NINA Rapport 239

Hubro on Karmøya and wind power

Nils Røv
Karl-Otto Jacobsen

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Norwegian Institute for Natural Research

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Nils Røv
Karl-Otto Jacobsen

Røv, N. & Jacobsen, K.-O. 2007. Hubro on Karmøy and wind power.
– NINA Rapport 239. 36 s.

Trondheim, mars 2007

ISSN: 1504-3312
ISBN: 978-82-426-1799-6

AVAILABILITY
Open

PUBLICATION TYPE
Digital document (pdf)

EDITORIAL
Nils Røv and Karl-Otto Jacobsen

QUALITY ASSURED BY
Inga E. Bruteig

RESPONSIBLE SIGNATURE
Research manager Inga E. Bruteig (sign.)

PRINCIPAL
Hydro

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KEYWORDS
- Karmøy, Rogaland
- Hubro
- Wind power
- Impact assessment

KEY WORDS
- Western Norway
- Eagle Owl
- Wind power development
- Impact analysis

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Summary

Røv, N. & Jacobsen, K.-O. 2007. Hubro on Karmøy and wind power. – NINA Report 239. 36 p.

In connection with the plans for the construction of the Karmøy wind power plant, we have carried out an investigation into the hubbro's status, and summarized relevant knowledge about the species' biology and the factors that threaten the species today. We have also discussed the significance of an ev. development can have for the hub population and which mitigating measures can be implemented. As a result of long-term decline, hubro is
the population in Norway is now categorized as Highly Threatened (EN) in the new Norwegian Red List. Past and present population estimates are believed to be far too high. Elsewhere in Europe, where the population has been in decline, conservation measures together with extensive breeding and the release of young birds have led to a recovery in the population in several countries. Death by electrocution by electr
risky installations (electrocution) are the most important threat factor for the hub bridge both in Norway and the rest of Europe. The species is very vulnerable to human activity at the nesting site until the young are half-grown. If it is not exposed to such disturbances and there is good access to prey, the hubbro can adapt to a way of life in densely built-up areas. Although it is very
insufficient knowledge about hub bridges and wind power, there are six documented hub bridges killed by windmills in a limited area in Germany. The hubroen's biology and hunting behavior means that it is believed to be vulnerable to the development of wind power plants. It is considered very likely that at least two hub territories will be destroyed and abandoned on Karmøy in the event of a possible development of the wind power plant. The most important mitigating measure will be to change the most dangerous parts of the electricity grid to reduce the risk of electrocution. Facilitation of traffic and care of heathers and grazing landscapes will also be required
interpretation.

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Abstract

Røv, N., K.-O. Jacobsen. 2006. Eagle Owl and Wind Power development at Karmøy, Western Norway. - NINA Report 239. 36 pp.

Due to a long-term population decline, the Eagle Owl has now been reclassified as endan gered (Norwegian Red List 2006). It is believed that until recently the population has been con siderably overestimated. Electrocution is probably the most important mortality factor in Nor way, as well as in other European countries. Although collision with wind turbines is poorly known for Eagle Owls, it is concluded that disturbance and collision risk may significantly affect at least two breeding pairs within the windmill development area at Karmøy. Territory aban donment is considered likely.

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Preface

In August 2006, Haugaland Kraft together with Hydro applied for a license to develop the Karmøy wind power plant. A professional report on the consequences for biological diversity was attached
the application. This was prepared by AMBIO Environmental Consulting in 2005, where it was assumed that development no one could have negative consequences for the hubrob population on Karmøy. In the Norwegian Red List 2006 which was published after the license application was submitted, the hub bridge was classified as very difficult threatened. With this background, the initiative owners wanted to have a concise overview of current knowledge about the hub bridge drawn up as a basis for being able to assess possible conflicts between hub
peace and development of wind power. Following a request from Hydro, NINA took on the task of creating such a study.

Thanks to Stein Byrkjeland, Espen Dahl, Arnt Kvinnesland, Bjarne Oddane, Jon Opheim, Martin Pearson, Arild Pfaff, Rune Roalkvam, Ingvar Stenberg and Ole Jakob Vorraa who have contributed with unpublished knowledge of the hub bridge.

We also thank the client Hydro for an interesting and important assignment.

Trondheim, 6. mars 2007

Nils Røv
Karl-Otto Jacobsen

1 Introduction

There is political agreement to invest in wind power development along the Norwegian coast. Initially, it was assumed that this would represent a way of producing "green" energy without major environmental conflicts. However, experience so far shows that wind power plants can have disturbing consequences, which the situation with the discovery of dead sea eagles on Smøla is an example of.

The hubroen's critical population situation and spread along parts of the coast have now led to the species coming into focus, among other things. in connection with wind power development. Currently, a license has been applied for two developments in two of the hub bridge's core areas in the country, Sleneset in Nordland and Karmøy in Rogaland. In both cases, the builders want a closer investigation by NINA about the hub bridge
in relation to wind power.

The aim of this report is briefly the following:

- Provide a status overview for hubro in Norway and elsewhere in Europe.
- Summarize relevant knowledge about the biology of the species.
- Clarify threat factors for the hub population.
- Explain the significance of the development area on Karmøy for the hub bridge locally and regionally.
- Investigate likely scenarios for the hub bridge in the event of a possible development at Karmøy.
- Discuss mitigation measures.

The work is mainly based on published literature, but to some extent unpublished information and reports have also been used. An inspection was also carried out in the development area on 30 January 2007, together with Ole Jakob Vorraa and Tor Asbjørn Aslaksen Simonsen from
Karmøy municipality.

2 Hubroen's biology, hunting and escape behaviour

The hubro is nocturnal, but starts its activity already in the evening before it gets dark, and is fast
sat actively in the gray light in the morning. In the northern parts of the country, it hunts in the summer, luckily enough,
also while it is light, which it can exceptionally do otherwise. The hubro is a very diverse hunter that finds its prey using
both sight and hearing. Hearing is special
well developed with asymmetrical ears and disc-shaped feather wreath around the face that makes it
possible to both judge the distance and determine the direction of the sound source. The anatomy of the eyes is also very
special. The hubro cannot move its eyes inside its eye sockets, but can instead turn its head 270ÿ around. It can modify the
focal length like a zoom telephoto lens and thus achieve very sharp vision also at night (e.g. Mikkola 1983). The hubroen's
specialized vision may be a reason why it is vulnerable to collisions with man-made structures such as cables and links

nings, barbed wire fences etc. It is also exposed to collisions with moving objects such as cars and trains. It is therefore an
open question how exposed the hub bridge is to collisions with wind turbines, and whether the sound from the windmills
can interfere with the hub bridge's use of hearing.

The hubro shows extreme variability in prey selection, suggesting that it uses many different techniques to locate and
capture prey (Willgohs 1974). There are few descriptions of hunting hubbro, both because it is nocturnal and moves over
large areas (Piechocki 1985). It uses two different hunting methods in particular: 1). Post hunting, sitting on an elevated

hunting post, usually completely motionless but turning its head occasionally to locate a possible prey. 2). Flying over the
landscape, in forests often above the treetops. During such hunting, it can detect and pounce on sleeping prey both in the
trees and on the ground. The hubro's "loose" plumage enables flight
is silent so that it can effectively surprise its prey. It is a very skilled flyer and can search
over large areas. Often the two methods are used interchangeably (Piechocki 1985). Hubroen has one
extreme adaptability and can be found in many different biotopes from desert to forest and arctic tundra.
It has the ability to adapt its hunting to the terrain, and most often hunts from low or moderate heights.
Willgohs (1974) describes the hubro's low hunting flight on the Helgeland coast when it hunts for eel. In position hunting,
the hubbro usually moves every 5 minutes to a new hunting position 50-
100 m away (Cramp 1985). This way it can scan the terrain. Ole Jakob Vorraa (pers. comm.) has observed the hubro's
hunting flight over the heather on Karmøy. It often flies at a height of 10-15 meters, then suddenly dives down towards a
smaller prey (frog, toad or rat) that swallows
is given on the spot before continuing the escape hunt.

