Title
Prevention of unwanted species immigrating to islands on strait crossings

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PREVENTION OF UNWANTED SPECIES IMMIGRATING TO ISLANDS ON STRAIT CROSSINGS

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Abstract: When islands are connected to the mainland by bridges or tunnels it becomes possible not only for humans to travel back and forth but also for wildlife, which uses these new means of access as migration corridors. The results can be disastrous, as can be seen from the example of the island of Tautra in the north of Norway (North Trøndelag).Tautra was proclaimed a wetlands area of international importance under the Ramsar convention in 1985. Parts of the island perform the multifunctional purpose of a breeding, migration, wintering and molting area, and have been used over the years by countless numbers of waterfowl. In the late 1970's a road to the island was built over a stone-fill embankment. Predators, such as foxes, badgers, martens and others, began appearing on the island, using the new road as a migration corridor. The most abundant species of waterfowl on the island, which was the reason for the island receiving its Ramsar wetlands status, declined sharply in numbers after the construction of the road. Indeed, today some species on the island have been reduced to barely 10% of their original populations before the road was built. This drop in numbers is due not only to the introduction of mammalian predators but also to the deterioration of the area as a wetland feeding ground, an effect resulting from the blocking of the ocean stream when the embankment was constructed. A predator extermination program for the island was established. Also, to prevent predators from using the road, loudspeakers were set up in the hope that the noise from the speakers would be enough to scare the predators away. However, after a time the deterrent effect of the loudspeakers weakened, possibly as a result of the animals becoming used to the sound and no longer associating the sound with danger. In regard to roads and bridges, little research has been done on wildlife deterrent methods, which employ no physical barriers. Noise, light and smell have been used in different ways, but these measures seem to lose their effect over time. In tunnels, however, noise deterrents have proven successful. It has now (2001) been decided to replace 350 metres of the road out to Tautra with a bridge; a measure, which it is hoped will restore the natural water currents around the island. To ensure the success of this project, which will cost nearly 50 million Norwegian crowns, an effective wildlife barrier must be set in place. The Public Roads Administration has therefore initiated a development project with the aim of producing a wildlife barrier device that is 100% reliable. The device will be tested out on foxes, martens and badgers in captivity. The trials will be carried out at the University of Oslo during the course of the year 2001. Specifically, the tests are designed to demonstrate how well these three species cope with different kinds of grids (width of mesh, wire-thickness, length, breadth).

Introduction

Roads and road building can have an impact on the natural environment in many different ways. Traditionally, we have been concerned by the land use itself; however, in more recent years we have also begun to focus upon a range of effects which, to a greater or lesser degree, are indirect; for example: pollution, road kills, the disturbance of vehicular traffic (noise, vehicle-lights, movement) and the erection of barriers that close off the paths used by different kinds of wildlife and divides the patterns of their natural living areas. The negative effects of these factors are many and complex, but the building of roads and other transport infrastructures can also create new migratory opportunities for wildlife. Areas beside the road can serve as linear habitats or corridors, which allow wildlife to migrate across unsuitable territory, joining together habitats and wildlife populations, which would otherwise have remained separate. Road building can also serve to protect habitats; remnant areas, for example, after construction can be left closed off, out of reach of undesirable human interference.

The Problem

However, when wildlife gains entry to areas from which it has previously been cut off, it can in some cases have particularly undesirable effects. This applies mainly to the building of road bridges to islands, but it can also be a problem when roads connect two areas on the mainland where the wildlife of the areas has remained isolated due to insuperable natural barriers; for example, high mountains or wide rivers. In the following discussion I will concentrate on the problems associated with islands, which have acquired, in one form or another, a link with the mainland, be it a bridge, a tunnel or a road on a landfill embankment.

