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Large-scale monitoring of the effects of human disturbance on waterbirds: a review and recommendations for survey design

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Disturbance, especially that caused by human recreational activities, is a threat to waterbirds, particularly since many recreational activities may be increasing in intensity and distribution. Disturbance can have a considerable effect on the numbers of birds using a site and in some circumstances may have consequences for the size of populations. The EC Birds Directive, Ramsar Convention and the African-Eurasian Waterbird Agreement provide the legislative framework for waterbird conservation along the east Atlantic flyway and require signatories to assess the extent, effects and impacts of human disturbance and to mitigate against any deleterious effects. There is also a good scientific basis for monitoring the effects and impacts of disturbance. We recommend that existing large-scale volunteer-based surveys should be used to monitor the extent and distribution of human activities at a variety of spatial scales. However, we argue that these surveys are of little direct use in measuring the effects and impacts of disturbance on waterbirds.

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1. Introduction

Wetlands and waterbirds are under intense pressure from anthropogenic activities such as land claim, habitat destruction, pollution, hunting and recreation (Bell & Owen 1990, Ward 1990, Yalden 1992, Tucker & Heath 1994). It is generally agreed that disturbance, especially that caused by recreational activities, is a threat to waterbirds, particularly since many recreational activities may be increasing in intensity and distribution (*e.g*. Ward 1990, Cayford 1993).

It has been estimated that 23 waterbird Species of European Conservation Concern (SPECs) have suffered moderate or large scale declines in the past, due in part, to some form of disturbance (Tucker & Heath 1994). Furthermore, 29% of European sites classified as Important Bird Areas (IBAs) are threatened by the effects of disturbance (Heath & Evans 2000). Although many experimental studies have shown that disturbance, which can be equated to deterioration of habitat, can have a considerable effect on the numbers of individuals using a site, it is generally much less clear how populations of species respond to the stimuli (see Madsen *et al*. 1995 and Hill *et al*. 1997 for reviews).

Effective waterbird protection requires the demonstration and minimisation of the effects and impacts of anthropogenic activity where there is a potential conflict between waterbird conservation and recreation interests. Hill *et al*. (1997) provided a comprehensive set of recommendations for disturbance research that would serve to provide the scientific basis to underpin disturbance research. In contrast, very little attention has focused on the ways in which large-scale volunteer-based surveys can contribute to the monitoring of disturbance at wetlands to fulfil conservation objectives.

In this paper we review the requirements for disturbance monitoring made under the European Community (EC) Birds Directive, the Ramsar Convention and the African Eurasian Waterbird Agreement (AEWA). These three international commitments, in conjunction, provide the legislative framework for the conservation of waterbirds throughout the east Atlantic flyway. We then focus on the scientific basis for monitoring disturbance by reviewing the methods used to measure the effects and impacts of disturbance. Using these reviews as a backdrop, and highlighting the strengths and weaknesses of current 'disturbance' monitoring in the UK by the Wetland Bird Survey (WeBS), we identify the extent to which existing large-scale volunteer-based count schemes potentially can be used to monitor the occurrence and consequences of human activities for waterbirds.

2. A legislative framework for monitoring waterbird disturbance

Nations are responsible for implementing various international agreements, directives and conventions that have been introduced to ensure that birds and their habitats are conserved effectively. Along the east Atlantic flyway, the EC Birds Directive 1979, the Ramsar Convention 1971 and the AEWA 1995 provide legislative requirements for disturbance research.

i. The EC Birds Directive

The EC Directive on the Conservation of Wild Birds (Council Directive 79/409/EEC) provides a legal framework for the conservation of naturally occurring bird species in Europe. Article 2 of the Directive requires the maintenance of populations of bird species 'at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the populations of these species to that level.'

