2013

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Batey, C. (2013) 'The effectiveness of management options in reducing human disturbance to wetland and coastal birds', The Plymouth Student Scientist, 6(2), p. 240-354.
http://hdl.handle.net/10026.1/14044

The Plymouth Student Scientist
University of Plymouth

*The Plymouth Student Scientist, 2013, **6**, (2), 340-354*

The effectiveness of management options in reducing human disturbance to wetland and coastal birds

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Abstract

Human disturbance to wildlife is a serious conservation issue for many groups of species. Birds inhabiting wetland and coastal environments may be of particular concern as they are exposed to disturbance both on land and on water, and due to growing pressure from tourism and leisure activities human disturbance in these environments may increase in the future. There are a wide variety of available management options referred to in the literature which aim to reduce or mitigate the negative impacts of disturbance to wetland and coastal birds. This review assesses the evidence for the effectiveness of these different management measures in reducing human disturbance to wetland and coastal birds such as waterfowl, shorebirds and nesting seabirds. The aims of this review therefore are to inform conservation decision making and to target future research in this field. Although the evidence base for the effectiveness of most management options is poor, there are some examples of successful conservation strategies to reduce disturbance to these groups of species and the benefits of using multiple management measures is also apparent. Future research should aim to fill the many gaps in our knowledge relating to the effectiveness of the management options discussed here, in order to better target conservation efforts.

Introduction

Human disturbance of wildlife is considered a serious threat to biodiversity conservation. Many groups of organisms are negatively affected by human disturbance, for example; turtles, seals, crocodilians and cetaceans (e.g. Cassini et al., 2004; Dans et al., 2008; Grant and Lewis, 2010). However, a large proportion of the literature and conservation concern focuses on the impacts to bird species. Wetland birds are currently facing numerous threats including human induced disturbance which can result in population level impacts (e.g. Long et al., 2007; Sutherland et al., 2012). Disturbance as a result of human activity to wetland and coastal birds is an issue of increasing importance, due to growing human populations and the attractiveness of coasts and wetlands as places of leisure and tourism. In particular, the popularity and development of extreme water sports and personal watercrafts are rising (Davenport and Davenport, 2006) and this has implications for both coastal and wetland bird populations.

There is extensive evidence of the negative consequences of human disturbance to wetland and coastal birds such as shorebirds, waterfowl and nesting seabirds (e.g. West et al., 2002; Beale and Monaghan, 2004a; Burton, 2007; Albores-Barajas and Soldatini, 2011), which are exposed to disturbance both on water and on land. Managing these disturbance impacts is important for the conservation of these groups of species. In order to reduce the negative impacts of human disturbance, it is desirable to know if disturbance has fitness consequences for individuals or populations, however, these impacts are rarely quantified due to being difficult to study. Basing management decisions on behavioural studies (the most commonly undertaken studies of disturbance) is questionable as there is contention around the applicability of behavioural responses (i.e. disturbance effects) in predicting fitness impacts (Gill et al., 2001; Beale and Monaghan, 2004b; Gill, 2007).

Although it may seem logical to adopt a precautionary approach and take steps to protect bird populations, when fitness impacts have been neither confirmed nor disproved, it is important not to limit human access unnecessarily. Finding a balance between encouraging human access and protecting bird populations is a challenge for conservation managers and acceptable levels of human disturbance may need to be determined (e.g. Beale, 2007; Gill, 2007; Martinez-Abrain et al., 2008). Very few studies measure the success of management measures to reduce disturbance impacts (i.e. the impact of human activity before and after measures are put in place) or compare different management options.

This review aims to inform conservation decision making and highlight the need for further study, on management options to reduce human disturbance to shorebirds, waterfowl, herons (Ardeidae) and nesting seabirds, hereby after referred to as wetland and coastal birds. Available on site management options are discussed in three broad categories: habitat management, human access management and education and enforcement.

Habitat management

Options to reduce or mitigate against negative impacts of disturbance to bird species through the management of habitats comprise; improving the quality of sites with low disturbance and habitat creation.

Improving the quality of sites with low disturbance offers an opportunity for mitigation against the impacts of disturbance on bird populations, by encouraging a greater proportion of the population to occupy low disturbance sites (Liley et al., 2011). This approach, however, does not address the impacts on sites with higher levels of disturbance and could only be applied where the management of multiple sites were being decided simultaneously. Research into the specific habitat requirements of target species has informed site management measures, improving habitat quality and productivity for some coastal breeding species (e.g. Ratcliffe et al., 2008; Maslo et al., 2011). Targeting such work at low disturbance sites could maximise the wider population's productivity. However, there is currently no available evidence of the overall population level impact to a species, as a result of landscape management strategies that focus on protecting some areas from disturbance, while sacrificing other areas to higher levels. This potential strategy is akin to the use of no take zones in the marine environment.