The flora and fauna of an island can be quite different from that of the adjacent mainland. The difference in the range of species found on the island depends upon its distance from the mainland and from other islands, ice conditions in winter, the ocean streams and the different abilities of each species to bridge the gap posed by the water barrier. Many bird species have little trouble making their way out to even far out-lying islands and the same is true for some mammals capable of swimming moderate distances. In a somewhat broader perspective, both geographically and historically, we might say that the range of species on an island is determined by the situation at the time the island was still a part of the mainland.

Over time the plants and animals on isolated islands can develop in quite distinctive directions. The absence of natural enemies can mean that some species find themselves in a very favourable position; ground-nesting birds, for example, are especially attracted to such islands. There are opportunities too for humans to influence and exploit the special range of species to be found on isolated islands. On islands without larger predators, for example, game animals can be introduced for hunting purposes, while predator-free islands are also well suited for the raising of domesticated animals. On islands along the Norwegian coast porcupines have been introduced as part of a campaign of "biological warfare" against snakes and small rodents.

On islands with only limited immigrations, be these of reptiles, rodents, ungulates or carnivores, an active combative campaign can be an effective measure in controlling or completely exterminating vermin and other unwanted creatures. Problems occur when migrations become so large that it becomes difficult or extremely costly to control groups of undesirable species. Moreover, for especially vulnerable areas the introduction of even a small number of new animals can be damaging. Predators pose the biggest problems; they are by nature more opportunistic and more curious than other animals. They move over wide areas and are capable of overcoming most barriers, both natural and man-made.

The Solutions

Little available documentation exists on the kinds of devices that have been used in the past to or on what effect these different measures have had. Fences and traditional cattle grids can usually effectively stop most hoofed animals, domesticated and wild. With regard to predators, however, finding effective barriers has proved much more difficult. Some of the measures employed to deter wildlife from using roads include the use of noise, light and smell, both singly and in combination. While we may, nevertheless, have our own opinions as to how effective these measures have been, no scientific follow-up programmes as such have been carried out on the deterrent devices. Nor, moreover, has the problem of wildlife migration to islands via roads been given high priority abroad. The following discussion of the different types of wildlife deterrent therefore will be based primarily upon the undocumented experience from a small number of Norwegian wildlife deterrent installations.

The use of *smelling agents* has been employed to repel both ungulates and predators. The artificially produced scent of predator urine, for example, has been used to frighten away ungulates from roads where they might be run over. The general conclusions from such attempts, however, are that smells alone are not enough to deter animals from crossing the road. The measure is also sensitive to wind. A degree of repulsion can be registered immediately after the smelling agent has been placed out, but the effect begins to weaken a short time later, even with regular renewals of the smelling agent.

The *lighting* of roads, bridges and tunnels has generally little deterrent effect upon animals. Indeed, for certain species light can have precisely the opposite effect by attracting insects and other small creatures that can serve as food for other animals.

Noises have been employed in various forms. It is most commonly used to frighten away birds from airports or food production plants. In such cases the noises employed are usually those of the enemies of the unwanted species – for example, the sounds made by a bird of prey. More monotone and sustained sounds of different frequencies are also used in a variety of situations and upon a range of species, from insects to rodents and from seals to land predators. The effect of these measures has been reported as varied. With regard to deterring predators from roads, sound-creating devices that produce strong sound signals are employed. In the tunnels out to the islands of Hitra (1994) and Frøya (2000) in South Trøndelag, Norway, loudspeakers were set up which produce sounds in the frequency ranges 5,000 Hz (from 07:00-16:00) and 7,000 Hz (from 16:00-07:00). In the Hitra Tunnel three pairs of speakers were set up 15m, 21m, and 27m from the mouth of the tunnel. In the Frøya Tunnel one pair of speakers was set up 100m from the mouth of the tunnel. Here the problem species are primarily badgers, martens, red foxes and stray farm foxes. The installations have been relatively dependable and results so far have been good. No sightings of the unwanted species have been made on Hitra, although a fox was spotted in the Hitra Tunnel, probably as a result of temporary equipment failure.

