Estuarine, Coastal and Shelf Science 107 (2012) 81–88

Contents lists available at SciVerse ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Mechanical grooming and beach award status are associated with low strandline biodiversity in Scotland

Andre S. Gilburn

School of Biological and Environmental Sciences, University of Stirling, Stirling, Scotland FK9 4LA, UK

ARTICLE INFO

Article history:
Received 7 July 2011
Accepted 5 May 2012
Available online 16 May 2012

Keywords:
biodiversity
beach grooming
wrack beds
threats
human impacts
Blue Flag

ABSTRACT

Beach grooming and beach award status are both shown to be associated with low macroinvertebrate taxon richness in Scotland. Previous studies in California have revealed that mechanical raking to remove wrack from sandy beaches has negative ecological consequences for coastal ecosystems. In the current study the presence and absence of eight common taxa that inhabit beached wrack on sandy beaches in Scotland was assessed at 60 sites, 24 of which were groomed and 29 of which were in receipt of a beach award. On average 4.86 of the eight taxa were found to be present on ungroomed beaches, whereas only 1.13 taxa were present on groomed beaches. Thus, beach grooming seems to be having a major effect on the biodiversity of beach macroinvertebrates in Scotland. Fewer macroinvertebrate taxa were also found on award (1.5) compared to non-award (4.38) beaches. It was also revealed that award beaches were much more likely to be groomed than non-award beaches, with 69% of award beaches surveyed being groomed compared to only 6% of non-award beaches. This pattern is surprising as the awarding bodies discourage the removal of seaweed and regulations state that beached wrack should only be removed if it constitutes a nuisance. It is concluded that award status, not nuisance level, has the main factor driving most beach grooming and that this has resulted in the substantial loss of macroinvertebrate biodiversity from award beaches in Scotland. In conclusion it is shown that beach grooming has a substantial negative impact upon strandline macroinvertebrate biodiversity in Scotland and that grooming is much more likely to occur on award beaches.

1. Introduction

Sandy beach ecosystems form a very narrow zone at the interface between the terrestrial and marine environment (Brown and McLachlan, 2002; Schlacher et al., 2008; Defeo et al., 2009). They are highly dynamic in nature, particularly as a result of the actions of wind and tidal forces. There is little primary production, with strandline communities predominantly being dependent upon the deposition of beach-cast wrack, particularly in the form of brown algae (Griffiths and Stenton-Dozey, 1981; Polis, 1996; Kirkman and Kendrick, 1997; Pennings et al., 2000; Orr et al., 2005; Ince et al., 2007; Lewis et al., 2007; Gonçalves and Marques, 2011). As a direct result of nearly 40% of the human population living at or near the coast (Millennium Ecosystem Assessment, 2005) many sandy beach ecosystems have now been lost (Nordstrom, 2000) and many more are increasingly suffering from the negative impacts of a range of anthropogenic activities. These activities include: leisure pursuits, such as trampling and driving motorised vehicles on beaches; management practices, such as beach nourishment and mechanical grooming, and additional anthropogenic side effects, such as the generation of contaminants and the release of non-native invasive species (Davenport and Davenport, 2006; Schlacher et al., 2007; Defeo et al., 2009). Furthermore, the scale of this human impact upon sandy beach ecosystems is predicted to increase as a result of expanding human populations along coastlines worldwide (Brown and McLachlan, 2002; Schlacher et al., 2007, 2008; Defeo et al., 2009).

The relative impact on sandy beach ecosystems of one of these anthropogenic activities, mechanical grooming, remains largely unclear, as it has been relatively little studied outside of California. Mechanical grooming is usually carried out by dragging surf rakes across the surface of sandy beaches, which results in the removal of sand and beached material including wrack (Dugan et al., 2003). Studies in California have shown that surf raking has had a major impact on the biodiversity of the macroinvertebrates and shorebirds inhabiting sandy beaches (Dugan et al., 2003) and also on beach spawning fish (Martin et al., 2006). Furthermore, Dugan and Hubbard (2010) have shown that plant abundance within coastal strand ecosystems was 15 times lower on groomed beaches and

E-mail address: andre.gilburn@stir.ac.uk.

0272-7714/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecss.2012.05.004

that plant species richness was more than three times lower on groomed beaches. The loss of strandline and dune plants combined with the loss of sand can increase coastal erosion, destabilise dunes systems and increase the likely impacts of rises in sea-level as a result of global warming (Piriz et al., 2003; Feagin et al., 2005; Conaway and Wells, 2005; Schlacher et al., 2007, 2008; Dugan and Hubbard, 2010; Harris et al., 2011). Decomposed wrack also provides a rich source of nutrients to dune, strandline and marine ecosystems (Orr et al., 2005; Williams and Feagin, 2010).

Despite the magnitude of the impact of beach grooming on coastal ecosystems in California, few detailed studies have been conducted on other coastlines. Consequently the nature of the impact of beach grooming is unclear in other regions and its global impact cannot be assessed. It is essential that the effects of beach grooming are studied in other regions of the world where this practice is also regularly adopted in order to determine its global impact. In Northern Europe a study of the impact of a single raking event showed little impact on upper intertidal meiofauna in Belgium (Gheskiere et al., 2006). In the UK only one study has been carried out and that only on a single beach in Wales (Llewellyn and Shackley, 1996). This study also found evidence of a negative ecological impact of beach grooming on both the biodiversity and abundance of macroinvertebrates. There was also a corresponding reduction of 90% in the populations of two shorebirds that feed on strandline macroinvertebrates.

