Ecological and anthropogenic constraints on waterbirds of the Forth Estuary: population and behavioural responses to disturbance

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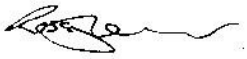
Submitted by Ross G. Dwyer, to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Biological Sciences, May 2010.

.....  .....

Abstract

Disturbance from engineering works is an increasing problem in terrestrial and marine ecosystems throughout the world. Many reported declines in population size, breeding success and body condition have been diagnosed as the result of anthropogenic disturbance, however little is known about the effect of long-term disturbance from large-scale engineering works. Understanding the mechanisms by which animals respond to anthropogenic activities is fundamental to explaining interactions, and resolving potential conflicts between humans and wildlife.

This thesis focuses on the factors affecting the habitat use and foraging decisions in wintering shorebirds and wildfowl. The first half of this thesis considers the direct and indirect impacts on waterbirds of a major engineering project in central Scotland; construction of the new Clackmannanshire Bridge at Kincardine-on-Forth. For individual bird species in close proximity to the bridge site, round-the-clock construction work had consequences ranging from neutral to considerably negative. Cormorant *Phalacrocorax carbo* declined in the area, probably as a result of the disturbance of an important low tide roost. Redshank *Tringa totanus*, previously abundant in the prey-rich areas adjacent to the construction site, were displaced into poorer areas for most of the construction period; where they may also have suffered from increased interference competition and elevated risk from raptorial predators.

Some positive effects of industrial development were also revealed; radio-transmitters combined with tilt-switch posture sensors indicate that Redshank were able to capitalise on the improved nocturnal visibility in areas around Grangemouth docks to assist with foraging and predator detection. Evidence is presented that birds switched foraging strategy (from sight to touch feeding) depending on ambient light levels; whereby artificial light was used in a similar manner to moonlight to assist with prey detection. Redshank also avoided riverine areas at night that were used frequently by day, probably in response to an elevated threat

from nocturnal predators. As the predator landscape changes from day into night, birds adopt different strategies to minimise the risk from nocturnal predators. It is clearly important, therefore, that information on nocturnal distributions is available to inform decisions on site management, especially where anthropogenic activity continues throughout the diel cycle.

Behavioural decisions were shown to vary widely within a species depending on individual state, metabolic demands and previous exposure to human disturbance. Prey resources were shown to change dramatically over the course of a winter. In response to this decline, the home range of Redshank contracted over a winter season. Similarly, animals responded less and took greater risks in response to experimental disturbance events later in the winter than earlier in the winter, and on days when the temperature was lower. This effect was strongest for individuals occupying heavily disturbed areas, which were possibly already compensating for lost feeding time and a negative energy balance. The results were consistent with the hypothesis that those individuals that respond most obviously to human disturbance were those least likely to suffer fitness consequences. This is the opposite from what is commonly assumed when behaviour is used as an index of disturbance impacts, most notably in the use of flush distance in the design of wildlife buffer zones.

In conclusion, this study demonstrated various negative impacts of disturbance, including local displacement, due to construction activity on overwintering waterbirds. It also revealed two key, but poorly understood, phenomena relating to mechanisms for coping with anthropogenic disturbance: routine utilisation of artificial light to extend night-time feeding opportunities amongst Redshank and an adaptive flexibility in escape responses across a range of species under varying conditions of risk.

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Contents

List of figures

List of tables