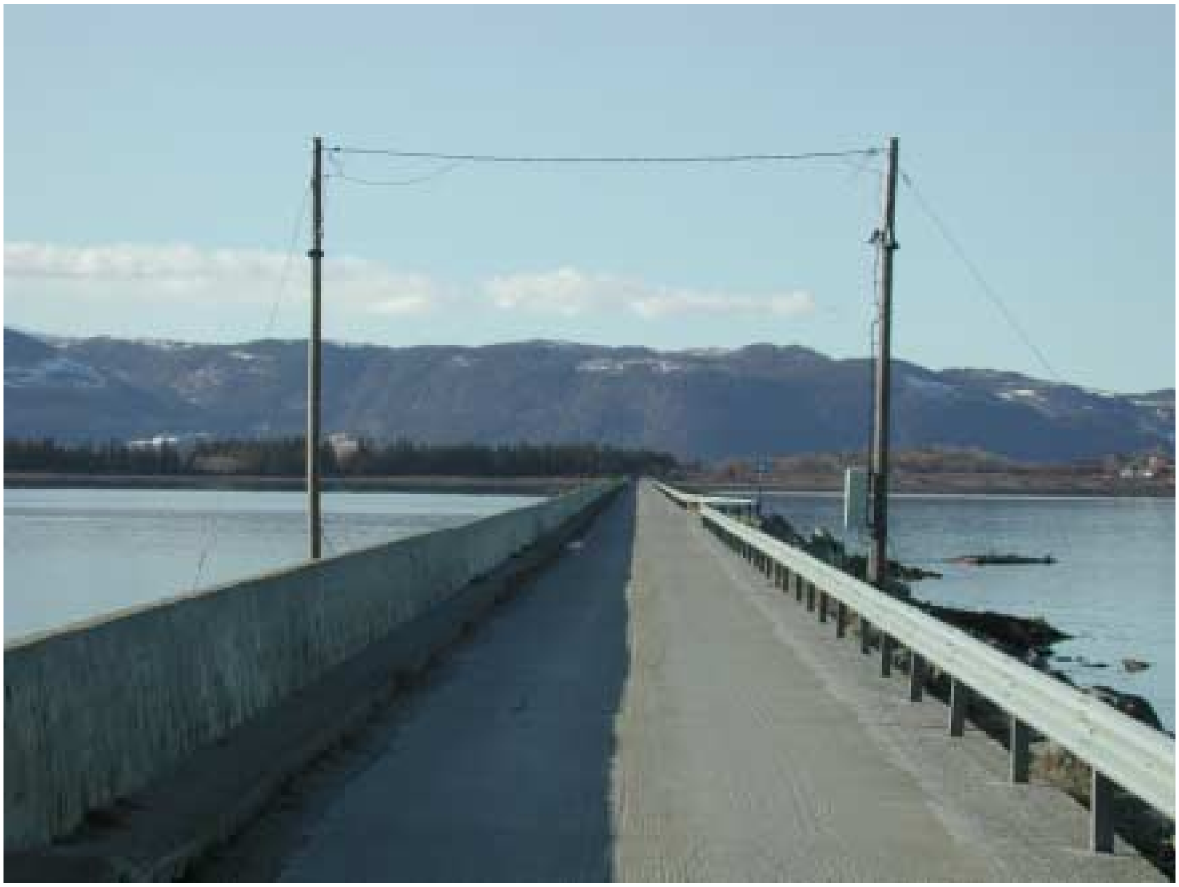

Fig. 1. A wildlife noise deterrent device on the road to Tautra, North Trøndelag, Norway. (Photo: Bjørn Iuell)

On the road out to the island Tautra in North Trøndelag, attempts have also been made using noise to keep out martens, badgers and foxes; but the results here have not been as good as in Hitra and Frøya. Loudspeakers were set up on poles on either side of the road approximately 50m from the shore (fig. 1). The equipment is the same brand as that used in the Hitra and Frøya tunnels, but the sound produced fluctuates within the 5,000-30,000 Hz frequency range. During outside tests on domesticated foxes the animals exhibited obvious signs of stress when exposed to sounds between 5,000-10,000 Hz. During the first 3-4 years the deterrent device appears to have had good effects; however, after this time the effect seems to have fallen off, with repeated sightings of the target species made since then. Shooting of mink, martens, badgers and foxes has therefore been introduced as a supplement to noise deterrent. During the period 1991-2000 a total of 64 animals were shot.