Beach grooming has been occurring in the UK for over 50 years and is becoming increasingly common (Llewellyn and Shackley, 1996; personal observations). In Scotland several councils use surf rakes to groom their beaches in the summer months. Personal observations suggested that this was often occurring at beaches in receipt of a beach award. There are two types of award, Blue Flag, an internationally recognised award run by the Foundation for Environmental Education (FEE) and Seaside Award, which only operates in Scotland, Northern Ireland and Wales and in Scotland is administered by Keep Scotland Beautiful.

The principal aim of this study was to determine if beach grooming affects the biodiversity of the macrofauna associated with beached wrack on Scottish beaches by comparing the macroinvertebrate taxon richness on intensively groomed and ungroomed beaches. The secondary aim was to determine if beach grooming was more likely to occur on award beaches, and whether as a result, the macrofauna of award beaches has been negatively impacted. This was achieved by comparing the level of beach grooming at award and non-award beaches and their macroinvertebarte taxon richness. An additional aim was to identify species that might act as simple indicators of the relative health of wrack bed macroinvertebarte communities.

2. Materials and methods

2.1. Study organisms

Taxon richness has been shown to be an efficient alternative to measurements of species richness as an indicator of biodiversity (Williams and Gaston, 1994; Balmford et al., 1996). Eight macroinvertebrate taxa commonly found in British wrack bed ecosystems (Egglishaw, 1958) were chosen as the study organisms. Six taxa were grouped to family level but one, mesostigmata mites, was grouped to order (due to the difficulty of separating the families *in situ*) and one to sub-class (due to the difficulty of separating the orders *in situ*). The eight taxa were as follows: 1) coelopidae – *Coelopa frigida* and *Coelopa pilipes* who are early colonisers of wrack beds and whose larvae play a key role in decomposing wrack beds; 2) sepsidae – a single species, *Orygma luctuosum*, which is another common Dipteran of wrack beds that prefers drier parts of the wrack bed; 3) anthomyiidae – a single species kelpfly, *Fucellia maritima*, that preferentially occurs in wrack strings rather than deep wrack beds and is often found on bare sand; 4) sphaeroceridae – *Thoracochaeta* spp. most which are likely to have been *Thinoseius zosterae*, which is the most common and abundant seaweed fly species found in UK wrack beds; 5) staphylinidae – a mixture os species, particularly the predatory species *Cafius xantholoma* and to a lesser extent *Aleochara algarum* which parasitises coelopids; 6) talitridae – amphipods of the following genera, *Talitrus*, *Talorchestia* and particularly *Orchestia*, which are commonly found within and under beached wrack; 7) mesostigmata mites – *Parasitus kempersi* which feeds on various diptera, nemotodes, oligochaetes and other mites, and *Thinoseius fucicola*, which occurs phoretically on coelopids and *O. luctuosum* and parasitically on talitrid amphipods and nemotodes, and 8) oligochaeta – oligochaete worms.

2.2. Surveys

Surveys of the eight taxa were conducted at 60 sites throughout Scotland (NB, site positions are unable to be given due to the political sensitivities of the work presented here). Site selection was initially determined by beach award status. A total of 29 of Scotland's 53 award beaches were surveyed. An additional six award beaches were also visited but these were disregarded as they had manmade sea defences which prevented the development of a community of terrestrial macroinvertebrates as any beached wrack present was regularly covered by high tides. Evidence of beach grooming was determined from raking marks in the sand and from talking to local beach users. Initially grooming status was determined on this basis but subsequent confirmation of this information was obtained from local councils. A total of 23 sites showed evidence of grooming. One additional site was determined to have been regularly groomed from information from the local council. The level of grooming ranged from daily to weekly, usually from April or May to September. Some beaches were also occasionally groomed out with these periods. Whenever a groomed beach was surveyed the nearest ungroomed beach was located. As grooming often only occurs on a section of a beach, for 17 of the groomed sites an ungroomed stretch of the same beach was surveyed during the same visit. Often the groomed section coincided exactly with the award section of a beach. Where this was not possible the nearest ungroomed beach was located. These were typically within 3 km of the groomed beach but one on occasion was 26 km away. Some beaches were also sampled on stretches of coastline grooming does not occur. On these stretches of coastline non-award beaches were sampled in close proximity to the award beaches.

Each site was initially surveyed to determine the location of any beached wrack present. The maximum depth of the wrack bed was also determined by placing a wooden metre rule into the deepest sections of wrack. The sampling procedure involved searching for each of the eight macroinvertebrate taxa within and underneath beached wrack for a period of 10 min. This period did not include time spent moving between patches of wrack at a site. Where possible wrack deposits at various positions up the beach, and therefore of different age, were sampled. Previous studies have found a tenfold difference in wrack cover between groomed and ungroomed beaches (Dugan and Hubbard, 2010). A short 10 min sampling duration was adopted as this was sufficient to survey animals living on, in, or under all the wrack present on some of the groomed beaches, where very little wrack was present. A longer searching duration is very likely to have resulted in higher scores for beaches with larger accumulations of wrack. As larger accumulations were much more likely to be found on ungroomed