Willgohs (1974) demonstrated many seabirds as prey for hubro at a locality in outer Sogn, and claimed that a part of these
must necessarily have been caught at sea. He raised the question of whether the hubbro can carry out so-called "wet
hunting" in the same way as sea eagles. The hubro was seen sitting on reefs out in the sea, and it often hunted seabirds
along the beach. Incidentally, fish is included as part of

hubro's prey both in Norway and Sweden (Willgohs 1974, Olsson 1979). According to Cramp (1985) the hubro can catch fish by striking directly into the water like an osprey. Vorraa (pers. comm.) has also found prey remains of seabirds on Karmøy, i.a. of sea urchin, eider and herring. This is species that rarely stay on land, sea urchin probably never at Karmøy. This may support the assumption that the hub bridge can strike prey at sea. Vorraa goes on to say that he has seen hubbro fly over a stretch of open sea of 5-6 km from Karmøy to Ferkingstadøyane to hunt rabbits and seabirds. There is reason to believe that the grebes that nest inside the island regularly fly down to the sea's edge and patrol the beach zone. It is also known that the hubro can hunt and pursue its prey in open air. Arne Follestad (pers. med.) has second-hand information about a hubbro chasing a greylag goose in the air. Cramp (1985) also mentions that hubbro can hunt birds in the air, and that it has been observed that it has caught shot birds in the air before they have reached the ground.

A telemetry study of young grebes in Switzerland (Aebischer et al. 2005) showed that they sometimes crossed mountain ranges and passes of up to 2500 m. In several cases, the birds flew over mountains over 3000 m. It is known that during long-distance movements, the grebe can turn rise to greater heights on upward air currents. According to Snow & Perrins (1998), hub bridges such as is startled, turns up to a great height and sails on the air currents like a wake.

The home range of a hubro pair can be extensive, often up to 10 km in diameter (Mikkola 1983). A radio-tagged adult male in Bavaria had a total home range of 20 km2 in winter and 9 km2 in summer . The core areas (where most of the activity took place) were smaller, 14 and 6 km2 respectively (Sitkewitz 2005). When the territory is marked, hub

roen move between singing posts along the borders of the territory (the area that is defended against neighbors and possibly intruders) which often has a radius of 4-5 km (Olsson 1979). The individual hubbros recognize each other by their calls due to individual differences that do not change from year to year. In this way, the mates can recognize each other and their neighbors by the sound, and identify foreign intruders in the territory (Lengange 2005). The hubro's "calling" is most often heard before egg-laying in late winter, but it can be heard all year round. Often it can have an active period in autumn. The hubro calls most at sunset and sunrise. Also young birds trying to establish their own territories can call in the spring even when they are not yet ready to nest.
While solitary male hubbubs can be very active, stationary pairs without close neighbors often can make little noise. The Hubro is strongly territorial and the pair is usually faithful to its nesting area. The mates stay together for life, but when one dies, a new mate will come in (probably a young bird).

In Norway, egg-laying starts in March-April. The 1-4 eggs (usually 2-3) are laid in a pit on the ground, preferably in a rocky landscape, most often close to or under an overhanging cliff.
The female incubates for 32-36 days and looks after the young while they are small. After 3-4 weeks the young leave

the nest and begins to wander around the nest area. After around 50 days, they can make their first move
t attempt to fly, and after a week of training the ability to fly is quite good. At the age of 70 days, they are able to catch prey themselves, but are still dependent on their parents until they are 20-24 weeks old, with us usually in September-October. In case of successful nesting, 1-2 young usually grow up (Cramp 1985, Hagen 1952, Mikkola 1983, Piechocki 1985). If the first clutch of eggs fails, the hubbro can lay eggs again, most often in another nest pit nearby, but sometimes as far as 1-2 km from the first nest. There are also reports that the hubroen

can move their young when disturbed.

The young birds leave their parents' territory at the age of 21 – 29 weeks. In the spreading phase it is found that they can cover 4 - 35 km per night, without any preferred direction of movement (Aebischer *et al.* 2005). After a period where the young birds search the terrain, they will normally settle in a relatively stable and defined area (settlement area). First winter
they then establish a "home-range" in an area outside of territorial pairs. The core areas of young birds can enclose (overlap) to some extent, often more than 50%. These areas correspond to the territories of breeding pairs. While in the past it was assumed that the hubbro only starts nesting after 3-4 years, telemetry studies have now established that the young birds can nest already in their first year of life, although this is probably not the most common. It has been established that barely one year old

Hubro females have laid eggs and successfully nested (Delgado & Penteriani 2005). In a study of two radio-tagged hubroung chicks in the Czech Republic (Mrlikova & Peske 2005) found that they established winter territories of 1 and 2 km2 between established couples. They showed marked nesting behavior al muddled as yearlings, with vocalization (sound utterances) and scraping of nest holes. It is concluded that such young territorial birds can be confused with nesting birds and that their nesting behavior can be misinterpreted as failed nesting.

3 Hubrobestanden i Europa

According to the most recent international status overview published by BirdLife International (2004), the European breeding population is between 19,000 and 38,000 pairs (including Turkey, Eastern Europe and European Russia). For several countries, the estimates are very uncertain. The species has the status of "depleted" due to the significant decline in the period 1970-1990. We will take a closer look below
more on the situation in some selected countries.

Sweden: In the years until the hub bridge was protected in 1950, the persecution of the species was so strong that it was almost extinct in large parts of the country. Only in a smaller area on the east coast did one survive
efficiently reproducing stock. Since the 1940s, six nationwide inventories have been carried out
rings, the last in 1998-1999. An extensive breeding and release project started in 1969 and up to 1999, 3,381 young birds have been released throughout the country. Although the mortality of the released birds was high, this led to the hubbro re-establishing itself where it had disappeared and the population gradually increased throughout the country. Around 1980, the population exceeded 200 inhabited areas, and rapid growth followed. In the last 10-15 years, extensive measures have also been implemented to reduce mortality at power lines, e.g. through positive cooperation with the electricity companies. While
the hub bridge in Sweden was previously threatened with extinction, today it has status as requiring attention
on the national red list. In 1999, over 600 occupied areas were registered, with an estimated ef
effective breeding population of about 500 pairs (ArtDatabanken 2006).

Finland: In the 1960s, 500-1000 pairs of grebes nested in Finland. Since then, the population gradually increased until it reached a maximum in the 1980s of around 2-3000 pairs. However, the monitoring program for birds of prey has shown that both population and reproduction have declined over the past 20 years (Valkama & Sau rola 2005). An important reason for the increase in numbers of the hubbro in Finland is believed to be the large populations of rats that were found at the many uncovered rubbish dumps in the country. As time goes by
when the landfills were covered, an important part of the hub bridge's nutritional base disappeared.