A noise deterrent device has also been set up on the Dyrøy Bridge in Troms County, primarily to stop the immigration of foxes. However, this deterrent device also exhibited reduced effect after only a few years of operation. The frequency range in the beginning was in this case between 20,000-30,000 Hz, but this was adjusted to 17,000 Hz after tests on dogs.

The conclusion then, when it comes to the use of sound deterrents, is that they seem to be more effective in tunnels than in open country. Moreover, something that can be said in general for all wildlife deterrents that are not physical barriers, is that there is a danger that a certain immunity to them will develop over time. Another problem is that the installations are prone to breakdown, either as a result of technical problems or because of vandalism.

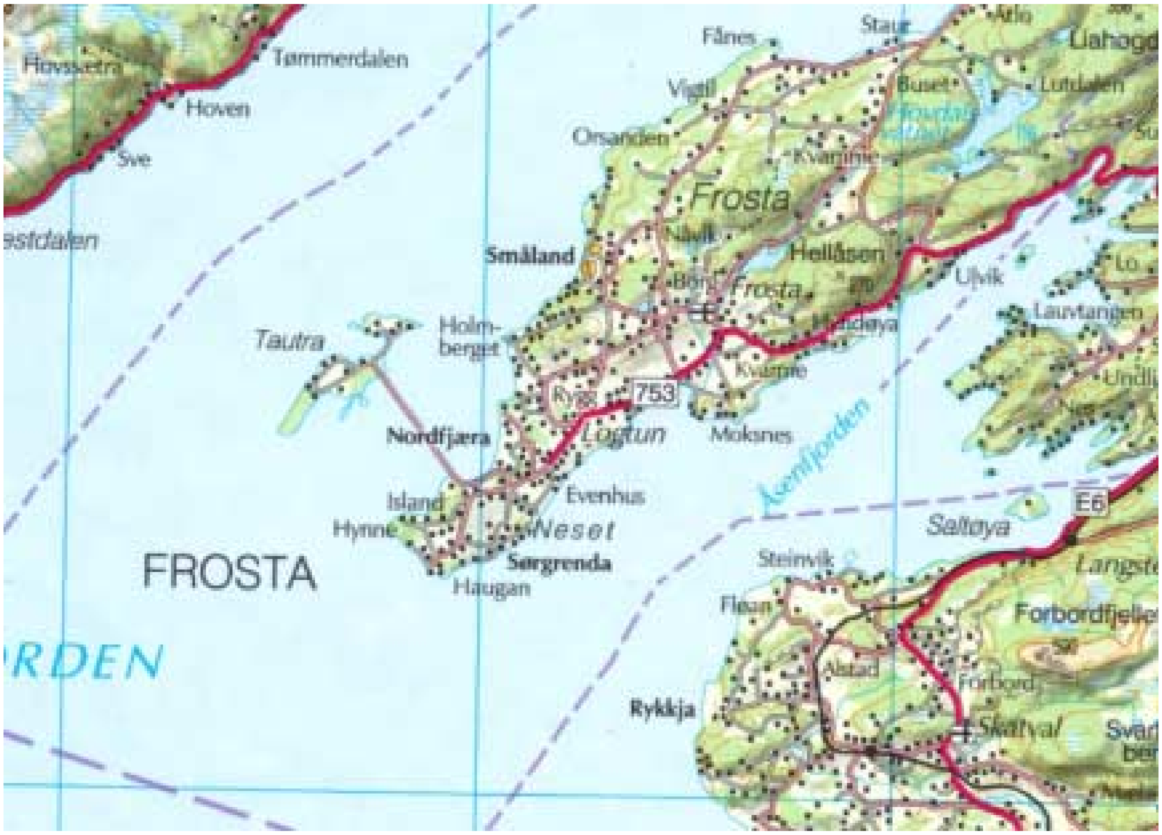

Fig. 2. The Island of Tautra, with a 3 km road constructed in 1976. (Map: Cappelens kart)

