen häckar 850–1050 par fåglar. Området undersöktes också år 2002 för MKB. Två arter uppvisade signifikant minskning i området; gråtrutens stam minskade från 55 par 2002 till 10 par

2011, en årlig minskning med 6.9 par, p=0,003. Orsaken till gråtrutens minskning var sannolikt stängningen av Mariehamns soptipp i Ödanböle, Jomala och dödandet av trutar vid flera soptippar på fastlandet i Finland. Silltruten minskade från 49 par 2002 till 26 par 2011, en årlig minskning med 2,8 par, p=0.004. Orsaken till silltrutens nedgång var troligen byggandet av ett vindkraftverk nära silltrutkolonin. Möjligen har en del trutar lämnat kolonin efter bygget startade men sen dess har stammen varit ganska stabil. En del av arterna har gynnats av byggandet, sådana arter är till exempel hus- och ladusvalor, ejder samt tobisgrissla och tordmule. Dessa arter utnyttjar de nya omgivningarna som exempelvis grusfält, stenpirar och renoverade byggnader och det skydd, exempelvis mot havsörn, som mänskans närvaro ger. Som helhet har byggande av vindkraftparken haft både för- och nackdelar för den häckande fågelfaunan.