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Monitoring of raptors in Norway

Monitoring ptic roparic na Norveškem

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All diurnal raptors and owls have been protected by law in Norway since 1968–1972. Since then, most species that had been heavily persecuted earlier (eagles and hawks), and those especially susceptible to environmental pollution (Peregrine Falcon *Falco peregrinus* and Osprey *Pandion haliaetus*) have increased in numbers. A national monitoring programme for the terrestrial environment in Norway, which also includes population monitoring of the Golden Eagle *Aquila chrysaetos* and Gyrfalcon *F. rusticolus*, was established in 1990. Monitoring of environmental pollutants in eggs of diurnal raptors and owls on a country-wide basis was started at the same time. A data series on pollutant levels in eggs of several species covers a time-span of up to 40 years for DDE and PCB, including shell thickness measurements. Only the Golden Eagle and Gyrfalcon are included in a comprehensive state-financed monitoring programme, while other species are locally financed and run by special interest groups and NGOs. The Golden Eagle is under pressure from farmers' and reindeer husbandry organizations, while the Goshawk *Accipiter gentilis* suffers from clear-cutting of old forests. High mortality of White-tailed Eagles *Haliaeetus albicilla* due to collisions with wind-turbines is a serious problem locally. The Osprey is on its way back to pre-DDT levels. In general, pesticide levels have dropped significantly during the last couple of decades, resulting in improved shell quality. The major constraints to comprehensive monitoring of diurnal raptors and owls in Norway are lack of funding and qualified personnel.

Key words: diurnal raptors, owls, monitoring, Norway
Ključne besede: ujede, sove, monitoring, Norveška

1. Introduction

In pre-World War II times, the classical attitude towards raptors in Norway was persecution by shooting, nest destructions and poisoning, encouraged by bounties. During the 1940s and 1950s, some pioneering work on raptor breeding numbers and reproductive rates in relation to fluctuations in their prey basis was performed, and a more realistic picture of their place in nature slowly gained foothold (Hagen 1952 & 1969). Still, no permanent monitoring schemes existed, while pesticides and persecution drove many species to the brink of extinction. Turning points came when all Norwegian diurnal raptors and owls were protected by law in 1968 (eagles) and 1972 (Barth 1971). Nevertheless, in 1975, when monitoring of Peregrine Falcon *Falco peregrinus* was initiated, only about eight pairs were known to breed in the whole country (Lindberg *et al.* 1988). At the same time, monitoring of Golden Eagle *Aquila chrysaetos* and White-tailed Eagle *Haliaeetus albicilla* was started by NGOs.

Initially, during the early 1990s, monitoring of flora and fauna in Norway focused on subalpine and alpine ecosystems to investigate impacts of long-range air pollution. Later, the objective was broadened to include effects of climate change and response to anthropogenic changes. Raptors positioned at the top of food-chains were included as sentinels of environmental pollution.

In recent years, predation on livestock by large carnivores and eagles has become a major issue. Therefore, there is an increasing pressure from the

farming and reindeer husbandry organizations, advocating culling and limiting of predators, including eagles. Also, there is an increasing conflict between forestry organizations and the conservation of forest-dwelling diurnal raptors and owls, especially those species depending on mature forest, such as the Goshawk *Accipiter gentilis*. At present, the development of wind farms along the coast poses a new threat, especially for the White-tailed Eagle, and electrocution by power lines has gained new attention owing to large declines of the Eagle Owl *Bubo bubo.*

2. National programmes

The *Monitoring Programme for Terrestrial Ecosystems* (TOV) is a national monitoring programme initiated and financed by the Directorate for Nature Management in 1990 (Løbersli 1989). The Norwegian Institute for Nature Research (NINA) coordinates a large part of the scientific investigations in the programme, including raptors. TOV generates knowledge of long-term changes in biota, and when possible relates this to the influence of: (1) acid rain (both sulphur and nitrogen), (2) long-range pollutants (metals and organic pollutants), (3) climate change, (4) land use, and (5) the interaction between several factors of influence. The programme focuses on commonly occurring habitats and species, mainly in forests and mountains, and is based on integrated monitoring of different species and other elements of the ecosystem in seven selected mountains and birch forest areas, plus a nationwide survey of selected parameters and vegetation monitoring in eleven spruce forest areas. Monitoring areas are distributed throughout the country from south to north in a way that reflects both climate variations and differences in the burden of long-range pollutants. All areas are located in places where they are not subjected to rapid changes in land use, mainly in protected areas. Raptor monitoring has only been performed in the southern part of the country up to present, but is currently being expanded (Figure 1). Only the Golden Eagle and Gyrfalcon *F. rusticolus* are encompassed within this programme.