The New Approach

Based on experience gained from the above cases the Norwegian Public Roads Administration has initiated a smaller development project with the objective of coming up with effective, dependable and lasting barrier devices for a wide range of species. Tautra Island in the municipality of Frosta in North Trøndelag County has been mentioned earlier. The island is approximately 3.5 km long and is situated in the Trondheim Fjord (fig. 2).

This is a unique island, which in addition to its national cultural and historical significance, is of strategic importance for migrating and nesting birds, with a highly productive wetlands area. This has led to large parts of the island being declared a national reserve under the Environment Act in 1984. Tautra is an important feeding and resting place for migrating birds nesting in the Arctic, as well as a nesting place for many other bird species. In all, 202 different bird species have been registered on the island, and in 1985 the area was proclaimed a Ramsar-area under the Convention on wetlands of international importance, especially as waterfowl habitat (Ramsar, Iran, 1971).

In 1976 the island was connected to the mainland with a 3km road (fig. 3). It was built to on a stone embankment, which has led to the silting-up of the wetlands area and to a considerably reduced level of food availability for the birds on the island. Furthermore, as mentioned earlier, there has been immigration of predators to the island in spite of the wildlife noise deterrent devices set up on the road in 1991.

Fig. 3. The road to Tautra, seen from the island. (Photo: Bjørn Iuell)

The situation has seen dramatic developments over recent years, with the most important bird species now reduced in number to just 10% of their original population before the road was built. To improve the flow of water around the island it has now been decided that the mid-section of the stone embankment where the strait is at its deepest will be removed and replaced by a bridge of approximately 350m in length. As part of this work, which has been estimated to cost almost 50 million Norwegian Crowns, an important consideration will also be the setting up of effective wildlife barrier devices in connection with the new bridge.

A project group with representatives from Frosta Municipality, the Regional Administration of North Trøndelag County, the North Trøndelag University College, the Directorate for Nature management, the University of Oslo and the Norwegian Public Roads Administration was set up in 2000 to consider wildlife barrier alternatives. After assessing the experience to date with existing deterrent installations, it was concluded that if the bridge emplacement project were to be effective, then deterrent methods other than noise, smell and light needed to be found.

Moreover, as any proposal would entail the exposure of equipment to harsh climatic conditions such as strong winds, ice formation and the effects of salt water, the demands upon technology and its reliability were great.

It was also concluded that the task of deterring wildlife from the road should be approached from two angles. Firstly, rather than the mainland end of the road and embankment virtually leading animals out onto the road as it does today, it should be constructed in such a way as to lead animals away from the road. The second way of tackling the problem is to stop those animals, which do manage to get onto the road from making their way any further out towards the island.

Leading-fence

As it stands today the embankment emerges on both sides of the road as a natural extension of the shoreline, which leads animals along the beach sands and thus out onto the road (fig.4). That is to say, the embankment appears to wildlife as the continuation of the shoreline, and they can end up on Tautra without ever intending to go there. It is therefore possible to repel animals from the island before they even get as far as the road by placing appropriate constructions between the shoreline and the road, which will lead the animals away from the road.

This should be possible by setting up a simple leader-fence that leads the animals back and over the road, somewhat like an inverted fish-trap. However, as the sea floor on either side of the embankment slopes away very gradually, an added challenge will be finding an effective deterrent method that also functions at low tide. Water recedes from large expanses of the shore area on both sides of the embankment at low tide thus allowing animals to pass freely (fig. 5). Another consideration, moreover, is that any wildlife deterrent emplacements must blend in aesthetically with the natural environment.