The use of man-made habitats such as islands by shorebirds and ground-nesting seabirds are well documented in the literature (e.g. Davidson and Evans, 1986; Parnell et al., 1986; Burton et al., 1996). Habitats such as islands made via the deposition of dredged-material, man-made roost sites for waders and man-made wetlands are often important for mitigation against feeding, roosting or nesting habitat loss (Davidson and Evans, 1986; Burton et al., 1996; Spear et al., 2007; Catlin et al., 2011). These studies provide evidence that created habitats are readily used by wetland birds and Catlin et al. (2011) have even shown fitness benefits of engineered sand bars which are preferentially selected by piping plovers (*Charadrius melodus*) on the Missouri River in the US. Furthermore, the creation of new mudflats has been predicted to remove the fitness impacts of disturbance for two out of three shorebird species in a behaviour-based model (Durell et al., 2005). Although one study (Rehfisch et al., 2003) suggested that waders on the Moray Basin, Scotland, showed a preference for man-made roost sites where human disturbance was either much reduced or predictable, there is no evidence of this having been quantified in any published study. Throughout the literature there is a distinct lack of research addressing the potential population benefits in creating habitats exposed to reduced levels of human disturbance.

Human access management

Managing human access to protect wetland birds from disturbance can include; the reduction or prevention of access to areas within a site, path management, limiting visitor numbers or strictly controlling specific activities.

Set-back distances or buffer zones, whereby human access is restricted at a specific distance from wildlife, are a very commonly used management option aimed at reducing disturbance impacts. These distances are usually the suggested management actions as a result of flight initiation (flushing) distances recorded in the course of behavioural studies of disturbance (Rogers and Smith, 1995; 1997; Lord et al., 2001; Rogers and Schwikert, 2002; Ronconi and Clair, 2002; Blumstein et al., 2003; Burger et al., 2010), although physiological responses such as increased heart rates can also inform set-back distances (e.g. Pfeiffer and Peter, 2004). Furthermore, it has been suggested, by Fernandez-Juricic et al. (2001) that set-back distances should be determined by alert distance rather than flushing distance, as this represents a more conservative indicator of bird tolerance (including a buffer zone of protection between alert and flight distances). Set-back distances have been widely applied to wetland birds such as foraging and roosting waders (Rogers and Smith, 1997; Rogers and Schwikert, 2002) and nesting seabirds (e.g. Pfeiffer and Peter, 2004), as well as other avian groups (e.g. Richardson and Miller, 1997; Fernandez-Juricic et al., 2005). The reason for the widespread use of set-back distances in site management is likely due to them being cheap, easy to set up and the fact that they are a common recommendation of behaviour-based studies.

The use of set-back distances has received some criticism (see Beale and Monaghan, 2004a) and there are numerous issues with setting blanket measures to protect all of the birds using a site from all types of human activity. It has been shown that responses to disturbance vary both inter- and intra-specifically (Blumstein et al., 2003; Beale and Monaghan, 2004b; Blumstein et al., 2005), while environmental conditions and time of year also influence disturbance responses and the scale of impact (Stillman et al., 2001; West et al., 2002). Characteristics of human activity not controlled by set-back distances, such as noise, human group size and boat size have also all been shown to contribute to the degree of disturbance (Ronconi and Clair, 2002; Beale and Monaghan, 2004a; Liao et al., 2005; Karp and Root, 2009; Remacha et al., 2011). Additionally, a study on whooper swans (*Cygnus c. Cygnus*) has shown that alert distance varies with site characteristics (such as field size and distance to nearest road or track), type of disturbance, flock size and disturbance frequency (Rees et al., 2005). A study on shorebirds also showed that flight distance varies by site (Blumstein et al., 2003). Finally, as set-back distances are usually a result of behavioural response studies, a proximate measure of disturbance impact, issues such as habituation, which can moderate the impact of disturbance (Baudins and Lloyd, 2007) are not considered when determining distances. Despite such issues, beneficial effects of buffer zones have been reported in a behavioural model (Durell et al., 2005) and the practicality of this management option is undeniable.