The national monitoring programme *Rovdata* was established by the Directorate for Nature Management in 2000 to ensure that monitoring and surveillance of large predators was performed in the best possible way throughout the country, using the standardized methods. Data on breeding, predators' tracks and kills are processed, compiled and reported at the national level by an independent research body (NINA). During the first years, only the four large carnivores, the Lynx *Lynx l. lynx*, Wolverine *Gulo gulo*, Brown

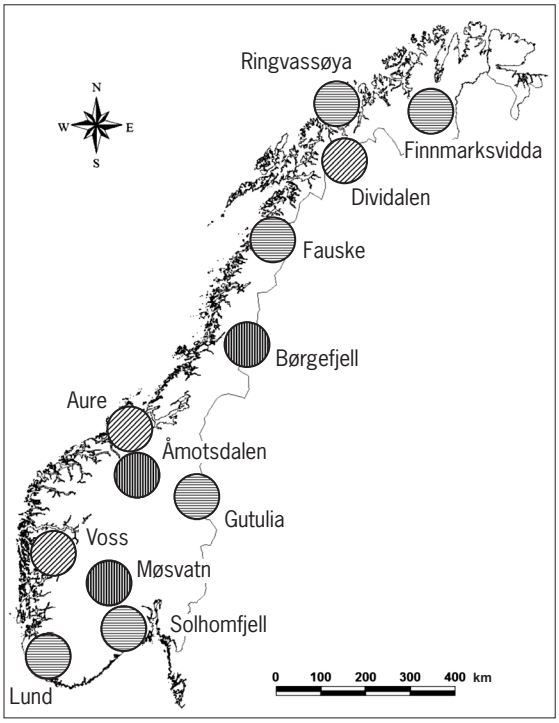

Figure 1: Existing (horizontal and vertical shading) and planned (slanted shading) areas for monitoring of Golden Eagle *Aquila chrysaetos* in Norway. In addition, Gyrfalcon *Falco rusticolus* is monitored in the vertically shaded areas. The areas have an approximate diameter of 100 km.

Slika 1: Obstoječa (horizontalno in vertikalno senčena) in načrtovana (poševno senčena) območja za monitoring planinskega orla *Aquila chrysaetos* na Norveškem. Poleg tega poteka v horizontalno senčenih območjih tudi monitoring arktičnega sokola *Falco rusticolus*. Premer vseh območij je približno 100 km.

Bear *Ursus arctos* and Wolf *Canis lupus*, were part of the scheme. From 2006 on, the Golden Eagle has been included. New modules for other large diurnal raptors and owls are presently being added.

The Species Databank (Artsdatabanken) of Norway, managed by the Norwegian Biodiversity Information Centre (NBIC), has a web-site open for on-line registration of bird observations, including diurnal raptors and owls, which over the years has accumulated a substantial amount of data regarding their occurrence and distribution. Some local interest groups (NGOs) also run their local monitoring projects.

3. National coverage

Today, only two raptor species are subjected to comprehensive, state financed population monitoring