Germany: There has mainly been an increase in the hubber population in Germany over the past four decades. By the 1950s, the population had been reduced to a very low level of only about 70 occupied territories. Recent registrations have now given a population estimate of around 1,100 territories. According to the ongoing population monitoring for owls that has taken place since the 1980s, the population is still increasing. Nevertheless, it is assumed that the population will never rise to the level of the population estimates for the 17th century (estimated around 2,500 pairs), primarily because of today's area
use, secondly because negative tendencies have now been registered in southern Germany, especially in Bavaria where there has been very low nesting success (0.42 - 0.64 young per territory). The reason for the re-establishment in many areas and the general increase is extensive conservation and management
ning measures together with breeding and release (Lanz & Mannen 2005).

Switzerland: The hubro was formerly widespread in the Alps, in the Jura Mountains and parts of the lowlands. The stock went drastically back in the late 19th century, and a few decades later it was extinct. Only after total protection in 1925 did the situation improve. In the 1980s, the species established itself in several places, but several nesting sites had an unstable presence. And in several places a decline followed, despite very good nesting success. Today, around 100 pairs breed in the country (Aebischer et al. 2005)

Czech Republic: The Hubro has always bred widely in the Czech Republic, up to 1,000 meters above sea level. The population was at its lowest at the beginning of the 20th century. After conservation in 1929, the population slowly began to increase again. The largest number was in the late 1980s. In West Bohemia, the population decreased from approx 150 pairs to 50-100 pairs in the period from 1990-93 to 2003 (Schröpfer et al. 2005). In total, it is assumed that there are 600-800 breeding pairs in the Czech Republic around the year 2000 (BirdLife Internasjonal 2004).

Other countries with significant breeding populations include: Austria (400-600 pairs), Croatia and Bosnia-Herzegovina (500-1000 pairs), France (1000-1200 pairs), Greece (200-500 pairs), Portugal (250-500 pairs), Romania (750-1000 pairs), Azerbaijan (100-1000 pairs), Serbia (450-700 pairs), Spain (2500-10000 pairs), Russia (3000-5500 pairs) and Turkey (3000-6000 pairs) in accordance with BirdLife International (2004). It can also be mentioned that in Denmark, where the hubbro was exterminated at the end of the 19th century, the species has immigrated again, from Germany where many birds have been released from

breeding. The population is increasing and now numbers around 30 pairs, all in Jutland (Ministry of the Environment, internet). In contrast, the situation is more uncertain in the Netherlands, where there are currently only 1-2 pairs (BirdLife International 2004),

4 Hubroen's status in Norway

No nationwide mapping of hub bridges in Norway has been carried out. Except
parts of Eastern Norway (Fremming 1986), Rogaland (Roalkvam 1985) and Troms (Jacobsen 1986),
nor have county-wise registrations been made. Some good basis for calculating the total Norwegian breeding stock has therefore never been present. The available estimates are all based on assumptions, often based on knowledge of local conditions. The raptor biologist Yngvar Hagen made population estimates for golden eagles and white-tailed eagles in the 1970s, which later studies showed to be very realistic (Hagen 1976). They were based on general knowledge of species
nes biology and distribution, and information from the game boards in various parts of the country. The garden (1964) estimated the Norwegian hubrob population at 500-600 pairs in 1963. JF Willgohs who, among other things, carried out thorough studies of the hub bridge in Western Norway, indicates, however, that the Norwegian breeding population has been estimated at more than 1,000 pairs, but he does not state how this estimate was arrived at (Willgohs 1979).

In the 1980s, an article was published about the hub bridge in Rogaland, where attempts were also made to a stock estimate for the whole country (Roalkvam 1985). The estimate is based on a study in Rogaland from around 1980, when 128 older and newer hubro locations were registered. The information was entered collected via contact with ornithologists and permanent residents in the districts, as well as appeals in the local press and the local ornithological journal "Falco". In this way, the author was able to form a car de of the species' distribution and number in Rogaland. It is not clear how many localities
ne that were inhabited in the period in question, but most of the information allegedly came from "the very last years", and only a few localities were said to have been abandoned. On the basis of these data, the author makes assumptions about neighbor distances between nesting pairs and the distribution of the hubbro in
lesser known parts of the county. Based on this, a population estimate of "over 100 breeding pairs, perhaps around 150 pairs" is arrived at. Furthermore, the author says: "It seems likely that tetthe
ten of hubro in the oceanic heaths along the entire west coast of Norway north to Troms is off
the same order of magnitude as in outer Rogaland." The conclusion is that with the above assumption "we will easily reach 2,000 couples with hubbro in Norway." Roalkvam's work was later referenced in the Fugleatlas for Rogaland (Carlsson *et al.* 1988), although the authors of this book state a
some doubt that the situation is possibly not so positive.

In the years that follow, Roalkvam's calculations are constantly referred to. In the mention of hubbro in the Norwegian Bird Atlas (Solheim 1994) it is assumed that there are 1400-2000 breeding pairs in Norway, and that both population size and development have been stable for the period 1970-1990. In the Norwegian Winter Bird Atlas, Solheim (2006) writes that there are still between 1,400 and 2,000 pairs of grebes breeding in Norway, without making any critical assessments of the species' current status. This estimate also exists

basis for the international population assessments of BirdLife International (2004) and the represen
therefore undermined the official view of the species' status in Norway.

4.1 Regional population estimates and development in Norway

In his classic "Rovfuglene og Viltpleien" Yngvar Hagen (1952) says: "For a couple of human ages
since then, the hubbro as a common breeding bird was widespread practically over all forest and mountain tracts in the whole of Norway up to the species' natural northern limit. Later, however, conditions have changed a lot, at least in southern Norway." And further about the Trøndelag counties: "At Hitra, the occasional pair breeds, while the hubbroke seems to have declined strongly in many places in South Trøndelag. In Nord-Trøndelag, too, it has long been so strongly sought after that, in relation to this county's large
tracts of forest and large wastelands must say there is a relatively sparse hubro population there."
The author concludes as follows: "In short, the hub bridge in Norway has been in constant decline for the last 100 years - but undoubtedly most strongly in the last 40-50 years. In the mid-1970s, Willgohs (1977) points out that the species appears to have been seriously threatened in parts of southern Norway in the last 10-15 years. Eastern Norway is mentioned in particular, but he points out that from around 1970 it seems that the same thing has also happened in parts of the coastal areas in Western Norway, while the situation for the hub bridge
in Trøndelag and Nordland is still stable.

Eastern Norway: On the basis of extensive registrations under the auspices of "Prosjekt Hubro" (World Wildlife
Found in Norway), Fremming (1986) concluded that the stock in Eastern Norway per 1980 was 60 - 240 occupied localities. This was a significant population decline from the original 1,100
couple in the 1920s.

Oppland: In the 19th century, hubbro was widespread throughout the county. The population has been in decline throughout the 20th century until approx. 1970, when only a few localities were known. The population has since remained fairly stable, with calling birds at between 5-12 locations annually. After 1980 is
it has been heard in 38 places in 18 municipalities, but only in 14 of these has it been detected for more than two years. IN
In the 1990s, it was found in 19 locations in 9 municipalities. Based on this, the county population is calculated
hardly more than 8-10 pairs (Opheim 1998). Today, a population estimate would be 5-10 pairs (J. Op heim pers. message).

Aust-Agder: According to A. Pfaff (personal communication) at the State Nature Inspectorate, in recent years there have been hubbro at 8 locations in the county.