The use of exclosures, which provide a refuge for birds through preventing human access to areas i.e. through landscape barriers or fences, is a commonly used measure in the protection of ground-nesting waders and seabirds e.g. terns (Sternidae). This management tool has been shown to be effective in reducing the effects of human disturbance to coastal birds including herons and beach-nesting waders (Ikuta and Blumstein, 2003; Liley and Sutherland, 2007; Weston et al., 2012). One study has also shown possible population benefits of protecting a snowy plover (*Charadrius alexandrines nivosus*) roost site using a rope fence (as well as signs and volunteers), which led to an increase in abundance and the establishment of birds breeding on the site (Lafferty et al., 2006). There appears to be no literature on the use of exclosures to protect cliff-nesting seabird colonies, however, this measure should be equally effective in protecting these sites as exclosures are suited to the protection of areas with definable boundaries.

The process of zoning allocates areas for particular activities and is often a part of coastal management not associated with wildlife disturbance. Zoning offers an opportunity to reduce disturbance impacts by controlling the most disturbing activities in or near to areas important to wetland birds. Beneficial effects of creating hunting free zones, where hunting is the most disturbing activity to birds, have been demonstrated in the UK and Denmark (Hirons and Thomas, 1993; Madsen, 1998; Evans and Day, 2002). Zoning could perhaps be employed more often to control particularly disturbing activities such as new extreme sports, which have been identified as conflicting with birds, e.g. kite surfing (Davenport and Davenport, 2006).

Regulating or restricting the number of visitors at a site is sometimes considered as an option to reduce disturbance pressure (e.g. Yorio et al., 2001; Beale and Monaghan, 2004a), however, it is difficult to decide on the level of visitor restriction (Newsome et al., 2002). Controlling visitor numbers requires careful consideration of the trade-off between minimising human disturbance and encouraging public access. Beale and Monaghan (2005) tested the relationship between daily visitor numbers and daily nest failure rates of two seabird species in Scotland and detected a weak correlation between the two variables for black-legged kittiwakes (*Rissa tridactyla*). Despite this, the authors concluded that capping daily visitor numbers is unlikely to be a useful management option to reduce human disturbance, as the fitness costs were small and visitor restrictions would lead to reduced public education and awareness. Limiting visitor numbers also has practical flaws as, although it could be implemented at sites where it is possible to physically control access (e.g. islands), it would be unfeasible to regulate numbers at sites with many entry points or where the majority of people enter on foot (Liley et al., 2011).

In addition to the number of visitors, the way in which visitors are distributed across a site may also have implications for the extent of disturbance impacts. Beale (2007) modelled the relationship between disturbance pressure and disturbance impact to calculate optimal visitor distribution at seabird colonies in Scotland. This model showed that the optimal management option varied with the extent of human disturbance, nevertheless, for seabirds, aiming for an even spread of visitors is probably the best strategy, unless considering species very strongly sensitive to disturbance, or sites with very high levels of disturbance (Beale, 2007).

Path design and management is a useful tool for controlling visitor distribution and therefore can be altered to manipulate the extent of wildlife disturbance in sensitive sites. Although the majority of people may stay on paths (e.g. Keirle and Stephens, 2004), there is great variation in paths effectiveness in guiding people through vulnerable areas (Pearce-Higgins and Yalden, 1997). A case study on the Pennine Way in northern England showed that despite increased recreational activity, the level of disturbance to breeding golden plovers (*Pluvialis apricaria*) was reduced by resurfacing a heavily used path, resulting in fewer walkers straying from the path (Pearce-Higgins and Yalden, 1997; Finney et al., 2005). Finney et al. (2005) argue that providing surfaced paths is a more publicly acceptable option to protect wildlife compared to access restrictions or exclosures. However, these less accepted options may be more suitable for narrow, linear habitats such as shorelines. There are no published results of manipulating coastal path designs to protect birds from human disturbance, although where people straying from paths is causing disturbance, re-surfacing or creating obvious edges to paths may be an effective measure of reducing disturbing activities. However, managing the spatial distribution of visitors is only likely to lead to conservation benefits at sites where disturbance is having a significantly negative population level impact (Beale, 2007).

Reducing the visibility of people to birds through screening of paths and the provision of hides for wildlife observers, is a management tool aimed at minimising disturbance that is apparent at almost all sites concerned with wildlife conservation.