Fig. 4. The embankment emerges as a natural continuation of the shoreline, thus leading animals out to the island. (Photo: Bjørn Iuell)

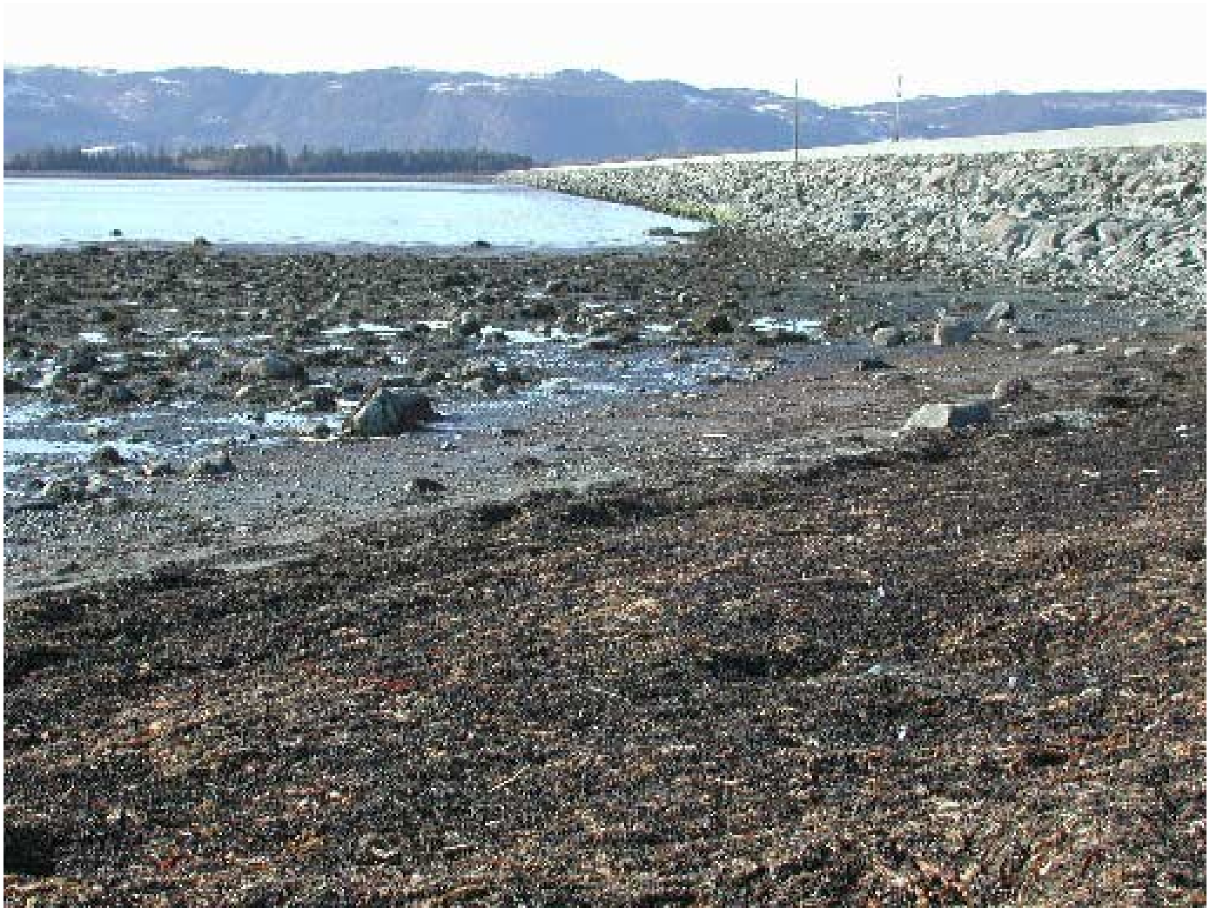

Fig. 5. At low tide, shore areas are exposed on both sides of the embankment, thus allowing animals free passage. This presents a challenge when it comes to finding a wildlife deterrent method that blends in with the natural environment. (Photo: Bjørn Iuell)