Rogaland: In the Bird Atlas for Rogaland (Carlsson et al. 1988) there is reference to surveys in 1986 and 1987 (Fylkesmannen environmental protection department) which indicate that the situation may not be so positive
as previously assumed, i.a. for the Dalane population. B. Oddane (personal communication) who has a good overview

above the population on Jæren and in Ryfylke have registered a decline in the hubrobium population in recent years the years. The local ornithologist A. Kvinnesland (pers. comm.) who has been monitoring the hubbub population on Karmøy, believes that in recent years the hubbub population has shown signs of decline and poor breeding success on this island. The same is the opinion of OJ Vorraa (personal communication), who suggests that the stock on Karmøy may have declined by around 50% in recent years. In a professional report on the consequences of a possible wind power development on Karmøy (Tysse 2006), it is assumed that there are still 100-150 pairs of terns nesting in Rogaland. Reference is made to Carlsson et al. (1988) and own assessments without stating what these are based on. R. Roalkvam (personal message) who beg

estimated the breeding stock in the 1980s, however, believe that there are probably no more than 50 breeding 100 pairs in the county.

Hordaland: S. Byrkjeland at the County Commissioner's environmental protection department (personal communication) believes that the population in the county may be "somewhere between 50 and 100 pairs" and is most common in the coastal municipalities. He emphasizes that the stock is definitely not growing, but also has no evidence to say that it is in decline.

Sogn og Fjordane: Willgohs, who investigated the hubro population in Sogn og Fjordane, concluded that in many of the localities where hubro had previously nested for years, there was little detectable nesting after 1970 (unpublished report to WWF, cited by Fremming 1985).

Møre og Romsdal: Already in the 1950s, a decline in the hubro population had been noticed. In Bygdesoge for Surnadal, Hyldbakk (1957) writes about the bird life in the municipality: "Of the birds that have recently disappeared most are the bergulen (hubro) and the field harrier...". The county branch of the Norwegian Ornithological Association in collaboration with NINA (Stenberg 2006; I. Stenberg and N. Røv unpubl.) has made records of known hubro localities in the county. A total of 178 localities are registered in the database and 129 of these were checked in 2000-2006. Hubbros were then registered in 65 nesting sites, and nesting was confirmed in 28 of these. The results show that the population situation for the species is now highly uncertain. In the inner and middle parts of Nordmøre in 2006 it was hardly possible to

demonstrate a single nesting pair, while there is much information that the hubbro has disappeared in the later years (I. Stenberg and N. Røv, unpubl.). The results indicate a stock combination breach in Nordmøre in the last 10-15 years of an already significantly reduced hubro population.

Sør-Trøndelag: M. Pearson (2006; unpubl.) has studied the hubrose stand on Hitra and Frøya for several years. In the 2006 breeding season, 16 hubro locations that have been in use one or more times during the last 10 years were investigated. Of these, there was nesting in only two locations with one young in each nest. At the same time, there were disturbingly few signs of hubbro at many of the locations.
Pearson has problems pointing to individual reasons for the population decline, but none

consideration and raising awareness of municipal authorities is probably central to the problem style
succeed.

Nord-Trøndelag: S. Garstad (unpublished report to WWF cited by Fremming 1985) who studied the hub bridge at Vikna assessed the population to have declined throughout the period from 1945-50 to the 1970s.

Nordland: Population declines have been reported in inner parts of Nordland (Comments to the Norwegian Red List 2006, internet). The core area for hubro in Nordland is Helgeland. About 25 pairs are thought to breed in Lurøy municipality, of which 14 pairs are in the planning area for the Sleneset wind power area (Shimmings 2005). This is probably the area with the densest population in the country, which has a connection with a very large population of vånd (ground rat) in an area without wild mink (a species that

effectively reduces the wind population on the coast). Today's population is currently undergoing new mapping, and a preliminary county estimate is 50-100 pairs (E. Dahl pers. medd; K.-O. Jacobsen and
K.-B. Strann upubl).

Troms: It has been assumed that the hubbro had its northern limit in Norway in Troms (e.g. Haftorn 1971), and the species was relatively common in the county at least until around the 1960s (Strann & Bakken 2004. Jacobsen (1986) carried out a mapping of the hub bridge in Troms. The study was based on a literature search as well as interviews with local people around the county with knowledge of birds and
wildlife. Appeals were also carried out in local newspapers and radio. The result was that there was still hell
tes 14 intact hubro sites, but that there had previously been at least 50 sites in Troms. The species has largely disappeared from the old classic localities in inland areas, but is still found in the coastal and fjord areas. Today's stock is currently being re-surveyed, and a preliminary estimate is 5-10 pairs (K.-O. Jacobsen and K.-B. Strann unpubl).

Finnmark: In Finnmark, the hub bridge is considered to have occurred more randomly in the past (Collett 1869, Schaanning 1916, Collett 1921, Løvenskiold 1947 and Hagen 1952). Haftorn (1971) states that "so
as far as we know, it does not breed in the county, but some roving individuals occur in both Western and Eastern Finnmark, e.g. in Porsanger, Kautokeino, Sør-Varanger and Nord-Varanger (Jakobselv)". However, Tromsø Museum has an egg from AB Wessel's collection labeled "Finmark" (Haftorn 1971). Rasch (1862)
however, writes that the hubro was numerous in Finnmark in the period 1849-51. Furthermore, he writes that in for
bond with shot prizes in 1854, as many as 250 out of a total of 303 hubbros were delivered from Finnmark. If this is the correct identification of the species, it suggests that the species was common at least until the middle of the 1800s
number (see also Frantzen & Bakken 1996). More recent information indicates that, in any case, since around 1960 there has been a small but stable population in the coastal and fjord areas of Western Finnmark (K.-O. Ja
cobsen et al. 2002; unpubl.). Today's stock is currently undergoing a new survey, and a preliminary estimate
food is 1-5 pairs (K.-O. Jacobsen and K.-B. Strann unpubl).

4.2 Hubroen on Karmøy

In a professional report on the consequences of a possible wind power development on Karmøy (Tysse 2006), the breeding population on Karmøy is stated to be 10-12 pairs, and that 5 of these breed within the area of influence. However, the local ornithologist A. Kvinnesland (pers. comm.) who has followed the hubrob population on Karmøy, believes that in recent years the hubrob population has shown signs of decline and poor breeding success on this island. OJ Vorraa (pers. report) which suggests that the stock on Karmøy may have declined by around 50% in recent years. According to Vorraa, "a number of years ago" there were 9 active hubro pairs on Karmøy, but he reckons that in the last 5-6 years there have only been 5-6 productive pairs.

The planned area for the wind farm appears to cover approximately the entire breeding and hunting area of 2 pairs of grebes, with a third territory on the edge of the area. This corresponds to a density of approx. 0.2 pairs per km2 . The highest density reported from Europe is from Spain and is 0.36 pairs per km2 (Delgado & Penteriani 2005). By comparison, the breeding stock in Lurøy on Helge land should be as much as 1 pair per km2 . This is by a good margin the highest density in Europe, and probably in the world (Shimmings 2005).