Astonishingly, there appears to be a complete lack of scientific study on the effectiveness of these measures in reducing disturbance impacts or even the behavioural responses of birds. The wide use and trust of screening methods seems to be based entirely on observational results i.e. closer encounters with wildlife. Due to the fact that birds do respond and incur fitness impacts as a result of human disturbance at all and that screening methods do reduce the conspicuousness of people, the benefit of screening is implied and certainly logical. However, quantifying the benefits of different types of screening in various circumstances is necessary.

One strategy in addressing wetland bird disturbance is to target the access of human activities identified as being particularly disturbing. Dogs have been identified as being highly disturbing to wetland birds when off the lead (Lord et al., 2001) and when barking (Randler, 2006). Management options aimed specifically at reducing the impacts of dogs include; providing dedicated dog exercise areas (Liley et al., 2011), dog control orders and keeping dog walkers greater distances away from birds than non-dog walkers e.g. via zoning or set-back distances (Lord et al., 2001). There appears to be no published evidence for the effectiveness of these measures in reducing disturbance impacts to wetland birds, however, the results of a study on woodland birds suggests that dog walking should be prohibited from sensitive conservation areas (Banks and Bryant, 2007). Boats and personal water crafts (PWCs) have also been documented as being highly disturbing to wetland birds and the scale of boat disturbance can be related to both speed and size (e.g. Ronconi and Clair, 2002; Burger, 2003; Bellefleur et al., 2009). Speed limits are sometimes recommended in behaviour-based disturbance studies (Ronconi and Clair, 2002; Bellefleur et al., 2009) but evidence for this measures effectiveness is not available. Burger (2003) has documented the success of management measures, including education, enforcement and targeted zoning, in reducing PWC disturbance to a nesting common tern (*Sterna hirundo*) colony in Canada, leading to increased reproductive success.

Education and enforcement

Educational measures are perceived as soft (i.e. preserving visitor freedom) and cheap approaches to reducing the negative impacts of disturbance (Littlefair, 2003; Mason, 2005). Measures targeted at site users, local residents and relevant clubs may include; codes of conduct, signage, leaflets, local initiatives and personal contact. The majority of site visitors may be unaware of their potential to cause wildlife disturbance (e.g. Sterl et al., 2008) and most visitor education efforts have been shown to be effective in altering visitor knowledge and behaviour (Marion and Reid, 2007). The content, delivery and style of communication all influence the effectiveness of education in changing visitor behaviour (see Marion and Reid, 2007). Although the effectiveness of education in reducing disturbance impacts is rarely quantified, Littlefair (2003) showed, in a terrestrial setting, that this can be achieved if measures are well targeted. Burger (2003) also reported the success of education in reducing disturbance impacts to breeding common terns (*Sterna hirundo*), however, continual education and enforcement is necessary to maintain this strategies effectiveness.

Signs can be used to inform site users of restrictions and provide information on conservation issues, including disturbance. Few studies have assessed the role of signs in reducing disturbance; however, Medeiros et al. (2007) have shown that the use of signs coupled with the presence of wardens during the weekend can be a successful strategy. This study showed that the presence or absence of these management measures was the most important predictor of nesting success in a little tern (*Sterna albifrons*) colony. Signs have also been shown to be an effective measure in altering visitor behaviour and reducing population impacts to breeding shorebirds (Weston et al., 2012).

Having wardens present at a site is often a desirable management option, with the dual purpose of educating site users and enforcing restrictions. Benefits of wardens can include: providing information to site users and encouraging positive behaviour through persuasion, as well as intervening to prevent disturbing activities. People may also behave more responsibly when an official is visible on site, for example, Muhar et al. (2002) found that there was a 20% increase in the number of dogs kept on a lead when a ranger was visible compared to when a ranger was not visible, in the Danube Floodplains National Park (where it is compulsory to keep dogs on a lead). The downsides of having a warden are that they are expensive, require training to be effective (e.g. Littlefair, 2003), are unlikely to reach a large audience and their usefulness in enforcement is reliant on their power to enforce current byelaws (Liley et al., 2011). The possible benefits of a voluntary warden programme in increasing the number of waders using a high tide roost have been reported on the Dee estuary (Kirby et al., 1993). However, this study does not provide evidence of warden effectiveness in reducing disturbance impacts as regional and national trends in wader species numbers over the study period were not considered. The beneficial effect of temporary wardens in reducing population impacts as a result of disturbance has been reported for nesting little terns (*Sterna albifrons*) in Portugal (when combined with signage; Medeiros et al., 2007) and for beach nesting shorebirds in southern Australia (Weston et al., 2012).