Wildlife barrier device

The Norwegian Public Roads Administration in North Trøndelag, in conjunction with the North Trøndelag Department of the Environment and the North Trøndelag University College, has drawn up a proposal for a wildlife deterrent device consisting of a gate with an automatic opening mechanism combined with a grid. The plan is to place the device over the crossing between the existing body of the road and the new bridge. There should be a height difference between the existing road and the bridge of approximately 2m, and a grid should be built into the apron of the road that slopes up to the bridge. A grid combined with an automatic gate should be enough to prevent animals from gaining access to the road. It is important, moreover, to ensure that animals cannot gain access by using other parts of the emplacement.

Gate

Badgers are quite poor at climbing and jumping, while foxes on the other hand can jump over barriers up to 1.5m high without difficulty. Martens, however, pose the greatest challenge, being extremely good climbers. The gate should therefore have a smooth surface and sit flush within the emplacement, and should be between 1.5 and 2.0m high. It must be ensured, moreover, that animals cannot gain access under the gate, while at the same time the gap under the gate must be large enough to prevent foreign objects from becoming wedged under it, thus preventing it from closing properly. The gate must therefore stand as close to the body of the road as possible and preferably have a stiff brush attached to its bottom edge. The gate must open out over the grid so that snow, ice or other material lying in front of the gate is pushed out over the grate so that it falls to the ground or water below.

The automatic opening function of the gate must be adapted to climatic conditions, take pedestrians and cyclists into account and be operable manually in the event of breakdown or power failure.

Grid

The most effective placement of the grid and gate is where the bridge and road join; firstly because at this junction it will be easier to prevent animals from gaining entry by use of other parts of the installation, and secondly because it is important to have a good depth under the grate. Animals will be less inclined to make their way out onto the grid, for example, if they can see water flowing at some distance beneath. Moreover, in the event of the gate remaining open, it is important that the grate function as an effective barrier in itself.

A certain level of maintenance will be necessary to ensure the effective operation of the automatic closing mechanism of the gate and to prevent the grid from becoming clogged.

The grid must be placed on the road apron between the existing road and the bridge, thus creating an inclined approach to the gate. However, the grid must not be too smooth, so that it becomes, as it were, "a hill-start under slippery conditions". A traditional cattle grid with a row of cross-pipes, for example, would not be particularly practical. The gate must perform the dual purpose of allowing walkers and cyclists to get through, while at the same time keeping the unwanted species in question out. Work has been carried out on different wildlife barrier devices on Tautra since 1988. For example, traditional cattle grids were used with animals in captivity. It became evident from these attempts that red foxes had no particular difficulty getting past this kind of grid. Nor, in our case, is an electrified grid an option, the emplacement being constantly exposed to salt water spray. Trials will therefore be run of the "pressure-welded lattice" type grid.

These grids will be tested out on foxes, martens and badgers in captivity. The trials will be carried out at the University of Oslo during the course of the year 2001. Specifically, the tests are designed to demonstrate how well these three species cope with three different kinds of grid (width of mesh, wire-thickness, length, breadth).

Conclusions

When islands are connected to the mainland by roads, bridges or tunnels it is necessary to evaluate to what extend the new connection can create unwanted ecological changes like immigration of new species. If necessary an effective wildlife barrier must be incorporated in the construction, adjusted to the local situation.

A certain level of supervision on the island will be necessary after these measures have been implemented both to ensure that the wildlife deterrent device is working as planned, and to remove any animals, which find their way out to the island in spite of the device. A camera monitor should also be set up on the road to document, if possible, how animals respond to the new deterrent device, and if any animals are able to gain entry past it. This is the only way to improve our knowledge about the behaviour of the animals and the effectiveness of the barrier devices.

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