The hubroterritories within the planning area border each other in the north/south direction, neighboring territories in the west and north and the sea in the east. It will be natural to consider the hunting area ne/territories as units since these are normally defended against neighboring pairs. The Hubroes hunt within their territories. Each pair has 4-6 alternative nest sites scattered around the terrain. Typical nest locations on Karmøy are upper parts of ridges, with a good overview of the hunting area and usually facing south or south-west. The nesting sites naturally often coincide with the proposed locations for wind turbines. It also seems that the hubbro prefers to nest near water or ponds. In some cases, there are hiking trails close to the hubbroke's breeding grounds (20 - 150 m. away) without this appearing to have caused serious disturbance. As long as the traffic is predictable for the hub bridge and that people do not seek out the nest site directly, it seems that the species can have fairly large tolerance for such traffic, with the extent it is today. Ole Jakob Vorraa (pers. comm.) has observed the hub bridge at the nest from a distance when people have passed by. Then has the hubro withdrew into hiding and lay down and pressed until the people had passed. Unpredictability of movement that can scare the hubbroke from the nest or day bed is far more serious.

It is not known what the hubro lives on on Karmøy, but there are several relevant prey animals: Pinn hog is common in the summer and is registered as prey for the hubro. The same also applies to various traffic-killed animals. There are also large populations of both frogs and toads. These amphibians mate and lay eggs in early spring and can then provide important food for the hubbro en in the period before egg laying, and before the migratory birds arrive. There is also a large stock of

brown rat on Karmøy. In the mild coastal climate, the rats can probably manage well in the outback without it about human settlement. During the inspection in January, a gulbole of hubbro was found containing two skulls of a brown rat. In winter, wintering ducks are probably an important source of food. There are north/south migratory beds on the island, and OJ Vorraa (pers. comm.) believes that migratory birds (including waders, ducks and geese) are important prey for hubro throughout spring and autumn. With the dense hubrobium population on Karmøy, it is obvious that the food base has been good. The fauna on Karmøy has over a long time adapted to a life in an island biotope without peat residual predators. However, this seems to have changed as a result of the arrival of red foxes and martens to the island in recent years, which in turn have had significant effects on the hubro's prey. An example of this is that the seagull colonies that previously existed on the island are now inhabited the.

5 The threat picture for the hub bridge today 5.1 Reasons for the decline in Norway

As late as the 1950s, Hagen (1952) pointed out: "The species is still exposed to an intense persecution and great destruction." Wilgohs (1977) mentions persecution by people, disturbance and electric lines as possible reasons for the population decline. He does not believe that lack of nutrients or reduced access to suitable habitats are important factors. Promotion (1986) who summarized the situation for the hub bridge in Eastern Norway believed that the main reason for the species' up hearing young production and population decline could be reduced incidence and available hot of important prey. He further claimed, without justifying it in more detail: "The cable network is therefore unlikely to be decisive for the population decline in Eastern Norway..." Together with the calculations of Roalkvam (1985), Fremming's conclusions have remained until now. Carlsson et al. (1988) mention the power lines as the "big threat" for the hub bridge in Rogaland. A. Kvinnesland (personal communication) believes that the hub bridge has had reduced nutritional conditions on Karmøy in recent years, but also points to power lines as a negative factor.

Bevanger & Overskaug (1988) investigated 58 killed hubbros submitted to the Directorate for Nature Management in the period 1987-1994. In the 38 birds where the cause of death could be determined, 25 killed by power lines and 5 killed by collisions with vehicles. What proportion of the hub bridges were killed by electric shock (electrocution) or collisions with wires was not established. In 1986-87, 27 young birds of the hubbro hatched in breeding cages were released in Østfold with attached radio transmitters (Larsen & Stensrud 1988). At least 12 of 22 dead radio-tagged hubbros that were recovered had died by electrocution. This tendency was confirmed during the search for ringed hubbros that were found dead (over 400 were released). Of 67 birds with identified causes of death, at least 75% were electrocuted. Eight of these hub bridges were found at transformers. It is unclear what proportion died in collisions with

power lines. In the Norwegian Ringmarking Atlas (Bakken et al. 2006) the cause of death is explained kene at 118 hub bridges. By far the most important cause of death (68 birds) was electrocution or collision with wires, or being hit by a car or train. 11 birds were shot, and three of these

after 1971 when the hub bridge was completely protected in Norway.

M. Pearson (2006; unpubl.) points out that on Hitra and Frøya, building cabins in the hubro's holding places in the beach zone is a problem. In recent years, these municipalities have become a pressure area for cottage construction. There are several examples in the two municipalities in recent years where roads, cabins, boathouses and other biotope changes have been approved at the hub bridge's nesting area. This despite the fact that the municipalities in some cases have known about the occurrences

5.2 Technical installations

All owls use electrical installations as perches. An increasing risk of electrocution has been found with increasing body size. In general, lines with 1 – 60 kV are problematic, and electrocution occurs most frequently in masts of 10 – 20 kV (Haas 2005). In case of extensive stu
dier in several countries, it is now documented beyond any doubt that the hub bridge is exposed to a great risk of death by electrocution. The same is the case with several species of diurnal birds of prey and vultures (e.g. Lehman et al. 2006). Haas (2005) states that all the 84 countries that have acceded to the Bonn Convention and the 46 countries in the Council of Europe must implement measures to solve the problem of electrocution. Here we will refer to a selection of international work that illustrates various threat factors for hubro.

The Alps and Apennines of Italy: Sergio et al. (2004) investigated how electrocution has affected the distribution and density of hubbro in the Alps and Apennines. The starting point was to test at the stand that electrocution can cause threatened species to leave their territories and the population to decline
no. In a review of 25 studies, electrocution is often mentioned as the most important cause of death in hubro and that this is a growing problem. The results show that in areas with a high risk of electrocution, an increasing number of nesting areas were abandoned over a 10-year period. This has led to a significant decline in the population and an increasing tendency towards scattered nesting in higher altitude areas, although the hubbroe normally prefers to nest in the lowlands. It was found that 17% of
the young birds died shortly after they became able to fly. The density of hubro was negatively related
to the risk of electrocution. It was recommended to isolate the most dangerous high-voltage masts and to mourn
for all new installations to be bird-proof.

Sweden: It is believed that an important reason why the species became extinct in large parts of the country was hunting and persecution. In the 1950s and 1960s, there was also the spread of environmental toxins, especially mercury
pickling of seeds, major negative impact on the hub bridge in southern and central Sweden. This factor is now significantly reduced. Increased construction and traffic near the hubbro's breeding grounds have gradually become a serious threat to the species. The hubro's propensity to hunt near inhabited areas has meant that mortality in the power grid, along with collisions with cars and trains, now make up the
greatest risk of death for hubro (ArtDatabanken 2006). Fransson & Stolt (2000) have investigated mortality from power lines (electrocution and collisions) in ringed Swedish birds recovered in the period 1960-1999. Of a total of 2,713 dead birds with such causes of death, 27% were hubbro. It is not clear from the results how the distribution is between electrocution and collisions, but it is stated that many were killed at transformers. Although much has been done to reduce the danger of the electricity grid, this is still considered to be the biggest threat. It is recommended that no human activity must occur closer than 50 m from the bridge's nest

places. This also applies to cutting and transporting wood.