Article 3 requires that Member States should 'take requisite measures to, maintain or re-establish a sufficient diversity and area of habitats for all the species of birds naturally occurring in Europe referred to in Article 1.' Article 4 requires Member States to classify suitable territories in number and size as Special Protection Areas (SPAs). Article 4 specifies that steps should be taken 'to avoid pollution or deterioration of habitats or any disturbances affecting the birds insofar as these would be significant' and that 'outside these protection areas, Member States shall also strive to avoid pollution or deterioration of habitats.'

ii. The Ramsar Convention on Wetlands of International Importance

The Ramsar Convention requires signatories to protect wetlands of international importance, to promote wetlands generally and to foster the wise use of wetlands. At least one site in each country must be designated for inclusion in the Ramsar 'List'. With respect to the impacts of human activities, Article 3.1 specifically requires Signatories to 'formulate and implement their planning so as to promote the conservation of wetlands included in the List, and as far as possible the wise use of wetlands in their territory' and, within Article 3.2, '...arrange to be informed at the earliest possible time if the ecological character of any wetland and its territory in the List has changed, is changing or is likely to change as the result of technological developments, pollution or interference.'

Signatories are also required to '...encourage research and the exchange of data and publications regarding wetlands and their flora and fauna.' However, the Convention text is no more specific than this regarding the measurement and monitoring of the effects and impacts of human disturbance.

iii. AEWA

The AEWA 1995 requires that Parties should take co-ordinated measures to maintain migratory species in a favourable conservation status, or to restore them to such a status. This Agreement goes slightly further than the Birds Directive and Ramsar; Article III, 2 (e) requiring Signatories to '...investigate the problems posed or are likely to be posed by human activities and attempt to implement remedial actions throughout flyways. Such information can only be collected by long-term schemes which monitor the effects of anthropogenic disturbance on waterbirds.'

For those waterbird populations with particularly unfavourable conservation status, Section 2.1.1 (b) of the Agreement Action Plan requests that Signatories should '...prohibit deliberate disturbance in so far as such disturbance would be significant for the conservation of the population concerned.' Section 4 deals with the management of human activities and in 4.3.6 requests that 'In cases where human disturbance threatens the conservation status of waterbird populations listed in Table 1, Parties should endeavour to take measures to limit the level of threat. Appropriate measures might include, inter alia, the establishment of disturbance-free zones in protected areas where public access is not permitted.'

Section 5 deals specifically with research and monitoring needs and in Part 6 states that Parties '.....shall endeavour to undertake studies on the effects of.......disturbance on the carrying capacity of wetlands used by the populations listed in Table 1 and on the migration patterns of such populations.'

In summary, if nations are to fulfil their commitments under this international legislation, it will be necessary to develop appropriate research that adequately measures:

- The causes, distribution and frequency of potentially disturbing activities nationwide.
- The 'effects' of human disturbance at site-level, especially at protected sites.
- The 'impacts' of human disturbance at the population level, ie what the consequences are of disturbance for the con-

servation status of individual waterbird populations.

2. A scientific basis for measuring the effects and impacts of human disturbance

It is important to differentiate between the terms 'effects' and 'impacts' when used in the biological sense. An effect is an observed response, ie a movement of birds (that may only be a temporary displacement) away from a site in response to some stimuli. Furthermore, birds may be able to use alternative sites during periods of high disturbance at the original site without any negative effects on their energy budget. Impacts are of primary conservation importance because they imply a reduction in survival of individuals, which may cause declines in population size. Impacts depend largely on whether alternative sites are available and the energetic costs of displacement (Gill *et al*. 1998). The stages of measuring the effects and impacts of human disturbance are summarised in Fig. 1 (slightly amended from Davidson & Rothwell 1993).

Two approaches have been taken to assess the effects of disturbance on waterbirds. The first method involves recording the distribution of animals before and after disturbance incidents (e.g. Draulans & van Vessem 1985, Bélanger & Bédard 1989, Madsen 1998a). A problem associated with this method is that disruptions to waterbird distribution subsequent to a disturbance event may not have negative consequences because the new distribution pattern may only be temporary; animals returning to their original distribution at a later date to exploit the remaining resources (Owens 1977, Underhill *et al*. 1993). The alternative method is to relate the numbers of animals to the varying rates of disturbance across a number of sites or patches within sites (*e.g*. Tuite *et al*. 1984, Sutherland & Crockford 1992). However, to be able to interpret these data correctly, an assessment of the number of animals using the site in the absence of disturbance is required. Without some

Stage 1. Presence of human activities

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Stage 2. Disturbance changes behaviour of waterbirds

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Stage 3. Disturbance causes a reduction in the numbers of waterbirds at a site **(site effect)**

↓

Stage 4. Disturbance causes waterbirds mortality at a site **(site impact)**

↓

Stage 5. Disturbance causes waterbird population declines **(population impact)**

Fig. 1. Stages in measuring the effects and impacts of human disturbance to waterbirds (amended slightly from Davidson & Rothwell 1993).

form of experimental control, the results of these types of studies are flawed. In an attempt to overcome these problems, Madsen (1998b) was able to vary the levels of hunting disturbance experimentally in Denmark and recorded the reactions of waterbirds in terms of displacement and redistribution.