Legal options for prohibiting disturbing activities comprise; Habitat Regulations, SSSI legislation, Special Nature Conservation Orders, Byelaws and Dog Control Orders (Liley et al., 2011). Enforcement measures to protect wetland birds from human disturbance may be required where any human access restrictions have been imposed, as people do not necessarily abide by such restrictions. Johnson and Acevedo-Gutierrez's (2007) study highlights the need for enforcement of wildlife restrictions, the authors finding that the majority of kayaks and stopped powerboats violated a 91m buffer zone around a seal haul-out near Yellow Island, Washington. Enforcement of zoning restrictions has been reported to contribute to reducing disturbance by PWCs on Mike's Island, New Jersey (Burger, 2003). However, there is currently no evidence for the effectiveness of any enforcement or legal measures alone, in reducing the incidence of disturbing activities or the impacts of disturbance to wetland bird species. This is clearly an area requiring future research.

The evidence for effectiveness of individual management options is summarised in Table 1. This highlights the gaps in knowledge and requirement for further research for managing disturbance to wetland and coastal birds.

Table 1. Summary of evidence for the effectiveness of management options in reducing behavioural effects and fitness impacts of disturbance to wetland and coastal birds.

Management option	Evidence for effectiveness in reducing behavioural effects	References	Evidence for effectiveness in reducing fitness impacts	References
Habitat management options				
Improving habitat quality of low disturbance sites	None		None	
Habitat creation	None		Limited	Durell et al., 2005
Human access management options				
Set-back distances	Good	e.g. Lafferty, 2001; Ronconi and Clair, 2002; Blumstein et al., 2003	Limited	Durell et al., 2005
Exclosures	Good	e.g. Ikuta and Blumstein, 2003; Lafferty et al., 2006	Good	Lafferty et al., 2006; Liley and Sutherland, 2007; Weston et al., 2012
Zoning	Some	Hirons and Thomas, 1993; Madsen, 1998; Evans and Day, 2002	Limited	Burger, 2003 (in combination with other measures)
Restricting the number of visitors	Limited	Ikuta and Blumstein, 2003	Limited	Beale and Monaghan, 2005; Liley and Sutherland, 2007
Managing distribution of visitors	None		Limited	Beale, 2007
Path design and management	None		None	
Screening wildlife	None		None	
Education and enforcement options				
Education programmes	Limited	Burger, 2003	Limited	Burger, 2003
Signage	None		Good	Medeiros et al., 2007 (in combination with wardens); Weston et al., 2012
Wardens	Limited	Kirby et al., 1993	Good	Burger, 2003 (in combination with education, signage and zoning); Medeiros et al., 2007 (in combination with signage); Weston et al., 2012
Legal measures	None		None	

The need for multiple management measures

In addition to a lack of monitoring (i.e. before and after management is put in place) another reason why there is a lack of definitive evidence for the effectiveness of many management options is because they are not used in isolation. In reality, sites use a combination of measures aimed at reducing disturbance impacts and this makes evaluating the effects of individual options in the field extremely challenging. Throughout the literature, the need for and benefit of using multiple measures is apparent. Examples of effective management option combinations include the use of signs with wardens (Medeiros et al., 2007), exclosures with visitor number restrictions (Ikuta and Blumstein, 2003) and zoning with education and enforcement (Burger, 2003). Bennett et al., (2011) also provide evidence for the benefits of multiple measures. Their behaviour based simulation model showed that using individual options only reduced disturbance to night heron (*Nycticorax nycticorax*) nestlings by 10%, whereas implementing multiple management measures completely removed disturbance.

Conclusions

On the whole, there is very little evidence for the effectiveness of most management options to reduce disturbance to wetland and coastal birds. Few studies measure fitness impacts of disturbance before and after management measures are put in place. Additionally, few studies assess the effectiveness of individual management options and it is therefore difficult to compare the relative benefits of each different option. However, management strategies are likely to be most successful if employing multiple measures which have been shown to be effective when used in combination.

There is a need for much more research on the usefulness of management measures in reducing disturbance and future studies should make use of behaviour or fitness impact based models to test management strategies effectiveness (such as; Durell et al., 2005; Bennett et al., 2011), as similarly thorough assessments are unfeasible in the field. Observational studies are, however, still necessary to provide supportive evidence for future management and highlight practical issues in the implementation of management strategies. Monitoring the effectiveness of employed measures should be an essential part of future management strategies to reduce disturbance to wetland and costal birds. Moreover, the results of such studies should be published and therefore available to aid the design of conservation strategies at similar sites.

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