Finland: The reason for the population increase from the 1960s to the 1980s is believed to be a combination of conservation measures and increased access to food at a large number of rubbish sites with a lot of rats. Increased access to good nest sites and hunting grounds due to efficient forest management is also believed to have been important. It turned out that the "wilderness species" hubro gradually adapted to human activity and buildings, e.g. by utilizing the landfills. However, the Finnish monitoring program for birds of prey has shown that both population and reproduction have declined over the past 20 years. One of the reasons are believed to be closure or modernization of the operation of the landfills. Rediscovery data of ringed hubbro shows that electrocution and collision with vehicles was the most important cause of death in reported birds. This mortality has had an increasing tendency, while the number of shot hubro has decreased in the latter part of the 70s and beginning of the 80s. In that In the last 10 years, it is believed that electrocution and traffic death have been the most important factors in death. The problem is partly connected to the fact that the hub bridge has now been established in densely populated areas in the south and southwest. Little has been done in Finland to prevent electrocution. It is recommended that measures such as those implemented in Germany are also implemented in Finland, since there is now good knowledge and feasible measures. Possible measures to reduce the risk of collisions with bees are also mentioned laughs, i.a. at reduced speed in some areas and during parts of the day (Valkama & Saurola 2005).

Germany: In Germany, a law was passed in 1985 which mandates that all new power lines must be constructed are so that they do not pose any danger. Dangerous older "death masts" must be replaced by the year 2012 i following the law of 2002 (Haas 2005). In the state of Hesse, the hub bridge was extinct. but re-established itself in the 1970s after release in nearby areas. The following causes of death were detected in 1972-1998 in 125 hubbros (out of 179 registered): 41% electrocution, 19% collision on road, 11% collision with train, 18% collision with wires, fences etc. and 2.4% pursuit. This is

the situation despite measures to reduce the problems with power lines (Brauneis & Hormann 2005). In Baden-Württemberg, the hubbroke started breeding again in 1963 after having been extirpated since 1938. The population is now around 80 pairs. The state has partly a very large population density and hugely developed transport network with railways and roads. The following death was found wound cases in 73 individuals (both ringed and others): Electrocution (30 ind.), car traffic (24 ind.), collision with wires and fences (10 ind.), shot etc. (5 ind.) and young birds killed by dogs or fox (4 ind.). Analyzes of eggs show that poison is not a problem (Rockenbauch 2005). In for in connection with the work on the new bird atlas for Bavaria, it became clear that the hubrob population has declined, which has also been recorded in other provinces (Lossow 2005). As much as 42% of all known Bavarian nesting sites, including 82% of nesting sites in quarries, were at risk. Therefore, an action program was launched in 2001 to preserve the species in Bavaria. The meaning of keeping the nest sites secret, while the administration needs to know the locations, is a topic for discussion. To succeed with a conservation plan, it is considered absolutely necessary with positive cooperation between all parties.

In *Austria and southern Germany,* 1990 hub bridges were ringed in the period 1962-2004 (Fiedler 2005). Of these, 221 (11%) recoveries have been reported. Of birds found in the years 1962-90, 63% were killed by electrical installations, 9% by hunting and 16% in traffic. In the years 1990-2004, 40% were killed by electrical installations, 31% by traffic and 3% by hunting.

Switzerland: Aebischer et al. (2005) have studied the causes of death in hubbros that have been cared for in natural history collections, and compared it with mortality in radio-tagged young birds. The following causes of death have been recorded in 228 collected wild hubbros: 33% electrocution, 19% collision with car, 9% collision with train, 15% collision with cables/wires. There were fewer collisions by car and train before 1970 compared to later. In young birds (but not adults) there were more died in the period September – November than at other times of the year, in the time they migrate from parent's territory. Of 35 young birds with radio transmitters, all lived until they were able to fly (about 2 months old), while 32% died before they left their parents. A total of 60% of the marked birds died during their first year of life. Of the birds that left their parents alive, 55% survived their first year of life. In the "museum birds", the correspondingly calculated survival was 77%, i.e. a significant overestimation of survival. In 16 radio-tagged birds with a known cause of death, 19% died from electrocution, 6% from collision with a car or train, 6% from collision with power lines, and 50% from starvation.

Czech Republic: In West Bohemia, the population has declined in the last 10 years. At the same time there has been a continuous decline in young production. In the years 1983-2003, 273 breedings were registered. Of these, 138 were unsuccessful, i.e. 50%. The main reason for this poor breeding success is believed to be persecution by humans. The hubro is very faithful to its location. Therefore, the nesting place becomes well known and can be visited every year by people. Without changes, there is little hope of being able to preserve hubroen i lands (Schröpfer 2005).

Spain: While human persecution was previously a major problem for the hubro in Spain, should it turns out that electrocution and collisions with electrical wires became increasingly serious cause of mortality during the 20th century. But the bridge is still accused of reducing the stocks of huntable game in Spain, and is therefore exposed to persecution. A thorough study of the causes of death for hubro in Spain in the period 1989-2003 showed the following causes of death: Electrical installations (20.1%), persecution (19.2%) and other causes (60.6%). Of individual causes, electrocution accounts for 16.3%, hunting 11.8%, and various injuries of unknown cause 19.3%. In an overview of various other studies, electrocution is the most frequent cause of death, but pursuit and collision ner with cars was also common (Martinez et al. 2006).

5.3 Environmental toxins

Environmental toxins have for a long time been one of the most important negative factors for birds of prey both in Norway and elsewhere in Europe. Many organic compounds have led to eggshell thinning and reduced young production. While the situation has generally improved for most species, it has come
met new connections into the food chains that cause concern (cf. Nygård et al. 2006). It is
carried out an investigation of selected environmental toxins in 10 dead hubbros that were found dead or missing in the coastal areas between Vest-Agder and Møre and Romsdal in the period 1996-1999. The results showed that the levels of PCB and DDE were relatively high compared to other species that have been the focus. For example, the median value of PCB in the liver of the ten individuals was
three times as high as in polar bear fat from Svalbard. Two of the individuals had extremely high
values compared to the others, which may be due to differences in business choices or a local pollution source. Studies of Norwegian hub bridges in the 1960s and 70s showed much higher concentrations of environmental toxins than the hub bridges in this study (Andresen 2002). Nygård et al. (2006) have investigated the development over time of environmental toxins and new toxins in raptor eggs in Norway. They conclude that certain hubbro eggs have had very high levels of environmental toxins, but the material is too small to
say something about the meaning of these. Still, there is reason to follow this species closely in the future, as the population is under severe pressure, and the environmental toxins will come as an additional burden in a situation that is already critical. On the coast, the hubbro lives on seabirds in addition to smaller mammals, and
this means that it comes into contact with the marine food chains, with their high environmental toxicity
spring.

5.4 Hubro's vulnerability to disruption

As a rule, the hubbroe prefers areas with minimal human traffic and disturbance, but in many places the species has shown an increasing tolerance for human activity. Different types of cultivated land are often included in the hubro's hunting grounds due to good access to prey. Nevertheless, it is very vulnerable to human activity near the nest area early in the breeding season, and easily avoids the nest when disturbed (Mikkola 1983, Olsson 1979). If the nesting area is exposed to an increase

human activity e.g. during forestry operations or cabin construction, disturbance of people, mountains
climbing etc., the hub bridge can disappear from the area, and the territory be left empty for a number of years (Ols son 1997). It is conceivable that hubbrokes that have been set out as a result of breeding projects may show greater tolerance to human activity and buildings, but this is not the situation in Norway today, except perhaps in some places in eastern Norway. In parts of the lowlands in Germany it is now a habit
like the hubbro nesting in quarries. As long as the immediate surroundings of the nest site itself are not too controlled, the hubbro can accept extensive activity and noise in the vicinity. Large building activity since the 1950s has led to countless quarries, also in sparsely populated areas. These often have high, steep mountain slopes, and are little used by tourists or outdoor enthusiasts, and usually not by climbers.
Disruption in the form of blasting and mass removal can be large in the quarries. Out of 465 secure

nestings in Baden-Württemberg in 1963-2004 were 2/3 in quarries, most still in use
(Rockenbauch 2005). It is nevertheless assumed that avoiding disturbance of the nesting sites is an important prerequisite for preserving the hubbroke in Germany as well. The importance of keeping the nest sites secret must be weighed against the management's need for knowledge of the localities (Lossow
2005).