Table 1: Known ongoing monitoring projects of diurnal raptors and owls in Norway

Tabela 1: Znani potekajoči projekti monitoringa ujed in sov na Norveškem

Species / Vrsta	Geographical area/ Geografsko območje	Responsible/ Odgovorna inštitucija	Red-list status in Norway/ Norveški Rdeči seznam
Honey Buzzard *Pernis apivorus*	locally in the south	Local interest groups	VU
White-tailed Eagle *Haliaeetus albicilla*	nationwide	NOF	LC
	Smøla Wind Farm area	NINA	LC
Goshawk *Accipiter gentilis*	some counties	Local governments and NGOs	NT
Golden Eagle *Aquila chrysaetos*	TOV areas	NINA	LC
	some counties	Local governments and NGOs	LC
Osprey *Pandion haliaetus*	some counties	Local governments and NGOs	NT
Kestrel *Falco tinnunculus*	Hedmark County	Agder Nature Museum and local enthusiasts (nest boxes)	LC
Merlin *Falco columbarius*	nationwide	TOV, for pollutants only, 5-year intervals	LC
Hobby *Falco subbuteo*	locally in the south	Local interest groups	VU
Gyrfalcon *Falco rusticolus*	TOV areas	NINA	NT
	Finnmark	Local interest groups	NT
Peregrine Falcon *Falco peregrinus*	some counties	Local governments and NGOs	LC
Eagle Owl *Bubo bubo*	nationwide, species of special concern	NOF, NGOs and district colleges	EN
Snowy Owl *Bubo scandiaca*	Finnmark County	NINA, Agder Nature Museum and NOF, research and monitoring	EN
Pygmy Owl *Glaucidium passerinum*	Troms County	NOF (nest boxes)	LC
Tawny Owl *Strix aluco*	Sør-Trøndelag County	Local interest groups (nest boxes)	LC
Ural Owl *Strix uralensis*	Hedmark County	Local interest groups (nest boxes)	VU
Tengmalm's Owl *Aegolius funereus*	Troms County	NOF (nest boxes)	LC

on a national basis in Norway; the Golden Eagle and Gyrfalcon (from 1990, ongoing, in selected areas under the TOV umbrella). For other species, such as the White-tailed Eagle, Peregrine Falcon, Goshawk and Osprey *Pandion haliaetus,* monitoring has been less systematic in time and space, but NGOs such as the Norwegian Ornithological Society (NOF) and other regional groups are active. The County Governors' offices in various counties finance regional monitoring projects for a range of species of diurnal raptors and owls, with NOF and local interest groups. The known monitoring activities of diurnal raptors and owls are listed in Table 1.

The Merlin *F. columbarius* has been monitored only for pesticides. A long data series is available in Norway for DDE, PCBs, HCB and HCH in eggs of bird of some prey (up to 40 years of monitoring), and from 1991 eggs have been analyzed for a wider range of pollutants, including brominated and fluorinated organic compounds (Herzke 2002 & 2005, Nygård & Polder 2012).

4. Key species and issues with overview of results

4.1. Key species

Golden Eagle

No long-term trend in the production of chicks has been shown in any of the six TOV areas. 10–15 territories are monitored in each area. The territory system of Golden Eagle is sufficiently stable from year to year to make the productivity monitoring

scheme suitable. Territory occupancy and chick production per territory in each area are recorded. It has been shown that the productivity of Golden Eagle is higher a year after the peak year of small rodents, when numbers of ptarmigans and other small game are high (Gjershaug 1996). Moulted feathers and addled eggs are collected for analysis of metals and organochlorine contaminants. In the future, feather DNA will be used to monitor adult turnover. There has probably been a population increase since the species was fully protected in 1968, but there are not enough historical data available to substantiate this assumption. The current population estimate is at 1,200–1,400 pairs. See Gjershaug *et al.* (2008) for details. Three monitoring areas in the north are to be added in the near future, two of them new, while the third (Finnmarksvidda) has been used since 2002 during a special research project (see Figure 1).

Gyrfalcon

Gyrfalcon populations are being monitored in three TOV areas in the southern half of Norway. One new monitoring area in Finnmark will probably be added in the near future (Figure 1). Breeding success and the number of large chicks are recorded. Line transects of Willow Ptarmigan *Lagopus lagopus* (the main prey of Gyrfalcon) provide data from same areas as explanatory variables for Gyrfalcon breeding performance. The annual proportion of territories with confirmed nesting attempts is related to population variation of its main prey species, the Rock Ptarmigan *L. muta* and the Willow Ptarmigan. The best predictor of Gyrfalcon reproductive success has been shown to be the production of Willow Ptarmigan chicks in year t–1 (Falkdalen *et al.* 2012). An estimate of 200–500 territorial pairs in Norway has been suggested (Myklebust 1996), but no comprehensive national census has been performed.

Peregrine Falcon

The species was on the brink of extinction in Fennoscandia in the mid-1970s (Lindberg *et al.* 1988), due to DDE effects on shell thinning (Nygård 1983). Local NGOs in the south and central parts of Norway have been monitoring its recovery and pollutant levels since that time.