To understand the impacts of disturbance on waterbird populations it is necessary to know not only whether a species avoids sites where humans are present, but also the consequent costs of moving to another site (Gill *et al*. 1998). Gill *et al*. (1996) described a method of quantifying the impacts of disturbance, based on the trade-off between resource use and risk of disturbance. The approach follows a similar technique used to study the effects of predation risk on patch use (Lima & Dill 1990). In effect, waterbirds perceive humans as potential predators. The technique proposed by Gill *et al*. (1996) measures the reduction in the use of a resource in response to disturbance. The approach allows both quantification of the effect of disturbance on numbers at a local scale, and exploration of the potential consequences of changes in disturbance on the size of populations.

Individuals-based population models have focused on the impacts of habitat loss on waterbird populations and provide a conceptual framework for predicting its consequences (Goss-Custard 1985, 1993, Goss-Custard *et al*. 1995a, b, Sutherland 1996a, b, 1998, Pettifor *et al*. 2000). Disturbance can be equated to habitat loss because both factors act to reduce the carrying capacity of a site. In simplistic terms, disturbance and habitat loss give rise to a reduction in food availability leading to movements of birds to other sites and therefore increased density (Goss-Custard 1977 1993, Sutherland & Goss-Custard 1991). Increased density, in turn, results in increased food depletion or competitive interference (or both) so that food intake is affected, reducing the optimality of the habitat and hence its 'carrying capacity' (Goss-Custard *et al*. 1995c, d; Stillman *et al*. 2000). The consequence of this at the metapopulation scale is to increase mortality as birds drop below a critical body mass threshold for survival, leading to flyway-scale population declines as habitat is increasingly lost through disturbance. As habitat is removed or disturbance levels are increased there may be no effects on bird numbers until a threshold density is reached. Beyond this density, density-dependent mortality occurs (Zwarts 1976, Goss-Custard 1977).

In some species, individuals may have to compete strongly to gain access to resources, perhaps because resources are uncommon, are depleted rapidly, because birds are near to the limits of their energy budget, because density is already high or because few suitable alternative sites are available. Therefore, these species are the most likely to be adversely affected by disturbance and habitat loss. Since density-dependent effects operate largely through interference competition between individuals on the feeding grounds in these species, and hence food competition, a method of measuring this density dependence is deemed to be the most appropriate method for estimating parameter values of density-dependent functions.

Density-dependence models can be used to predict the movements and mortality of birds in response to disturbance or habitat loss at a range of spatial scales, from individual-site to global levels. Clearly, the accuracy of such models relies on the accuracy of the parameter values used and therefore intensive studies of the demography, foraging behaviour, intake rates and physiological condition of the waterbirds involved (Goss-Custard 1995c).

3. Recommendations for volunteer survey design

The Wetland Bird Survey (WeBS) - monitoring human activities in the UK

WeBS is a large-scale volunteer-based scheme that aims to monitor all non-breeding waterbirds in the U.K. At present, WeBS volunteers record a range of human activities at wetland sites and indicate which of these activities are perceived to be disturbing birds. Counts are generally conducted at the weekend, during the morning and, at coastal sites, at high water (Gilbert *et al*. 1988). Many counters stop counting during the summer months when there are few waterbirds at their site. In light of the results of recent review of the human activities data collected by WeBS (Robinson & Pollitt 2002) and the legislative and scientific requirements for measuring the effects and impacts of disturbance on waterbirds, we identify those stages of disturbance measurement (see Fig1) that could be contributed to by volunteer-based count schemes:

Stage 1

With the possibility that disturbance may be increasing in many countries in Europe, measuring the extent and distribution of human activities remains a conservation priority. Previous work examining human activities occurring at wetlands in the UK by Davidson *et al*. (1991) and Robinson & Pollitt (2002) has indicated that the ability to monitor the distribution and occurrence of human activities can be of great value in highlighting potentially disturbing activities at sites, without measuring disturbance per se.