5.5 Mortality at windmills

Hötker et al. (2005) have carried out a review of 127 studies of wind farms in 10 countries, the most in Germany. Harmful effects for large bird species have been assessed. The biggest problems are for steering leading to exclusion or relocation from the wind farm area and mortality in collisions down. No study has demonstrated negative effects at population level, although there is general agreement among researchers that such effects exist. Waders, for example, showed a tendency to avoid the advice of wind farms during the breeding season, but many potentially sensitive species have not been studied.
Outside the breeding season, wind farms had a significant negative effect on local populations of e.g. brown neck, heilo, and vipe. These and other species in the open landscape avoided approaching the wind farms closer than a few hundred meters. Outside the breeding season, the avoidance distance increased with the size of the wind farms for most species, most markedly for vipers. There were no signs of habituation (adaptation). The collision frequency in different species varied between 0 and 30 collisions/mill/year. There was a particularly high risk of collision in wetlands. Where wind farms were

in places on mountain ranges (USA, Spain) there was a high frequency of collisions, especially with birds of prey. IN
In Germany, many sea eagles (13) and gannets (41) have been killed since 1989. Choosing the right areas for the wind farms is the only known way to reduce the harmful effects on birds and bats. Hötker et al. (2005) further asserts: "There is a great need for more research regarding collisions between bald eagles and sea eagles, the effects on rare and endangered species (including hubbro) of wind turbines, migratory birds at night, and illuminated tall windmills" . It is also pointed out that, despite numerous studies, the ecological effects of wind power for larger bird species are still disputed. In particular, this applies to the hub bridge, which can be found in the state bird watchdog's list of finds

ten in Brandenburg with **six wind power victims** per 11.4.2005 (unpublished).

Center for Biological Diversity, San Francisco (undated publication on the Internet) explains them covering the collision problems at the Altamont Pass Wind Resource Area in California. Wind
The power plant was established in 1982 and consists of 5,400 wind turbines. The power plant has resulted in the largest number and frequency of birds of prey killed by wind turbines in the world. The reason is stated to be poor planning which has led to the wind power plant being located in a migratory corridor for birds of prey with a high number of wintering birds, and in the area with the highest density of golden eagles in all of North America. The wind turbines kill an estimated number of between 880 and 1,300 raptors each year
birds, including 116 golden eagles, 300 Red-tailed hawks *(Buteo jamaicensis)* and 380 Burrowing

owls *(Athene cunicularia),* and in addition hundreds of other birds of prey including kestrels, greater falcons kers, vultures and other owl species. The close relative of our own hubbro, the Great Horned Owl *(Bubo virginianus),* is also listed as one of many species that have perished. The situation represents serious violations of several laws. According to the California Energy Commission, the negative public attention surrounding the wind power plant has contributed to the fact that it has become very common opportunities to fulfill the plans for further development of wind power in California. Now it must be said that both the size of the wind turbines, their number and their location in the terrain were maximally unfavorable at the wind power plant in Altamont compared to more modern wind power plants. The experiences from there can therefore not be transferred without reservation to other developments, even if they represent value full knowledge.

It has also been found at other wind power plants in the USA that owls make up a certain proportion of birds killed, e.g. Montezuma Hills (11.9%), San Gorgonio (11.9%), Tehachapi Pass (12.2%), and the Foote Creek Windpower Project (1.0%) (See summary by Shimmings 2005).

The hubro's biology and hunting behavior mean that it is believed to be vulnerable to disturbances and collisions during the development of wind power plants. Although there is very little knowledge about hubro and wind power, six wind turbine-killed hub bridges have been documented in a limited area in Germany. When the close relative Great Horned Owl (Bubo virginianus) is also reported to have been killed by windmills in California, there is no doubt that this species group may be prone to collisions.

5.6 Hubroen's vulnerability to wind turbines compared to sea eagles

The hubro is a large nocturnal bird of prey that is able to take down prey of considerable size, such as e.g. hares, roe deer calves, eiders, large gulls, greylag geese, grouse and large birds. It can hunt prey at sea or hunt in open air, but most often hunts by sitting motionless on fixed vantage points in the terrain. Therefore, there are several similarities between the white-tailed sea eagle's and the osprey's hunting technique and choice of prey. Sea eagles mark their territory by perching on easily visible places in the terrain, as the hubbroke can also do. However, the sea eagle also sails a lot on the air currents to land re the territory and also carry out territorial battles. It generally has much greater flight activity than the hubbro which, in turn, signals its ownership of the territory primarily by sound. The hubro's cry "ooo-ooo" can be heard up to 4 km under favorable conditions (Glutz von Blotz heim 1980), while the sea eagle does not use vocalizations in the same way. The biggest differences between the two species are therefore territorial behaviour, while hunting technique and prey selection are more similar.

The sea eagle's territorial behavior sometimes results in dogfights between different individuals. It is particularly risky in an area with windmills. On the coast where both species are found, one can say that sea The eagle rules the sky during the day and the eagle at night. The sea eagle's greater flight activity makes it reasonable to assume that it is somewhat more exposed to wind turbines than the hub bridge. This is imid-

clay time somewhat uncertain. The white-tailed eagle is diurnal and should thus have greater opportunities to discover the windmills than the hub bridge which is nocturnal, and perhaps to a lesser extent will be able to avoid physical obstacles in the airspace. It is regrettable that we have too little knowledge about this today.

6 Discussion

The decline in stock at hubro has apparently been going on for a long time. It is noteworthy that this serious situation has not received sufficient attention in the past.

What distinguishes many of the newer estimates is that they are based on assumptions that have not been further investigated. There is every reason to regard the calculations based on Roalkvam's (1985) assessments as overly optimistic. Firstly, the current population in Rogaland is probably considerably lower than the estimates from the early 1980s, which may also have been overestimated. Moreover, it is quite obvious that the assumptions for extrapolating the estimate from Rogaland to apply to the coast north to Troms are not tenable. And thirdly, there is do
commented on a significant population decline in many parts of the country. We are now working on obtaining a sufficient basis to be able to create a county-by-county overview of the hubber population in Norway. So far, it appears that Hagen's (1964) estimate from 1963, i.e. 500-600 pairs, is not far from the truth. Although this estimate was too small in the 1960s, it must be taken into account that the stock has been in continuous decline until now. Although there still appear to be good stocks on parts of the coast (Rogaland and Helgeland), the situation is obviously serious for
other parts of the country. On the basis of the knowledge we have so far, we can suggest a preliminary estimate of 400-500 pairs in the country as a whole. The reports of population decline have led to the hub bridge being now classified as highly threatened in the Norwegian Red List 2006 (Gjershaug et al. 2006.). The species should probably have been classified as highly threatened already on the previous red list, perhaps even earlier. The species' classification on the red list means that the stock is now assumed to have a 20% chance of dying out in the next 20-100 years.