White-tailed Eagle

Its population has been monitored in Norway since 1974 by the NOF as part of an international monitoring programme initiated by the WWF. Nesting success and production of chicks has been monitored nationwide since 1974 and is ongoing, and an extensive ringing scheme has been in place (Folkestad 2003). Since the White-tailed Eagle was fully protected in 1968, its population has increased from about 700–800 territorial pairs to a minimum of about 1,900–2,200 territorial pairs in population (Folkestad 2003), which probably amounted to about one third of the European population, and numbers have probably increased since. The increasing populations of Golden Eagle and White-tailed Eagle in Norway are most probably a result of protection, but lowered pollutant loads have also probably played a role. However, the quest for "green" energy has led to the allocation of large amounts of public subsidies into the development of wind-power in Norway, which may pose a long-term threat to White-tailed Eagle populations. At the 68-turbine wind-power plant at Smøla alone, 53 White-tailed Eagles have been found killed since 2005 (Bevanger *et al.* 2011 & *unpubl.*).

Eagle Owl

The Eagle Owl has decreased dramatically in Norway during the last few decades, mainly because of electrocution (Bevanger & Overskaug 1998). Therefore, it was red-listed as a species of special concern, and is presently subjected to nation-wide surveys, monitoring and research. A national census in 2008 revealed that less than 300 sites still had territory-holding Eagle Owls (Øien *et al.* 2009), and it has almost disappeared from large tracts of its former range, especially in the interior of the country. The national government is now financing mitigation measures to remedy the situation through a national action plan (Direktoratet for naturforvaltning 2009). A research and monitoring project, focusing on electrocution and mitigation measures, is ongoing. Mitigation by mounting perching devices on power-poles to prevent electrocution seems to be effective (Bevanger *et al.* 2013).

Other species

The Goshawk, once very numerous in the forested areas in Norway, has been severely reduced in numbers since the advent of large-scale forestry in Norway. From an estimated number of 10,000 pairs, its present population level is now probably less than 2,000 pairs (Grønlien 2004). Regarding Merlin and Osprey, banning and restrictions in use of poisonous organochlorines and mercury have been of vital significance to the recovery of their populations. The Merlin was heavily burdened by pollutants, but no good historic population data are available. However, the migration counts at the bird station Falsterbo on the southern tip of Sweden indicate a historic trend

similar to that of the Peregrine Falcon (Nygård 1999). The Osprey was long absent from large areas of its former range, but has now recovered greatly, and the present estimate is now ca. 500 pairs (own estimate based on enquiries).

4.2. Monitoring of persistent pollutants

The monitoring of pollutants in eggs of raptors is part of TOV, and samples of addled eggs and moulted feathers are collected for analysis when possible. For Merlin, we have been able to collect fresh eggs under special permission during sampling campaign every fifth year. Addled eggs and moulted feathers from other raptor species are collected *ad hoc* during ringing efforts and local monitoring activities. By incorporating available published and unpublished data, we are able to produce time trends for pollutants and shell thickness over 4–5 decades. Recently, data on organobromines and fluorocarbons have also become available (Herzke *et al.* 2005, Nygård & Polder 2012).

Eggshell thinning

Eggshells in most species have gradually increased in thickness since the ban on DDT became effective in 1972, but have in most species still not obtained values comparable with the pre-DDT era (before 1947) (Figure 2). Severe shell thinning has been observed in the Peregrine Falcon, Merlin, and Osprey, which coincides in time with very depressed populations of these species.

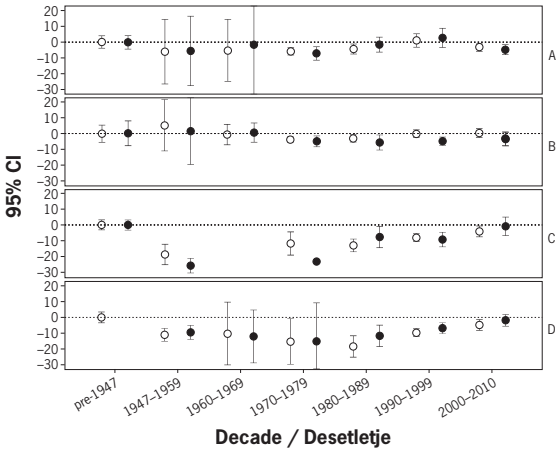

Figure 2: The change in eggshell thickness (white dots) and shell indices (black dots) in four raptor species (A – White-tailed Eagle *Haliaeetus albicilla*, B – Golden Eagle *Aquila chrysaetos*, C – Peregrine Falcon *Falco peregrinus*, D – Merlin *F. columbarius)* in Norway; average values per decade. Values before 1947 are considered base levels.