In light of the current success of WeBS in collecting these types of data, we suggest that the occurrence of various human activities at individual sites should be monitored through volunteer-based count schemes, which provide a cost-effective monitoring tool that can cover very large areas. There is some evidence to suggest counters are reluctant to provide disturbance data on a regular basis; only 60% of WeBS counters currently provide information on human activities at their sites (Robinson & Pollitt 2002). Therefore, to avoid over-burdening counters, we suggest this type of review should be undertaken periodically using a counter consultation approach, e.g. by questionnaire. A comprehensive list of the types of activities that could be recorded through this consultation is presented in Davidson *et al*. (1993). We also suggest that temporal and spatial variations in the occurrence of potentially disturbing human activities at a site should also be recorded.

This consultation technique would remove the inaccuracy of recording just those activities encountered during single ‘snapshot’ count visits and allow counters to record additional features, e.g. marinas or sailing clubhouses, which are indicative of potentially disturbing activities that may not be recorded on a specific count date but probably occur regularly. Furthermore, human activities that occur during the summer months, when waterbird numbers are low and no counts are made, can also be recorded using this method.

Stage 2

As we have explained above, the measurement of behavioural changes within a site as a consequence of disturbance require intensive field studies using an experimental approach, i.e. before-and-after studies using control sites for comparison (Hill *et al*. 1997). In contrast, we suggest that subjective questions, asking counters to measure the perceived 'effects' of human activities on waterbirds, should be avoided. Robinson & Pollitt (2002) suggested that there may be a positive correlation between WeBS counters indicating the presence of disturbance and the degree of disturbance at sites. Furthermore, as mentioned above, 'snapshot' counts, such as those used by WeBS and other volunteer-based count schemes in Europe, do not provide information on human activities occurring at times other than during the count itself. For example, many volunteers prefer to make their counts during late morning when disturbance events may have already caused changes in the behaviour and local distribution of birds.

Stage 3

Assessing the long-term effects of disturbance on waterbirds at individual sites is necessary, primarily to ensure that site management is continually sympathetic to the conservation of the waterbirds. It is generally accepted, that site-based work examining the long-term effects of disturbance is best undertaken through more intensive, and scientifically robust methods (*e.g.* following Madsen 1998b).

As mentioned above, WeBS counts are generally undertaken during the weekend, during the early morning and at high water. The potential biases in the data collected as a consequence of these restrictions suggest that such schemes may not be representative of overall human activity patterns across sites. In addition, 'look-see' count methods do not provide an accurate measure of the occurrence or intensity of disturbance at a site. For example, a counter may record numbers of waterbirds on a wetland regularly used for watersports yet, because he arrives there prior to peak activity, his records underestimate levels of human activity at the site. Relationships, or lack of them, between waterbird numbers and levels of human activity measured through volunteer-based surveys are therefore likely to be spurious.

Stages 4 and 5

Realistically, it will always remain the responsibility of professional ecologists to measure the impacts of disturbance using predictive population models and resource utilization studies like those suggested by Gill *et al*. (1996). This is largely because of the complexity and rigorous nature of the research required. However, to test the predictions of individuals-based population models there is a need to measure trends in abundance at the population level. To this end, we suggest that survey organisers and population modellers should work more closely together to investigate if and how volunteer-based count schemes could be improved to deliver the data required to test these predictive models.

4. Conclusions

In summary, existing volunteer-based count schemes are useful in monitoring the extent and distribution of human activities at sites. In addition, the ability of count schemes to accurately identify worrying trends in the numbers of waterbirds at sites can be of great use in informing sympathetic site management for waterbirds. In the UK, links between downward trends and the effects of potentially damaging activities can prompt statutory regulation of the damaging activity at site-level. However, to demonstrate the effects, let alone the impacts, of such activities requires scientifically robust research rather than existing volunteer-based monitoring. We also suggest that population monitoring through count schemes can be used to test models that predict the likely impacts of disturbance. Predicting the impacts of disturbance accurately will substantially improve our ability to evaluate site-based proposals for potentially disturbing activities rather than having to react to contemporary problems.

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