The long-term population decline recorded in Norway has been even more marked in other parts of Europe. In fact, the species has been close to extinction in countries such as Germany, Sweden and Switzerland. Systematic persecution since the 19th century is believed to be the main cause. Later was the species exposed to environmental toxins like other birds of prey. Today, the trend has changed to the positive in both Germany and Sweden. The reason is the extensive program for breeding and release of hubro, together with concrete measures to reduce the most important man-made negative factors. These factors are eventually very well mapped in several countries in Europe, also in Norway.

Mortality in connection with electrical installations is now very well documented in a number of countries (e.g. Fransson & Stolt 2000, Bevanger & Overskaug 1998, Rubolini et al. 2001). Although collision with power lines can also occur, there is a general agreement that electro
cushion is the biggest problem. In many countries, i.a. Sweden and Germany, a constructive collaboration has been established with power suppliers for the implementation of concrete measures to eliminate the installations that are most dangerous for the hub bridge, i.a. by laying wires in cable, insulate
wires at dangerous masts or design the masts so that the risk of electrocution is reduced.

Technical and economically feasible solutions have now been thoroughly investigated, e.g. in the USA where elec trocusion in larger birds of prey has long been an acute problem (Lehman 2001). There is a lot of good knowledge about how the problems with the electricity grid can be solved within the framework of acceptable financial frameworks. In Germany, too, the problem has been taken very seriously and comprehensive measures have been taken, e.g. by legislation, has been implemented.

There is every reason to believe that electrocution is the most important reason for the constant decline in the hubbro's population in Norway. Limited measures have been attempted to reduce mortality in young birds that were released after breeding in Eastern Norway, which had a documented positive effect
(Larsen & Stensrud 1988). Otherwise, there are the problems of electrocution and collision with power links nings have been completely ignored in Norway (K. Bevanger pers. message).

7 Possible scenarios for wind power development on Karmøy

On the basis of the knowledge presented here, it seems undoubted that the planned development will affect two nesting pairs of grebes, while a further 2-3 pairs will be affected to a lesser extent. Although there is little concrete knowledge about how hubbro is affected by wind power development, it is now known that hubbro has been killed by wind turbines. General knowledge of the hubro's flight habits and hunting technique suggests that the species may be exposed to collisions with wind turbines. It is also possible that noise from wind turbines can affect hunting. The need for knowledge is specified by Hötker et al. (2005) who point out that there is particularly great uncertainty and a need for knowledge about the hub bridge's vulnerability to wind turbines. In this situation, it is reasonable to assume that it is large

probability that the two mentioned hub rotterritories on Karmøy will be destroyed by a possible wind power development. The extent to which the neighboring territories will be negatively affected is, on the other hand, an open question, but it cannot be ruled out. This conclusion is in line with what is assumed in the professional report on consequences for biological diversity (Tysse 2006).

Based on the knowledge we have about the hub bridge's biology and vulnerability to disturbance and collisions with physical obstacles, we can derive the following possibilities:

1). Two of the hub pairs will leave the area due to extensive disruption in development
phase and reduced hunting opportunities in the wind farm area. If this happens before the wind farm arrived
longer in operation, these hubbridges will be able to survive and establish themselves in nearby areas, either by recruiting territories with solitary birds or establishing their own territories outside of existing pairs. If we assume that there are as many as 10 pairs of hub bridges on Karmøy, and that two of these pairs
will disappear, this could mean that the stock on Karmøy will be reduced by around 20%. However, the stocks are uncertain.

2). The two hubro pairs will try to hold their territories. Then it is considered reasonably probable
that one or both hub bridges in the pairs will be killed in a collision within a shorter or longer time
with the windmills. In any time perspective, it is unlikely that killed hubbros will be replaced by non-established hubbros, especially since the population on Karmøy is believed to be in decline. Where, contrary to conjecture, the pairs of humpbacks should manage to adapt to the wind farm, it is considered likely that young birds may be killed by collisions with wind turbines in the first period after they have become capable of flight. However, it must be specified that we do not know how great this risk is.

3). If the two territories are left empty, the area will be able to attract non-territorial young birds due to good nutritional conditions. In such a situation, the wind power plant could cause increased mortality to the non-breeding population. However, this scenario is considered

unlikely, as the wind farm represents a troubled area that will be unattractive
roaming hubbros.

8 Mitigation measures

With the scenarios we have outlined, it will probably be of little help to adjust the location of the various wind turbines. It is the hubroen's territory/hunting areas that will be affected.

However, there are good opportunities to improve the current living conditions for the hub bridge on Karmøy. It is known that the hub bridge is also highly susceptible to electrocution on Karmøy, where there are many of them dangerous power line masts and transformers (own observations). If it is carried out end rings and improvements, it will be able to increase survival considerably in both adults and young people hub bridges. Today, there is very good knowledge about which installations are dangerous for hubro, and what can be done by improvements (Haas et al. 2003). It may be mentioned that certain measures to reduce electrocution were undertaken by Haugesund Energi (later merged into Haugaland Kraft) already in the early 1990s. The wires were then insulated 1 m from the posts and caps were placed over the insulators on masts with so-called spike insulators. The measures were carried out on two power lines, one on Karmøy and one in Haugesund (Brynjelsen, D. 1995, T. Stenersen, pers. comm.). This ended the problem of power outages and electrocution of birds on these lines. For all new transformers, Haugaland Kraft now insulates the lowering cables and lays insulation drain hood over the transformer. But there are still many older transformers that are not isolated, according to T. Stenersen in Haugaland Kraft (personal communication).

It is also possible to channel leisure traffic in the hubro's habitats on the island, and through information to warn people against disturbing the breeding grounds. It is also undoubted that maintaining the open cultural landscape through the care of the heaths and pastures are important measures to take care of the biological diversity on Karmøy, which will also benefit the hub bridge.
Care of the heather moors on Karmøy involves intensive grazing by small cattle and heather burning afterwards old traditions. Such measures require active participation and cooperation with the landowners in the area.

The measures mentioned above should be carried out regardless of any wind power development, but will be particularly important if it is decided to expand the wind power plant, in order to compensate for the negative effects of the development.

9 Conclusions

After a long-term decline, the hubrobium population in Norway is now severely threatened. Previous stock estimates have been based on incorrect assumptions and have therefore been far too high.

In many other countries in Europe too, the hubbub population has been in decline, but extensive conservation measures together with breeding and release of young birds have led to the population recovering. The most important reason for the population decline is electrocution and various types of collisions, as well as human disturbance and land use. The species is very vulnerable to human activity, especially in the nest area before the young are half-grown. It has nevertheless

demonstrated ability to adapt to a way of life in more densely built-up areas if access to food is good.

The hubro's biology and hunting behavior mean that it is believed to be vulnerable to disturbances and collisions during the development of wind power plants. Although there is very little knowledge about hubro and wind power, six wind turbine-killed hub bridges have been documented in a limited area in Germany. When the close relative Great Horned Owl *(Bubo virginianus)* is also reported to have been killed by windmills in California, there is no doubt that this species group may be prone to collisions. By a possible expansion of the Karmøy wind power plant, it is considered likely that at least two hubs will rot ritories will disappear in the short or somewhat longer term.

The most important mitigating measure will be to make changes to the parts of the electricity network that pose a risk of electrocution for hubro. Facilitation of traffic and care of heather and grazing landscapes will also be important.

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NINA Rapport 239

ISSN:1504-3312
ISBN: 978-82-426-1799-6

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