Slika 2: Sprememba v debelini jajčne lupine (bele pike) in indeksih lupin (črne pike) štirih ptic roparic (A – belorepec *Haliaeetus albicilla*, B – planinski orel *Aquila chrysaetos*, C – sokol selec *Falco peregrinus*, D – mali sokol *F. columbarius)* na Norveškem; povprečne vrednosti na desetletje. Vrednosti pred letom 1947 so obravnavane kot izhodiščne.

Contaminant levels

The results show in general that the levels of the "classic" pollutants such as DDTs and PCBs are decreasing in Norwegian diurnal raptors such as the White-tailed Eagle (Figure 3). Similar trends are documented for other species, as well as for pesticides such as dieldrin, HCH, and HCB. The trends of the "new pollutants" such as brominated flame retardants, i.e. polybrominated diphenyl ethers (PBDE), polybrominated biphenyls (PBB), and hexabromo-cyclo-dodecane (HCB) and perfluorinated compounds (PFCs) are still somewhat uncertain, because of the limited number of analyses, and the time series is short. We still know very little about the possible biological effects of these compounds, which are extensively used in fire-fighting foams, surface treatment of textiles, etc.

In general, the Golden Eagle is exposed to low levels of pollutants, due to its position at the apex of a short terrestrial food-chain. However, in a study of long-term reproductive performance in a coastal population, there was evidence of reduced productivity, which correlated with elevated pollutant levels in eggs. This was attributed to an influx of pollutants from coastal birds as prey, representing the longer marine food-chains with much higher pollutant levels than the terrestrial ones (Nygård & Gjershaug 2001). As for the Golden Eagle, the contaminant levels in Gyrfalcon eggs were in general low. The levels of pollutants in White-tailed Eagle eggs are now below the levels known to be detrimental to the species (Helander *et al.* 2002). The DDT-transformation product *p,p'*-DDE is still a prevalent pesticide in all predatory bird eggs, 40 years after the ban in western countries, and is the dominating pollutant in the migratory and bird-eating species such as Merlin and Sparrowhawk *A. nisus*. In other species, such as the White-tailed Eagle, PCBs today accounts for the major organochlorine burden, which is typical of marine environments.

5. Strengths and weaknesses

The strength of a monitoring programme is connected with the predictability and level of financing, and

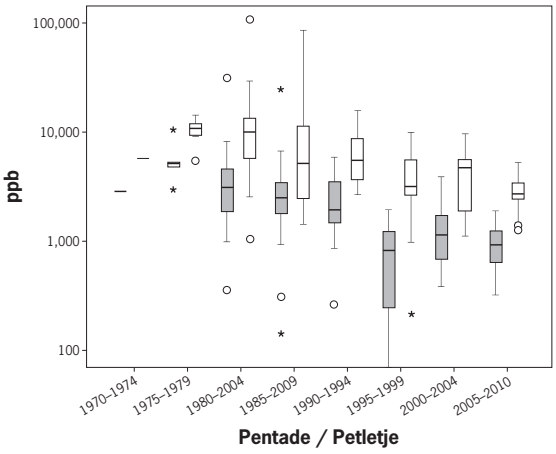

Figure 3: Box-and-whiskers chart (medians and quartiles) showing time trends of DDE (grey columns) and PCBs (fresh weight, white columns) in eggs of White-tailed Eagle *Haliaeetus albicilla* in Norway during 1970–2010

Figure 3: Grafikon z medianami in kvartili, ki prikazujejo časovne trende DDE (sivi stolpci) in PCB-jev (sveža teža, beli stolpci) v jajcih belorepca *Haliaeetus albicilla* na Norveškem v obdobju 1970–2010

also with the quality and strength of the responsible institution. Only the national projects financed by the Directorate for Nature Management are of such a type (TOV-projects, Golden Eagle, Gyrfalcon, pollutant monitoring and the Rovdata system). Some monitoring projects financed by the regional County governors have also been long-lasting and suitably financed. Weaknesses are often seen connected with projects run by NGOs and other interest groups, often being poorly financed over time and based on idealism. Such time-series can suffer greatly from poor descriptions and consistency of methods, poor and inconsistent data-storage, and change of personnel. Lack of harmonization of methods and cooperation between local groups may be a problem when trying to compile data over a larger geographical scale.

Norway is a large and thinly populated country, and there is a lack of competent personnel to carry out the necessary monitoring. Volunteers can be hard to find, so proper financing is needed. The Government only finances monitoring of species that have political and economic issues. More comprehensive monitoring of the Golden Eagle is required due to problems with illegal persecution and compensation issues. Better monitoring of the Goshawk is needed due to the threats posed by large-scale forestry, especially connected to the mature spruce forests of the lowlands. A sufficient overview of the status of the Eagle Owl is still needed, and so is proper implementation of mitigation measures. An assessment of cumulative future effects of wind farm developments on raptors is also lacking.

We have much to learn from our neighbouring countries, Sweden and Finland, regarding monitoring and management of Golden Eagle. They have a system of monetary compensation to the communities and reindeer husbandry units, which hold breeding Golden Eagles on their land. Compensation is given per occupied or breeding eagle territory. This requires comprehensive monitoring. In Norway, however, compensation is given per killed animal, mostly reindeer and sheep. The documentation process is problematic, and in practice the owners are given compensation as a certain percentage of their losses. The claims are therefore often grossly exaggerated (Gjershaug & Nygård 2003), thus giving the Golden Eagle a bad reputation.

6. Priorities, capacity-building

Other future threats come from habitat and climate change, urban spread, developments on the coast (wind-power developments, industry, tourism), in the mountains (tourism, roads, power lines, wind-power developments). The main goal must be to secure funding through long-lasting monitoring state-run projects, preferably with a research platform. Furthermore, one needs to educate state wildlife officers of proper species recognition and ecology. Also, there is a need to develop and strengthen co-operation between NGOs and state agencies. Education and information to the public and management authorities about the value of raptors as environmental sentinels is important, and so is the dissemination of results by publishing and making them available on the web.

The use of addled raptor eggs has proven a nondestructive and efficient way to perform environmental monitoring on a broad scale. It is important that the national monitoring scheme for pollutants in raptors is continued, especially in light of the high levels of new contaminants, where the trends, sources and pathways are not yet well understood. A national repository for biological samples, aimed at long-term monitoring of pollutants in the Norwegian environment, is under implementation under The Environmental Specimen Bank (ESB Norway), and will archive eggs and tissue samples for future analyses (http://www.miljoprovebanken.no).

7. Povzetek

Na Norveškem so vse ujede in sove zavarovane z zakonom, sprejetim v letih 1968 in 1972. Od takrat se je število večine vrst, ki so bile predtem neusmiljeno preganjane (ujede), in vrst, ki so bile še posebno občutljive za okoljsko onesnaževanje (sokol selec *Falco peregrinus* in ribji orel *Pandion haliaetus*), povečalo. Leta 1990 je bil na Norveškem osnovan nacionalni program monitoringa kopenskega okolja, v katerega je vključen tudi monitoring populacij planinskega orla *Aquila chrysaetos* in arktičnega sokola *F. rusticolus.* Hkrati pa je po vsej državi začel potekati tudi monitoring onesnažil v jajcih ujed in sov. Niz podatkov o ravni onesnažil v jajcih več vrst ptic roparic zadeva obdobje 40 let za DDE (dikloro-difenil-dikloroetilen) in PCB-je (poliklorirani bifenili) kot tudi meritve debeline jajčnih lupin. Sicer pa sta v celostni program monitoringa, ki ga financira država, vključena samo planinski orel in arktični sokol, medtem ko druge vrste lokalno financirajo in preučujejo posebne zainteresirane skupine in nevladne organizacije. Planinski orel je pod močnim pritiskom kmetov in organizacij, ki se ukvarjajo z rejo severnih jelenov, medtem ko na kragulja *Accipiter gentilis* negativno vpliva golosečnja starih gozdov. Velik lokalni problem je visoka smrtnost belorepca *Haliaeetus albicilla* zaradi trkov z vetrnimi turbinami. Populacija ribjega orla se vrača na raven iz obdobja pred uporabo DDT-ja (dikloro-difenil-trikloretan). V zadnjih dveh ali treh letih se je raven pesticidov na splošno močno znižala, kar se navsezadnje kaže v boljši kakovosti jajčnih lupin. Največja ovira za celosten monitoring ujed in sov na Norveškem je pomanjkanje finančnih sredstev in ustreznega osebja.

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